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THE DEVELOPMENT OF A PROJECT PROCESS EVALUATION (PPE) FRAMEWORK THAT AIMS TO MEASURE THE EFFECTIVENESS OF IMPLEMENTING A NEW DESIGN AND CONSTRUCTION PROJECT PROCESS

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DECLARATION

The bulk of the research detailed within this thesis was undertaken under the Process Protocol II project, which was funded by the Engineering and Physical Sciences Research Council (EPSRC) under the Innovative Manufacturing Initiative (IMI). Although the results of the project have since been the topic of several associated papers and documents, the author undertook all the work presented in this thesis. I also hereby also declare that no portion of this thesis has been submitted in support of an application for another degree or qualification, of this or any other university or institute of learning.

Angela Lee
(Researcher)

ABBREVIATIONS

AMSP	Alfred McAlpine Special Projects
BAA	British Airports Authority
BAe	British Aerospace
BPF	British Property Federation
BPR	Business Process Re-engineering
BSC	Balanced Scorecard
CAD	Computer Aided Design
CAM	Computer Aided Manufacture
CBPP	Construction Best Practice Programme
CCF	Construction Clients Forum
CI	Continuous Improvement
CIB	Construction Industry Board
CMI	Construction Manager’s Instruction
CSF	Critical Success Factor
DETR	Department of Environment, Transport and Regions
DTI	Department of Trade and Industry
EDI	Electronic Data Interchange
EFQM	European Foundation for Quality Management
EPSRC	Engineering and Physical Sciences Research Council
GDCPP	Generic Design and Construction Process Protocol
IDEF	Integrated Computer Aided Manufacturing Definition
IMI	Innovative Manufacturing Initiative
ISHA	Islington and Shoreditch Housing Association
IT	Information Technology
JIT	Just-In-Time
KHT	Kennington Housing Trust
KPI	Key Performance Indicator
M&E	Mechanical & Electrical
NPD	New Product Development

PDCA	Plan-Do-Check-Act
PIC	Project Information Channel
PII	Partners In Innovation
PIP	Performance Improvement Plan
PMU	Pharmaceutical Manufacturing Unit
PPE	Project Process Evaluation
R&D	Research and Development
RIBA	Royal Institute of British Architects
SME	Small and Medium sized Enterprises
TQM	Total Quality Management
UK	United Kingdom

PUBLICATIONS

The following papers have been produced from the work conducted in this thesis.

Lee, A., Wu, S., Aouad, G. & Fu, C. (2002) Towards nD Modelling. Submitted to the European Conference on Information and Communication Technology Advances and Innovation in the Knowledge Society. E-sm@art, Salford.

Marshall-Ponting, A., **Lee, A.,** Betts, M., Aouad, G., Cooper, R. & Sexton, M. (2002) Information Technology Support to Improved Construction Processes: Inter-disciplinarity in Research and Practice. Submitted to Hong Kong.

Lee, A., Betts, M., Aouad, G., Cooper, R., Wu, S. & Underwood, J. (2002) Developing a Vision for an nD Modelling Tool (key note speech). In proceedings of CIB W78 Conference – Distributing Knowledge in Building(CIB w78), Denmark, 141-148.

Kagioglou, M., **Lee, A.,** Cooper, R., Carmichael, S. & Aouad, G. (2002) Mapping the Production Process: A Case Study. In proceedings of the 10th Annual International Conference for Lean Construction, Brazil.

Lee, A., Cooper, R. & Aouad, G. (2001) An Analysis of the UK Construction Industry's Performance Metrics. Submitted to the Journal of Construction Innovation: Information Process Management.

Lee, A., Cooper, R. & Aouad, G. (2000) Production Management: The Process Protocol Approach. Journal of Construction Procurement, 6(2), 164-183.

Lee, A., Cooper, R. & Aouad, G. (2000) Do Construction Based Document Management Systems Reduce the Cost of Posting and Printing Project Documents? Proceedings of the 1st International Conference on Post Graduate Research in the Built and Human Environment, University of Salford, Salford, 71-81.

Wu, S., **Lee, A.,** Aouad, G. & Cooper, R. (2000) Process Protocol Toolkit; An IT Solution for the Process Protocol. In the Proceedings of 3rd European Conference on Product and Process Modelling in the Building and Related Industries, Lisbon, Portugal, 193-199.

Fleming, A., **Lee, A.,** Cooper, R. & Aouad, G. (2000) The Development of a Process Mapping Methodology for the Process Protocol Level 2. In the Proceedings of 3rd European Conference on Product and Process Modelling in the Building and Related Industries, Lisbon, Portugal, 187-192.

Lee, A., Wu, S., Aouad, G. & Cooper, R. (2000) The Process Protocol, A Solution for the Problems of Construction. In the Proceedings of the 7th Annual Conference Promoting Business Ethics, New York, USA, 101-108.

Lee, A., Cooper, R. & Aouad, G. (2000) A Methodology for Designing Performance Measures for the UK Construction Industry. In the Proceedings of the 1st National Conference on Post Graduate Research in the Built and Human Environment, University of Salford, Salford, 30-41 (received prize for best presentation).

Nelson, M. M., **Lee, A.,** Cooper, R., Kagioglou, M. & Fleming, A. (1999) Process Re-engineering in the Construction Industry - Buzzword or Reality. In the Proceedings of the COBRA 1999 Conference, Royal Institute of Chartered Surveyors, Salford, 225-234.

ABSTRACT

Increased globalised competition and the need to meet continuously changing customer requirements has forced the UK construction industry to consider its practice. The industry has been repeatedly criticised for its inefficiency, fragmentation, profitability, and lack of co-ordination and communication by many governmental and institutional reports (Phillips, 1950; Emmerson, 1962; Banwell, 1964; Gyles, 1992; Latham, 1994; Egan, 1998). Latham and Egan cited that process improvement and learning from the manufacturing industry could aid the prevailing situation. Following such recommendations, a number of construction clients started developing their own design and construction process, including BAA (British Airports Authority), BAe (British Aerospace) and London Underground, as a way to improve the prevailing situation. An appraisal of these industrial approaches highlighted a common structure that contributed to the development of the Generic Design and Construction Process Protocol (GDCPP). This research project, led by the University of Salford, proved to be the impetus for a flurry of other construction companies to remodel their processes.

However, the success of a construction project is not always directly attributed to the performance of the new project process, and vice versa. Framed in these terms, how can the effectiveness of implementing a new design and construction project process be measured in recompense to this growing trend of process improvement?

Construction performance measurement today is myopic. For too long, construction organisations have focused on short-termism. If they are to remain competitive, they need to embrace broader issues other than the traditional time cost and quality metrics of construction performance (Love & Holt, 2000). They must also consider the performance of the project process itself (Neely et al, 2000) as to determine the true barriers to success, be that the process itself or implementation factors. However, there is at present a lack of understanding on how the measurement of project processes should be approached. This is attributable in part to the absence of publicly available information, and in part to the inherent difficulty of measuring a complex and creative process. This thesis describes the development of the project process evaluation (PPE) framework that aims to address this research gap.

Literature reviews and a scoping survey questionnaire were used in this research investigation for the discovery and building of the PPE framework. The framework consists of five steps, which guides the user from the identification of performance indicators governing the selection of the new project process, through into a knowledge-learning domain in order to improve upon future projects. A case study research strategy was then used to test and validate the model, which employed various research methods to collect both qualitative and quantitative data for the study; the Process Protocol was deployed on the case studies in order to certify the framework. The resulting PPE framework provides an original, prototypical solution to assessing the effectiveness of implementing a new design and construction project process.

CHAPTER 1: INTRODUCTION

1.0 Context and rationale

This thesis investigates the effectiveness of deploying a new design and construction project process through performance measurement. It is the purpose of this chapter to provide an introduction to the subject and the contextual background of the research. It begins by illustrating the growing need to improve the performance of the UK construction industry, as illustrated by many governmental and institutional reports. These reports prompted the emergence of a number of new initiatives, including drives for process improvement and to learn from the other industries such as manufacturing (Latham, 1994; Egan, 1998). In addition, the lack of understanding on how to measure the performance of construction project processes is also highlighted. Therefore, the need for industrial and academic guidelines or examples of how to approach the subject of measuring the effectiveness of implementing a new design and construction project process is conveyed as timely. This leads to the generation of a novel research need. The outline research design of this thesis is described to inform the reader of the content of the enquiry and to provide an initial structure towards achieving the research aim and objectives.

1.1 Research focus

The UK construction industry is under increasing pressure to improve its practices (Hill, 1992; Howell, 1999). It has been continuously criticised for its less than optimal performance by several government and institutional reports, such as Phillips (1950), Emmerson (1962), Banwell (1964), Gyles (1992), Latham (1994), and more recently, Egan (1998). Most of these reports conclude, time and time again, that the fragmented nature of the industry, lack of co-ordination and communication between parties, the informal and unstructured learning process, adversarial contractual relationships and lack of customer focus is what inhibits the industry's performance. In addition, construction projects are often also seen as unpredictable in terms of delivery time, cost, profitability and quality, and in addition, investment into research and development is usually seen as expensive when compared to other industries (Egan, 1998; Fairclough, 2002).

According to Howell (1999), the 'inefficiency' of the industry has tended to be the way of life. This may be due to the fact that none of the reports have been sufficiently acted upon apart from the Latham (1994) and Egan (1998) reports. As Latham (1994) points out '…some of the recommendations of those reports were implemented… but other problems persisted, and to this day, even the structure of the industry and nature of many of its clients has not changed dramatically.' Therefore, Latham (1994) suggests using manufacturing as a reference point, and Egan (1998) in his 'Rethinking Construction' report, recommended process modelling as methods of improvement.

The ability and transfer of practices and theories from other sectors, as suggested by Latham (1994), has since been a constant subject of discussion following the publication of his report. Some construction practitioners are adamant that their industry is unique and that the translation of principles cannot be adopted whole-heartedly. Ball (1988) highlights some of the most common arguments used to distinguish construction from other industries: -

- The one-of-a-kind product
- The spatial fixity of buildings
- On-site production
- Dependence on land for determined price
- The requirement for long-life expectancy
- The inexperience of clients
- The merchant/producer role of companies
- The overwhelmingly domestic industry
- The masculine stereotype of workforce
- The long cycle from design to production
- The high cost of the projects
- The amplified reaction in economic crisis

- The labour intensive production
- The fragmentation of the industry

In contrast, there are also many practitioners and academics that believe that the construction industry has much to learn from manufacturing. Howell (1999) goes as far as to suggest that this learning could be a two-way learning process; manufacturing could learn from construction in areas such as project-based management, and construction could learn from manufacturing's developed and developing solutions, to improve its competitiveness. According to Koskela (1992), Love et al (1996), and Kornelius and Wamelink (1998), manufacturing has been a constant reference point and a source of innovation in construction for many decades. Solutions that have been recommended to help overcome the problems of construction include industrialisation (i.e. prefabrication and modularisation), computer-integrated construction, robotics and automated construction (Koskela, 1992; Love & Gunasekaran, 1996; Kagioglou et al, 1998a). However, their implementation in manufacturing is still well advanced in comparison to construction. Koskela (1992) believes that the underlying theories and principles of manufacturing should be harnessed in order to deliver the full benefits to construction rather than the 'technological solutions.'

The realisation that the construction industry might not be as unique as it was traditionally thought has initiated new research in recent years. In particular, this stance led to the development of the 'Construction as a Manufacturing Process' research fund under the Innovative Manufacturing Initiative (IMI) sector of the Engineering and Physical Sciences Research Council (EPSRC, 1998) to continue and expound upon current thinking.

There now appears to be a new phenomenon that is being steadily exploited within construction companies alongside the new technologies taken from manufacturing. It is based upon the development and use of fundamental core processes, with great emphasis upon the basic theories and principles underlying the design and construction process in order to improve the efficiency of the industry. Egan (1998) highlighted this factor by reporting that due the fragmented nature of the construction industry, very little work had gone into process modelling. Manufacturers are accustomed to taking a process view of their operations; they usually model both discrete product activities and holistic high-level processes for both internal and external activities. In particular, there has been a growing volume of research focusing upon the consolidation of the Just-In-Time (JIT) and the Total Quality Management (TQM) philosophies, with an array of other practices such as Total Productive Maintenance, Visual Management and Re-engineering (dos Santos et al, 1999). Investigations by construction practitioners and academics alike have now sought to develop the content and structure of the core ideas underlying these theories, namely world-class manufacturing, agile production and lean production (Womack & Jones, 1996; Shonberger, 1996; Gilgeous & Gilgeous, 1999). This has led to an array of corresponding practices, for instance, world-class construction, agile construction and lean construction as it is believed that process improvement may well be a significant strategy for success in getting the right product to get to the right market, at the right time, cost and quality for the construction industry (Pheng & Tan, 1998).

Following the Latham (1994) and Egan reports (1998), a number of construction clients started developing their own design and construction process, including BAA (British Airports Authority), BAe (British Aerospace) and London Underground, as a way to improve construction practice. The leading construction clients realised the acute benefits of organising their own project procurement process that will ultimately deliver their desired building or facilities. An appraisal of these industrial approaches highlighted a common structure, which contributed to the development of the Generic Design and Construction Process Protocol (GDCPP).[1] The model aimed to provide the industrial co-ordination and clarity in the drive for process improvement.

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[1] The Process Protocol is funded under the 'Construction as a Manufacturing Process' research fund and uses manufacturing ideals to remodel the construction process. Since its publication in 1998, it has been widely accepted by industry and has proven to be an impetus for internal process development in many UK construction companies.

Added to this trend of process improvement is the growing attention of measuring construction performance (CBPP, 1999; Fairclough, 2002). Construction projects are usually evaluated by the '…extent in which the client's objectives, like time, cost and quality were achieved' (Ward et al, 1991). These measures are traditionally seen as the three indicators of construction performance, and although they provide an indication as to the success or failure of a project, they do not in isolation provide a balanced view of the project's performance (Mohsini & Davidson, 1992). The emergence of key performance indicators (KPIs) from the government's Construction Best Practice Programme (CBPP, 1999) is such an attempt to improve the prevailing situation. Hibberd and Djebarni (1991) assert that the project process should be measured to assess how well it achieves its proposed performance, and this is particularly apparent when adopting a new project process. Project performance is not always directly attributable to process performance. A well-organised and structured process may not always lead to project success, and likewise, a successful project may occur without the conviction of a planned process. Therefore, it is unwise to assess the effectiveness of a new project process on the success of the implementation project. Process performance is rarely assessed in construction due to its temporary project nature and the numerous procurement routes available (Hibberd & Djebarni, 1991). Whereas in manufacturing, consistent processes are commonly adopted and are subsequently assessed to enhance performance. This area of performance measurement appears to be timely due to the growing number of process improvement initiatives in the UK construction industry.

1.2 The research need

The factors illustrated in section 1.1 suggest that the growing trend of deploying new design and construction project processes has affirmed the need to measure their effectiveness. It is essential to justify the adoption of the new project process and/ or its need for change; changes may be small incremental adjustments to assist project team implementation or a complete overhaul of the new process, after all, project failure is not always a resultant of the process itself. This research investigation therefore aims to understand the nature of process performance management in order to satisfy the ‘gap’ that currently exists in the literature. The ‘gap’ will be made more apparent in chapters 2, 3 and 4 and will form the original and novel contribution of this thesis, extending the current boundary of knowledge in this area available in the public domain. The researcher aims to achieve this by integrating two, seemingly diverse, areas of knowledge i.e. new design and construction project processes, and the measurement of project processes. In addition, the research methodology deployed in this investigation is also considered as novel, in that it may be used to satisfy other ‘gaps.’ The following section provides an overview of the structure of this thesis and a summary of the chapters that make up this research investigation.

1.3 Aims and objectives of the study

The primary aim of this thesis is to identify the issues affecting construction project processes and performance management. The objective is to develop and test a: -

> ‘Project process evaluation (PPE) framework that will measure the effectiveness of implementing a new design and construction project process.’

In doing so, the researcher has the following sub objectives: -

- To gain a theoretical knowledge and understanding of the construction project process and how it is measured
- To investigate current and future thinking in process and performance related issues in manufacturing and construction sectors
- To develop and implement an appropriate research methodology to undertake this research
- To investigate the value of the PPE framework
- To provide the empirical evidence to support the benefits of implementing the Process Protocol

1.4 Outline research design

To meet the research objectives as outlined in section 1.3, an outline research design was firstly developed detailing the activities that would be undertaken during this investigation (see Figure 1.1). Once the research proposal for this thesis was formalised, it became clear that the relevant literature should be further investigated in support of the research aim. Reviews in project processes and performance management was undertaken in order to outlay their historical development and contemporary issues (chapters 2 & 3). Further, the research direction of this doctoral investigation was supported by the findings of a scoping survey questionnaire (chapter 4). A detailed research methodology was then identified to provide a clear and comprehensive illustration and justification of the methodological choices made by the researcher in undertaking the research (chapter 5). Following such methodology, the literature reviews and diagnostic survey questionnaire was used to develop the PPE framework (chapter 6). The validity of the framework is examined in two case studies, which implemented the Process Protocol, the results of which are extensively discussed (chapters 7 & 8). Thus, the validity of the framework is tested on two case study projects, and the value on the Process Protocol is examined on one study as each project implemented differing aspects of the model.

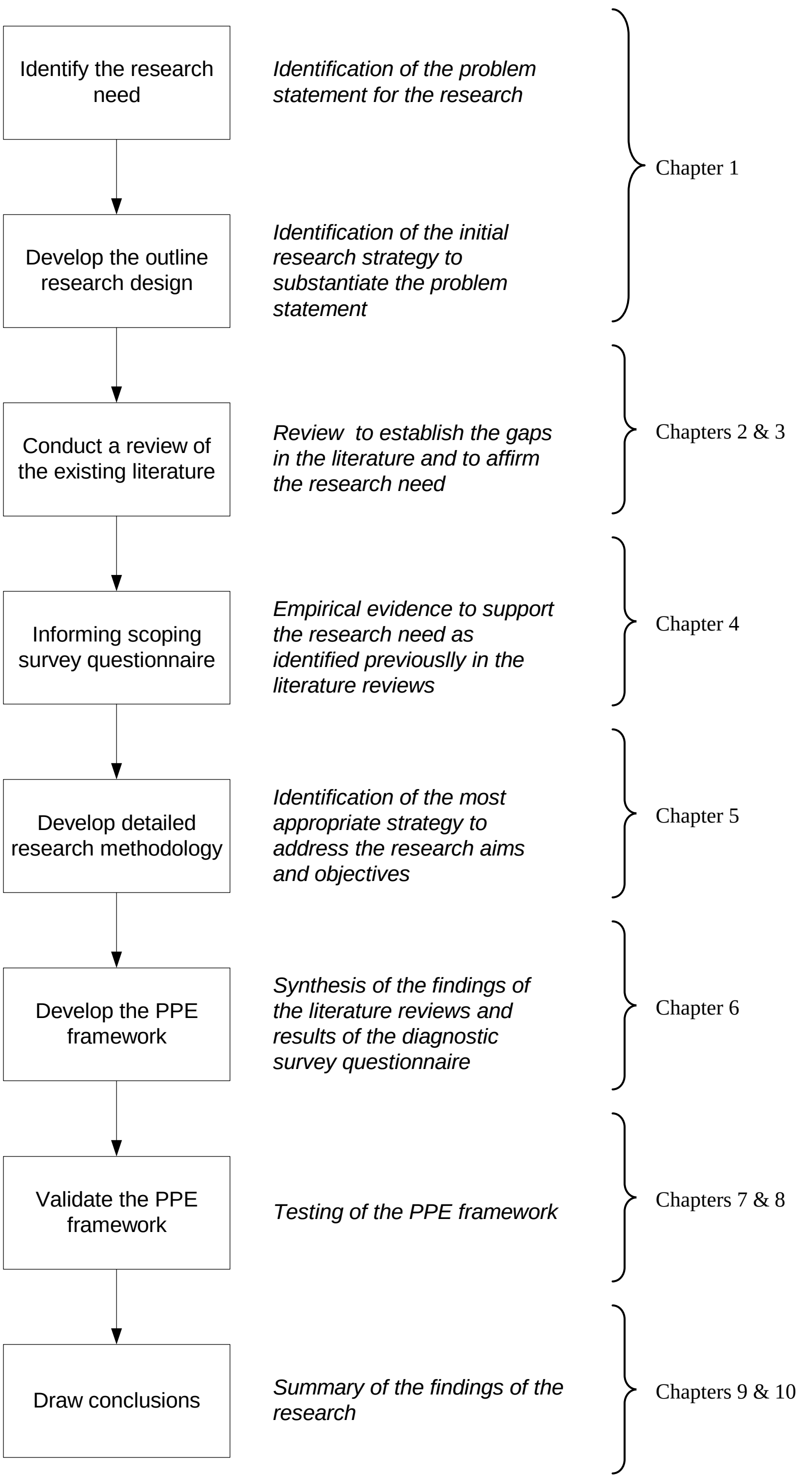


Figure 1.1: Graphical representation of the outline research design

The formulation of the thesis aims to present the author's understanding of the research area, the academic rigour of the research, and the development and testing of the PPE framework.

1.4.1 Structure of the thesis

The research design, as highlighted in Figure 1.1, is documented throughout this thesis in the following chapters: -

- Chapter 1: Introduction
  - Provides an overview of the issues related to construction process and performance improvement. Briefly introduces the concept of process modelling and learning from the manufacturing industry. Discusses the research need, aims and objectives of this investigation
- Chapter 2: Project processes
  - Examines the barriers of construction process performance. Introduces the topic of process modelling, and discusses the use of project processes in both manufacturing and construction industries, with the aim to transfer best practice to construction
- Chapter 3: Performance management
  - Provides an overview of current frameworks and guidelines in the performance management field. Analyses the implementation of these frameworks and their practical implementation on construction projects
- Chapter 4: Scoping survey questionnaire
  - Survey to inform the research direction of the thesis by affirming current and future thinking in project process and performance related issues in both manufacturing and construction industries. Summarises its development and subsequent results
- Chapter 5: Research methodology
  - Outlines the research methodology undertaken in this study, includes survey questionnaires and case study methodologies. Discusses triangulation of research methods. Describes a case study protocol that is used to guide the testing of the PPE framework

- Chapter 6: The PPE framework
    - Synthesises the literature related to measuring construction project process performance. Develops a theoretical framework that assesses the effectiveness of implementing a new construction project process
- Chapter 7: Castle Vale case study
    - Describes the results of testing the PPE framework on the Castle Vale project that introduced a new construction communication process
- Chapter 8: Britannia Walk case study
    - Describes the results of testing the PPE framework on the Britannia Walk project that introduced aspects of a new construction project process, the Process Protocol
- Chapter 9: Discussion and analysis
    - Brings together both the literature and the results of the two case studies. Analyses the two case studies in terms of the research objectives
- Chapter 10: Conclusion and recommendations for future work
    - The work undertaken in this thesis is concluded in this chapter. Limitations are provided and recommendations for future work.
- Appendices
    - Provides additional detailed information related to the research, where their inclusion in the main body of text in the thesis would have disrupted the flow of information

1.5 Conclusion

This chapter provides an overview of the area of research of this thesis. Section 1.1 illustrated the inefficiencies of the UK construction industry. The need for process reform was highlighted and it was also suggested that learning from the manufacturing industry could aid the drive for improvement. This led to the development of ‘new’ design and construction project processes. In addition, the lack of project process performance measurement was also identified. These issues were summarised to form 'the research need' and the 'aims and objectives of the study' (sections 1.2 and 1.3), forming the development of a novel contribution to knowledge – a project process evaluation (PPE) framework that will assess the effectiveness of implementing a new design and construction process. The final part of this chapter illustrated an outline research design that would facilitate the research investigation and the structure of this thesis.

CHAPTER 2: PROJECT PROCESSES

2.1 Introduction

The previous chapter identified that the UK construction industry has been continuously criticised for its less than optimal performance by several government and institutional reports (Phillips, 1950; Emmerson, 1962; Banwell, 1964; Gyles, 1992; Latham, 1994; Egan, 1998). It was suggested that learning from other industries, such as manufacturing, and process improvement could be the way forward (Latham, 1994; Egan, 1998). This chapter focuses on the project process by discussing the limitations of existing design and construction project processes, and exemplifying the subsequent need for new/ improved initiatives. The use of project processes in manufacturing is explored, with the aim of transferring best practice to construction. The development the Generic Design and Construction Process Protocol (GDCPP), a manufacturing-based project process, is finally presented.

2.2 The design and construction project process

In 1959, the United Nations defined the building (project) process as '…the design, organisation and execution of building project' that has come to be recognised as '…normal practice in any country or region… it is characterised by the fact that all operations follow a set pattern known to all participants in the building operation' (United Nations, 1959). However, the whole of this description is not succinctly true today. The nature of the design and construction process has grown in complexity since the 1950s, thus leading to an increased number of actors in the project. According to Howell (1999), variation occurs in every project process. Indeed, there now questionably appears to be no 'standard project process' of construction neither within a country nor a region, with no clear indication of the roles and responsibilities of the project participants.

The term largely associated with the 'traditional building process' today usually refers to the practice where, upon perceiving a need for a new facility, a building client approaches an architect/ engineer to initiate a process to design, procure and construct a building to meet his/ her specific needs. The process, in turn, almost invariably consists of the project being designed and built by two separate groups of disciplines who collectively form a temporary multi-organisation for the duration of the project: the design group and the construction group (Mohsini & Davidson, 1992). The design group, typically, is co-ordinated by an architect/ engineer. Depending upon the circumstances of the project at hand, it may also include other design professionals and specialists such as engineers, estimators, quantity surveyors etc. The principal function of this group is to prepare the design specifications of the work and other technical and contractual documents. The construction group, on the other hand, is usually co-ordinated by the main contractor and consists of a host of sub contractors and suppliers/ manufacturers of building materials, components, hardware and subsystems. This group is primarily responsible for the construction of the building project.

The two groups typically do not work coherently together (Kagioglou et al, 1998). The design activities in construction are usually isolated from the realities of the real issues facing production, as each function is expected to play a specific and limited role in any phase, thus contributing to the industry's problems, as highlighted by the many governmental and industrial reports (Phillips, 1950; Emmerson, 1962; Banwell, 1964; Gyles, 1992; Latham, 1994; Egan, 1998). This factor has contributed to the problems of construction of poor supply chain co-ordination, fragmented project teams with adversarial relationships (Mohsini & Davidson, 1992). Subsequently, new procurement routes have emerged in the last few decades to ease the problems; some of these are outlined below: -

- Construction Management: a construction manager is employed along side the design team as a project is initiated. The manager defines and manages the work packages to allow construction work to commence long before the design of the entire project is complete. However, costing of the project cannot be actually forecasted until all the packages have been let (Kagioglou, 1999)

- Management contract: design by the project sponsor's consultants and construction overlap. A management contractor is appointed early to let elements of work progressively by trade or package contracts. All contracts are between the management contractor and the trade contractors. As with construction management, the final cost can only be accurately forecast when the last package has been let (Carty, 1995)
- Design and Manage: similar to the Management Contract, but here the contractor is also responsible for detailed design or managing the detailed design process (Fryer, 1997)
- Design and Build: contract for both the design and construction of a project by a single contractor for a lump sum price (Carty, 1995)

2.2.1 Construction project process models

The emergence of various forms of procurement routes was perhaps the most significant attempt that the UK construction industry has made to improve its services (Masterman, 1992). According to Hibberd (1991), the concept of procurement raises awareness of the issues involved in challenging generally accepted practices and establishing strategies. Latham (1994) argues that reducing variations in the project process will improve performance and make significant cost savings. The fundamental benefit of such an improved design and construction project process should be to optimise predictability (Kagioglou, 1999). This could only be ensured when a truly co-operative project environment exists. The project process should look to facilitate team working and effective communication between participants (Kagioglou et al, 1998). Further, information technology (IT) can assist the attainment and maintenance of a new project process if its operation and relationship between the parties is sufficiently prescribed and detailed.

Unfortunately, there does not exist a means by which to reduce variation in construction in order to improve performance (Latham, 1994). The current perception is that flexibility is difficult within the process because the supply chain changes for every project, and relationships are dynamic. Despite the lack of a ‘standard’ project process, there are several well-recognised models of the construction process, namely the Royal Institute of British Architect’s (RIBA) Plan of Work (1964) and the British Property Federation (BPF) manual (1983). (Other process models that have been recently developed tend to only replicate a particular aspect of the design and construction process, such as Austin et al’s (1998) design process).

2.2.1.1 RIBA Plan of Work

The Royal Institute of British Architects’ (RIBA) Plan of Work (RIBA, 1997) was originally published in 1963 as a standard method of operation for the construction of buildings, and it has become widely accepted as the operational model throughout the building industry (Kagioglou et al, 1998). However, it was designed from an architectural perspective, which has in some way restricted its applications to Joint Contracts Tribunal components, and it is not generic enough for wide construction works.

The plan (see Figure 2.1) represents a logical sequence of events that should ensure that sound and timely decisions are made during the course of the project. It suggests that all the decisions, set out or implied, have to be taken or reviewed (RIBA, 1997), and it is anticipated that the model will only need slight adjustments depending upon the size and complexity of the project. The project progresses from inception to feedback, i.e. from stages A to M, in a linear fashion requiring the completion of one stage before proceeding to the next. However, the design and construction process is essentially not linear and cannot be viewed in such a functional fashion. Moreover, this sequential flow only aids the hard breaks between the organisational structure of the industry and contributes to the problems of fragmentation, co-ordination and communication between project team members (Sheath et al, 1996), as highlighted earlier by many governmental and institutional reports (Phillips, 1950; Emmerson, 1962; Banwell, 1964; Gyles, 1992; Latham, 1994; Egan, 1998).

Pre-design	A B
Design	C D E
Preparing to build	F G H
Construction	J K L
Post-construction	M

Stage A: Inception	Stage B: Feasibility
Stage C: Outline proposals	Stage D: Scheme design
Stage E: Detail design	Stage F: Production info
Stage G: Bills of Quantities	Stage H: Tender action
Stage J: Project planning	Stage K: Operations on site
Stage L: Completion	Stage M: Feedback

Figure 2.1: RIBA Plan of Work

2.2.1.2 British Property Federation Model (BPF)

The formation of the British Property Federation (BPF) model was a direct result of the growing concern of the increasing problems within the construction industry, notably, poor design, inadequate choice of materials and poor supervision of the works, combined with a lack of representation of the private sector client (Kagioglou et al, 1998). The model was intended for use by all those involved in a construction project i.e. client, design consultants, contractors, sub-contractors and suppliers, which was where the RIBA Plan of Work lacked. It highlights the formal and informal relationships between these parties, and aims to provide the client with value for money from the construction process by dividing the design and construction process into five stages (British Property Federation, 1983): -

- Concept
- Preparation of the brief
- Design development
- Tender documentation and tendering
- Construction

The model sets out to be flexible and allows the client to make a decision as to continue with the project at the end of each stage. Furthermore, the model can determine the actual position of the dividing line between stages, outlining when to make that decision. Although the model has not been widely implemented, which may be due to its close link with repetitive house building projects, it has many advantages over the 'normal' methods of design and construction, such as (British Property Federation, 1983): -

- It produces better buildings quicker and at lower cost
- It removes the overlap of effort between design team members
- Through more thought at the initial stages of the project fewer variations are needed when on site resulting in less delays, a lower cost and improved performance by the design team

2.2.2 Project organisation

The success of construction projects largely hinge on both the efficacy of the project process and the team enacting the work (Sidwell, 1990). The construction team is a living organism, usually formed from various organisations for the temporary duration of the project (Lingle & Schiemann, 1996). Although they have different priorities and capabilities, they are expected to work cohesively together from the outset. However, cultural issues between project team members have often been cited in the literature as limiting the project success (Sidwell, 1990); team-building exercises are commonly introduced to counterbalance this.

In addition, the number, and subsequent variations of design and construction project processes, exerts a much deeper problem to the efficacy (Howell, 1999). It was identified in section 2.2 there existed no standard project process (Latham, 1994). This gives a clear indication to the problem facing construction and towards the identification of a novel contribution for this research investigation; how are professionals meant to instinctively organise themselves into a team working environment when the process is full of infinite variation, in that their roles and responsibilities vary project to project. This is particularly apparent with the introduction of new design and construction project processes. Latham (1994) and Egan (1998) suggested learning from manufacturing and process modelling would aid project success. Therefore, the definition of 'project process' needs to be firstly explored, followed by the methods of process improvement that could later be applied to the transfer of manufacturing initiatives to construction.

2.3 The process demystified

Research shows that that every successful firm needs a '…formal blueprint, roadmap, template or thought process for driving a new product from the idea stage to market launch and beyond' (Cooper, 1994). The term 'process' is defined in Table 2.1.

Author	Definition
Davenport (1993)	'A process is simply a structured, measured set of activities designed to produce a specified output for a particular customer or market' and that they are 'the structure by which an organisation follows that is necessary to produce value for its customers'
Oakland (1995)	'The transformation of a set of inputs, which can include actions, methods and operations, into outputs that satisfy customer needs and expectations, in the form of products, information, services or – generally – results'
Bulletpoint (1996)	Suggests that regardless of the definition of the term process there are certain characteristics that this process should have the following: - • Predictable and definable inputs • A linear, logical sequence of flow

	• A set of clearly definable tasks or activities • A predictable and desired outcome or result
Zairi (1997)	'A process is an approach for converting inputs into outputs. It is the way in which all the resources of an organisation are used in a reliable, repeatable and consistent way to achieve its goals'

Table 2.1: Definition of a process

A process can simply be stated as having an input and an output, with the process receiving and subsequently transforming the input into the desired output (see Figure 2.2; Vonderembse & White, 1996). It provides the thinking and action framework for transforming an idea into a product, and it can either be tangible or intangible, functionally based or organisationally based (Cooper, 1994).

Figure 2.2: A process (Vonderembse & White, 1996)

2.3.1 The project process

Today, companies introduce new projects in a variety of ways, ranging from chaotic to systematic; the project process being that of the enabler of the business strategy (Harrington et al, 1997). While successful results are the obvious payoffs, it is unwise to constantly rely on luck to salvage the organisational procedure of the work at hand (Peppard & Rowland, 1995). However, there are companies that mistakenly believe that an idea or impetus will easily become a successful new product. Furthermore, once a superficially attractive idea has been articulated, such a company pushes ahead but may forget or overlook some steps, and so will consequently slip from its desired schedule. Unstructured development, a chaotic or random approach, usually leads to problems when fostering change in a new product's specification every time anyone has an embellishment. Without a formal structure in which to freeze specification and evaluate changes, creeping elegance often runs amok and nothing is ever introduced (Elzinga et al, 1995).

The 'transformation process' of the project, as illustrated earlier in Figure 2.2, is often depicted/ modelled in greater detail to enhance team co-ordination. Modelling techniques such as IDEF (Integrated Computer Aided Manufacturing Definition; Olsen & Simon, 1997) and analytical reductionism/ process decomposition are commonly used (Koskela, 1992). Process decomposition involves breaking the process down into levels of granularity, as demonstrated in Figure 2.3, with the lower level sub processes further defining its corresponding upper level process. The level in which differentiates a process from a procedure is, however, still a topic of discussion in the process management field.

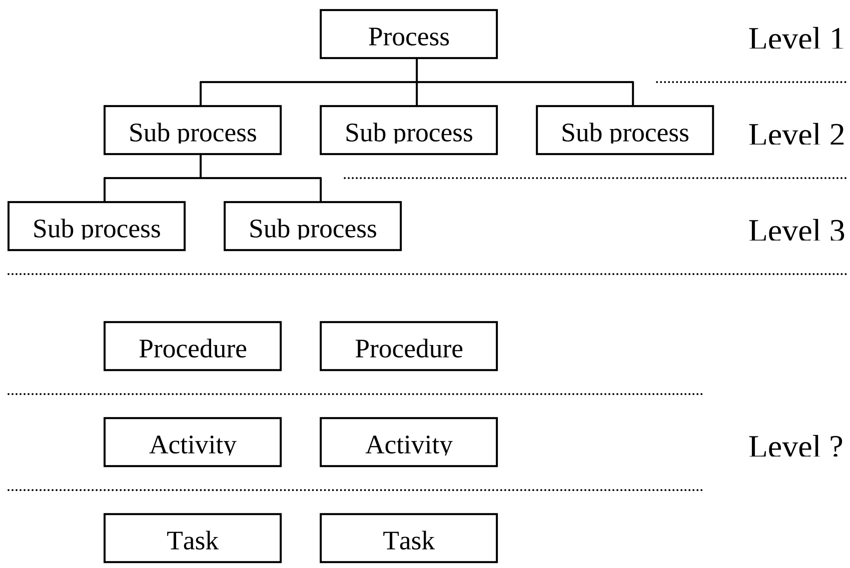


Figure 2.3: Process levels

A process (Koskela, 1992; Cooper, 1994; Vonderembse & White, 1996): -

- Converts inputs into outputs
- Creates a change of state; by taking the inputs (e.g. material, information, people) and passing it through a sequence of stages during which the inputs are transformed or their status changed to emerge as an output with

different characteristics. Hence processes act upon input and are dormant until the input is received. At each stage the transformation tasks may be procedural but may also be mechanical, chemical etc

- Clarifies the interfaces of fragmented management hierarchies
- Helps to increase visibility and understanding of the work to be done
- Defines the business/ project activities across functional boundaries

A procedure (Lee et al, 2001): -

- Is a sequence of steps, it includes the preparation, conduct and completion of a task. Each step can be a sequence of activities, and each activity a sequence of actions. The sequence of steps is critical to whether a statement or document is a procedure of something else
- Is required when the task we have to perform is complex or is routine and is required to be performed consistently
- Defines the rules that should be followed by an individual or group to carry out a specific task; their definition is usually rigid, leaving no opportunity for individual initiative
- Supports the process

2.3.2 The need for process improvement

Organisations today, big and small, public and private, domestic and global are finding themselves in an era of inherent competition. White (1996) proposes that years from now around 75% of the organisations that we recognise as household names will be gone, from being taken over by a more successful competitor or simply ground down by obscurity, whilst others will emerge as international giants.

If the world were stable, there would be no need to change business operations and methods, or to understand what has changed and what works well. However, firms operate in dynamic environments, and not stable ones, as both external competition and internal environments evolve over time. In response, processes must also continuously change so those firms can remain effective and profitable throughout the changing conditions (Moran & Brightman, 1998). Therefore, those organisations that wish to undertake improvements in productivity, quality and operations need to reconsider their working practices (Elzinga et al, 1995). Katzenbach (1996) reports that organisational change is becoming everyone's problem and that customers require it, shareholder performance demands it, and continued growth depends upon it. This is because customer/ client awareness and desires has increased in terms of quality and value for money, due to numerous pressure groups and consumer rights organisations informing the public on what they can buy for their money and what provides the best value for money. Egan (1998) supports this drive, and suggests that the construction industry could improve its performance by process modelling (see chapter 1). According to Lee and Dale (1998), process improvement follows one of two main streams: -

- Management and continuous improvement of existing processes
- Designing or redesigning of new processes

The first stream aims to optimise and continuously improve the on-going processes that are in operation within an organisation; and the second stream endeavours to change the organisation's processes, perhaps somewhat radically. Both streams are explored, with the aim of later applying manufacturing improvement initiatives into construction.

2.3.2.1 Continuous improvement (CI)

Continuous improvement (CI; sometimes referred to as continuous quality improvement, company-wide quality improvement, business improvement and process improvement) originated from the field of quality management. As its name suggests, is concerned with the continuous improvement of an organisation's process (Kagioglou, 1999). McNair (1991) defines it as '…an incremental change process that focuses on performing existing tasks more effectively …small improvements are made in the status quo as a result of ongoing effects.’ It adopts the stance that creating a development process is never completed (Oakland, 1995) and will only occur if attempts are made to learn from new information generated by the process itself rather than the product. This process is commonly associated with the Plan-Do-Check-Act cycle (PDCA; sometimes referred as the Demming Wheel or Shewhart Cycle; see Figure 2.4; Oakland, 1995).

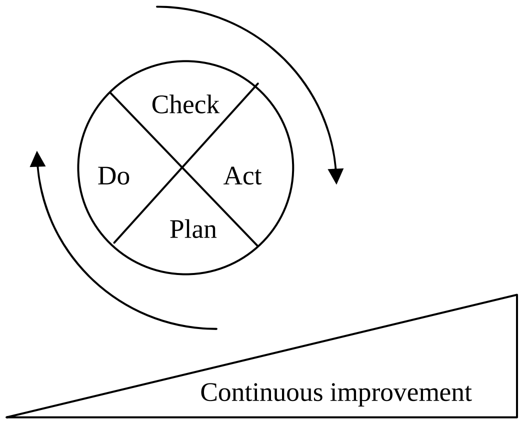


Figure 2.4: The PDCA cycle (Oakland, 1995)

When continuous improvement is in place, the PDCA cycle is repeated over and over again. Each phase of the cycle has an important role to sustain the ongoing improvement (Vonderembse & White, 1996): -

- Plan: identify problems or opportunities for improvement, develop a plan to make changes
- Do: implement the plan, documenting any changes made
- Check: analyse the revised processes to see if the goals have been achieved
- Act: standardise, document and divagate the results. In case of not achieving the goals, determine why not and proceed accordingly

2.3.2.2 Business Process Re-engineering (BPR)

According to Davenport (1993), intense competition and other pressures on large organisations often oversaw the quality initiatives that were introduced as part of continuous improvement programmes. Therefore, to achieve substantial business improvement, a powerful new tool emerged to facilitate the fundamental redesign of work so that significant improvement could be achieved (Davenport, 1993), namely business process re-engineering (BPR; sometimes called process innovation, business process redesign, business engineering or process engineering). It is essentially a strategic business management theory and is now actively one of the new buzzwords in construction industry. BPR differs fundamentally from CI in that it deals with breakthrough improvements as opposed to gradual changes (Wesner et al, 1995). According to Ovenden (1994), improvements of 10 – 15% can be achieved in most companies by using CI. However, where quantum leaps in performance are required, where the old should be completely replaced with new, then re-engineering is the way forward, and this may well be the solution to improve construction. Further, BPR processes appear to have a definitive start and finish whereas CI is a never-ending process (Zairi, 1991).

No two people have been more responsible for the re-engineering solution than Michael Hammer and James Champy (1997). The theory was well acclaimed after their book 'Reengineering the Corporation: A Manifesto for Business Revolution,' was published in 1993. They define re-engineering as '…the fundamental rethinking and radical redesign of business processes …to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service and speed.' That is, not small incremental changes to the process and leaving the basic structures intact, but rather, abandoning long-established procedures, conventional wisdom and assumptions from the past, to look afresh at the work required in creating a company's product or service to deliver direct value to the customer. An analysis of the definitions with respect to 'what,' 'how' and 'expectations' of the theory is illustrated in Table 2.2 (adapted from Choi &Chan, 1997): -

- What: the area of BPR concern
- How: ways to deal with BPR as suggested in the definitions
- Expectations: objectives expressed in the definitions

Authors	What	How	Expectations
Davenport et al (1990)	Business process, IT, strategy, organisational structure	Analysis and design	Seeking for improvements
DeToro & McCabe (1997)	Cross functional work teams	Examine, challenge and change work methods	Seeking for improvements
Dixon & Arnold (1994)	Key value business process	Radical or breakthrough changing	Dramatic orders of magnitude, distinguish from incremental improvements
Elzinga et al (1995)	Systematic approaches to analyse, improve, control and manage processes.	Process analysis	To improve the quality of products and services
Fiedler et al (1994)	Business process Information technology	Radical alteration, departing from existing practices, deliberating to plan	Bringing about remarkable improvements
Hammer & Champy (1997)	Business process performance	Fundamental rethinking, radical redesigning	Seeking for dramatic improvements
Kim (1994)	IT, business operations and organisation structures	Changing the way of doing business	Maximising the benefits of information technology
Manganelli & Klein (1994)	Strategic value-added business process, systems, policies and organisational structures	Rapid and radical redesigning	Optimising the work-flow and productivity
Paper (1997)	Strategy-driven organisational approach	Redesigning critical business processes	Dramatic improvements in quality, cost, service and speed
Ryan (1994)	Company's market, customers, products, services, suppliers and competitors	Making fundamental changes	Seeking for improvements
Teng et al (1994)	Existing business process	Critical analysis and radical redesigning	Breakthrough improvements in

			performance
Zairi (1997)	Manufacturing, marketing, communications	Analysis and design	To continually improve fundamental activities

Table 2.2: Definitions of BPR

Re-engineering is a top-down approach led by senior management and aimed at rapid and dramatic performance improvement (Ardhaldjian & Fahner, 1994). It views improvement from the process perspective rather than the functional or organisational stance (Klein, 1994) and is intended to align the process with the strategic objectives and customers' needs. When a process is re-engineered, jobs evolve from narrow and task-orientated to multidimensional. Moreover, managers stop acting like supervisors and behave more like coaches (Hammer & Champy, 1997). Workers focus more upon the customer's needs and less on their bosses'. Attitudes and values change in response to new incentives.

2.3.2.2.1 Implications of re-engineering

Although BPR has been a popular buzzword since it was widely publicised in the 1990s, the verdict on its success remains uncertain (Choi & Chan, 1997). Hammer and Champy (1997) estimate that as many as 50 – 70% of the companies that try to re-engineer will fail, but it is important to note here that this assertion was neither documented nor empirical evidence. Moreover, Champy reported in 1995 that re-engineering is in trouble, in that even substantial re-engineering payoffs appear to have fallen well short of their potential; '…Reengineering the Corporation set big goals: 70% decreases in cycle time and 40% decreases in cost; 40% increases in customer satisfaction, quality and revenue; and 25% growth in market share …although the jury is still out on 71% of the ongoing North American re-engineering efforts in the sample …overall, the study shows participants failed to attain these benchmarks by as much as 30%.'

Surely if the 'gurus' openly acclaim that there are risks attached to the process of re-engineering, then simply, why should we re-engineer? Chan and Peel (1998) conducted a survey of 37 companies spanning from 17 different industries world-wide who had re-engineered, and they concluded that about 73% of the sample experienced a significant reduction in cost, whilst successfully fulfilling the customer's needs. Furthermore, 68% reported that re-engineering had helped them to achieve their objective of improving organisational efficiency, dramatic company-wide improvements and reducing throughput time. The study concludes that the efforts of re-engineering have more often than not paid off, and that those companies that are willing to try can achieve substantial payoffs in several respects. However, there does appear to be a series of critical implementation strategies to increase the likelihood of success (Hammer & Champy, 1997; Chan & Peel, 1998; Revenaugh, 1994; Lee & Dale, 1998; Choi & Chan, 1998), and this can be attributed to the actual definition of the term (see Table 2.3). Hammer and Champy (1997) believe that the most egregious way to fail at re-engineering is by not re-engineering at all, but rather conducting process changes and calling it re-engineering. The term has acquired a certain cachet and has been attached to many programs that have nothing to do with radical process redesign. Bartram (1994) reports that some managers still admit that they still do not wholly grasp the concept. Furthermore, a survey performed showed that less than half of the 88% of executives that were re-engineering, could successfully define BPR as process redesign (Klien, 1994). The presiding factors are summarised in Table 2.3 (adapted from Choi & Chan, 1997).

Category	Factors	Failure reasons	Success conditions
Definition	Concepts	Unclear definitions, too many terms and definitions, misusing the term	Understand and clarify the concepts
	Methodology	Lack of standard methodology	Select an appropriate approach, conduct change management, proper project management

	Expectation	Unrealistic expectations	Clear goal setting, expectation set on condition basis and review during the project
Human	Change resistance	Employees resist change, difficulty in culture shift, fear of downward decision-making authority	Establish communication channel, well-informed workers, provide training, care of those unable to adopt
	Top management commitment	Lack of top management commitment	Include senior executive in the steering committee, set strategic directions, having clear authority and project team motivation
	Workers involvement	Neglect line workers, depends only on outsiders	Balance between two parties, broad involvement of employees, comments for adjustments
Skill	Information technology	Over-reliance, mix up automation and BPR, lack of corporate information system	Maximising benefits of IT in BPR process, establish corporate overview at information flow, adequate budget
	Project duration	Delay of delivering the result	Proper project management, setting agreeable project duration, divide project into phases
	Scope and objective	Incorrect objective, wrong scope, wrong process selection	Prioritise objectives, establish business context, identify valuable processes
	Process re-conceptualisation	Limited by localised expertise, confuse function with process	Need a shared vision for better communication
	Benefits recognition	Incapable of recognising the benefits of BPR	Encourage creativity, help by simulation

Table 2.3: Critical success and failure factors of BPR

2.3.3 Change management

Improvements to a process, either through CI or BPR, will only lead to positive outcomes if the effects of change management are also considered during implementation (Ovenden, 1994). The concept of 'change' has recently become an inherent feature of process improvement. Since the 1980s, the concept that change has given way to more radical ways of thinking; archaic and traditional structures are history, whereas agility and flexibility are the new key concepts (Ovenden, 1994). Business leaders tend to envision reconfigurable processes that can change almost on demand. New managers often learn and use techniques and management polices disseminated by gurus and consultants, the focus being on speeding up processes, improving workflow and output. However, according to Elzinga et al (1995), it is important to understand that any change to a process disrupts the work environment. In order for an organisation to continue to function during the disruption, it is essential to plan the change carefully and to align the three elements that make up an organisation (Ovenden, 1994): -

- The product or service
- The human factor
- The culture

The importance of the process actors and their culture was discussed earlier in section 2.2.2. More too, an organisation ideally adapted to change would not only have a clear vision of where it wants to go, but a well-thought-out strategy for getting there. However, people resist change more often than not (Ovenden, 1994). Organisational development experts often like resistance or negative responses in which they take as signs of vitality, however, management who find themselves fighting resistance every step of the way are wasting energy better spent in the future (Katzenbach, 1996): -

- Negative responses: by shattering the status quo, change naturally provokes resistance. This is even more the case in a period of economic uncertainty; the workforce perceives any difference in the work environment as job threatening

- Positive responses: experience shows that the greater employee involvement in change, the greater the positive response. Management gurus suggest giving people a sense of safety in learning, in trying new things, without fear of punishment. Further, failure is not blamed but considered part of the learning process, hence encouraging change and hopefully improvement.

2.3.3.1 Implementing change

Despite economic indicators all clearly pointing to the necessity of process change, many companies remain risk-averse and prefer to proceed with caution (Ovenden, 1994). Therefore, several models on the character and process of change have been developed, each encompassing three common cores (Elzinga et al, 1995): -

- They address change in a comprehensive manner: classifies the key social behavioural factors that influence performance in an organisation. These factors, divided into transformational (leadership, organisational culture, mission, strategy etc) and transactional (management practices, systems, individual needs etc), are organised into causal relationships: affecting one variable means affecting others. In a change management situation a systems theory approach is useful in determining the sequence in which key factors should be addressed
- They follow a process for introducing change: any change should be firstly assessed (analyse data for an accurate diagnosis of the 'as is' situation and create an understanding of the change problems), planned (articulate and define the tactical process required to bridge the gap between 'as is' and 'to be'), implemented (support and reinforce organisational commitment) and finally reviewed (involve and empower people towards a shared vision and culture change)
- They address a set of critical success factors: when organisations set aside assumptions and axioms that no longer work and start looking at structural and cultural elements, a whole new set of success factors appear. By

addressing these factors throughout the change process, limitless opportunity for organisational growth can be reached

The two most notable frameworks illustrating the evolution of organisational change include: -

- 7S framework: presents the seven most important categories that managers should concentrate their efforts in managing organisations, and in particular, how structure, systems, style, staff, skills and shared values interrelate with strategy (Peters & Waterman, 1982)
- 7C framework: concentrates on the capability, change and information, communication, causes and commitment, crisis points, and control and culture (Waterman, 1987)

The critical task of these frameworks is to understand how the different elements balance off one another, how changing one aspect affects the rest, and how sequencing and pace affect the whole structure (Duck, 1993).

2.4 Manufacturing project process

In order to improve construction performance, learning from other industries such as manufacturing, was suggested as a solution (Latham, 1994). Although manufacturing has been a constant reference point and source of innovation in construction for many decades (Koskela, 1992; Love et al, 1996; Kornelius & Wamelink, 1998), the industry has somewhat failed to seek out ways to reform existing processes to improve productivity, a complete contrast to that of manufacturing (Howell, 1999). Davenport (1993) suggests that manufacturing firms seek not fractional but multiplicative levels of improvement, that is ten times rather than 10% of that of construction. Manufacturing success depends largely upon an organisation's ability to identify the needs of its customers, to quickly create the desired products and to produce them at a low cost. Furthermore, achieving these goals is not solely a marketing, a design or a manufacturing problem, but rather a management problem involving all of these functions (Evans, 1993). This factor may indeed help to improve the fragmented nature of the construction industry.

This section aims to describe an apt manufacturing project process in order to augment construction process practice (Kagioglou et al, 1996). Ball (1988) highlighted a number of factors as key distinguishing elements of construction that may prohibit translating lessons from other industries in section 1.1. Akin to his argument of 'one-of-a-kind product' is the New Product Development (NPD) project process in manufacturing (Kagioglou, 1999). The high level process of NPD is standard/ generic, and in a similar fashion it is anticipated that construction can be modelled likewise. This thus addresses Latham's (1994) concern (see section 2.3) that there is no means in which to reduce variation as to improve performance.

2.4.1 New Product Development (NPD) process

The development of new products and services that can successfully compete in local, national and global markets has become a key concern for a large majority of manufacturing organisations (Cooper, 1992). The NPD process is fundamental for organisations to support this growth (HM Treasury, 1998). The process has received, and continues to receive, much attention by academia and practitioners to improve its effectiveness and efficiency (Owen, 2001).

A new product is one that has not been previously manufactured by a company (Crawford, 1994); likewise, it is commonly cited that construction eventuates 'one-of-a-kind products' (Ball, 1988). The fundamental aim of the NPD programme is to get the right product to the market or customer as quickly as possible. This limits the chance of a competitor gaining an advantage by first entry, and therefore enjoying an early market position. It is possible to trace similar stages of NPD to that of the construction industry. The NPD process is composed of a number of activities (Crawford, 1944). Generically, these activities can be separated into three main broad categories, namely (Cooper & Kleinschmidt, 1988): -

- Pre development activities: idea generating/ establishing the need, followed by a number of preliminary market, technical, financial and production assessments
- Development activities: the physical development of the product
- Post development activities: the final launch of the product into the market place

Depending upon the type of contract or procurement strategy in construction, NPD can refer to: design and build, build to own, develop and construct, design–build–finance–operate, build–own–operate or design and construction (Kagioglou et al, 1998a). The NPD activities adopted by a company can be arranged in various ways to represent the sequence of implementation and the interactions between them, forming the NPD model. From a historical point of view, NPD models can be classified into three main streams: sequential, overlapping and stage gate (Cooper & Kleinschmidt, 1988).

2.4.1.1 NPD models

In the 1960s, the NPD process was still in its first generation, following a simple linear sequential structural model whereby the development moved through different, almost mutually exclusive, phases in a logical step-by-step fashion (McGarth, 1996). The development only proceeded to the next phase only after all the requirements of the preceding phase were satisfied, and in each succeeding phase, different intermediate results were created, with the outputs of one phase forming the major inputs to the next (Coughlan, 1991). In this sense, the major activities of the process were isolated from each other, creating an over-the-brick-wall effect, whereby each discrete activity played little or no regard to the next activity (see Figure 2.5).

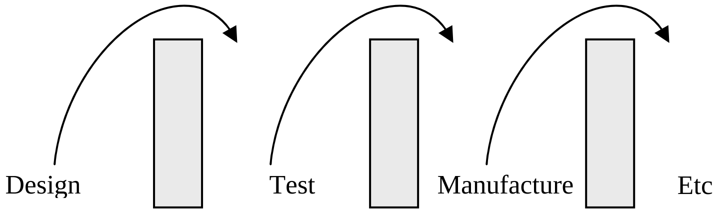


Figure 2.5: Sequential over the 'brick wall' approach

Since the first generation, the NPD process steadily evolved into a more increasingly complicated second generation 'coupling' model (Tidd et al, 1997). This phase bought about the introduction of the stage gate process, which broke NPD into discrete stages, with review points (gates) at the end of each stage (see Figure 2.6). Each stage represented a number of activities that needed to be performed before progressing to a 'decision' gate before the next stage. These gates were clearly defined as 'yes' or 'no' decision points that provided organisations with the capability to measure and control the process and match subsequent funding to meeting the requirements at each gate (McGarth, 1996). Further, the stages, unlike that of the first generation, were multi-functional activities involving numerous people from different departments.

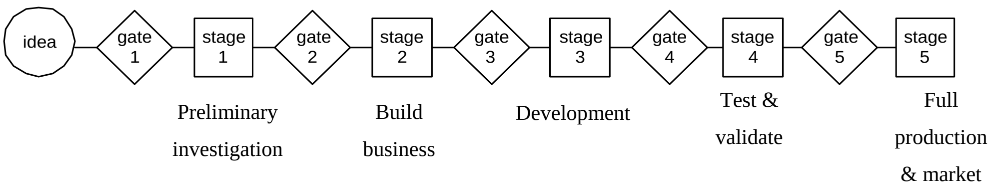


Figure 2.6: Second generation NPD stage gate process (Kagioglou et al, 1998a)

Whilst enabling a higher degree of control and understanding of the progression of a project process, such gates required variable tasks to be checked off against predetermined lists. This often made the process both cumbersome and slow (Cooper & Kleinschmidt, 1992). Projects were forced to wait at each gate until all tasks were completed and so not to stray from a process through which all projects had to progress; any overlapping of activities was impossible (Devinney, 1995). Therefore, in order to overcome unnecessary delay and to enable smoother progression, the more recently developed third generation 'parallel' processes have therefore sought to accommodate the need for certain tasks to overlap during a NPD programme (Cooper, 1994). Through modifying the individual gates to become fuzzy to allow conditional-go decisions, a degree of fluidity was introduced into the process that allows the stages to overlap (see Figure 2.7). In addition, by being more outcome focused, these processes have permitted organisations to build prioritisation models enabled projects to move through the process with more flexibility.

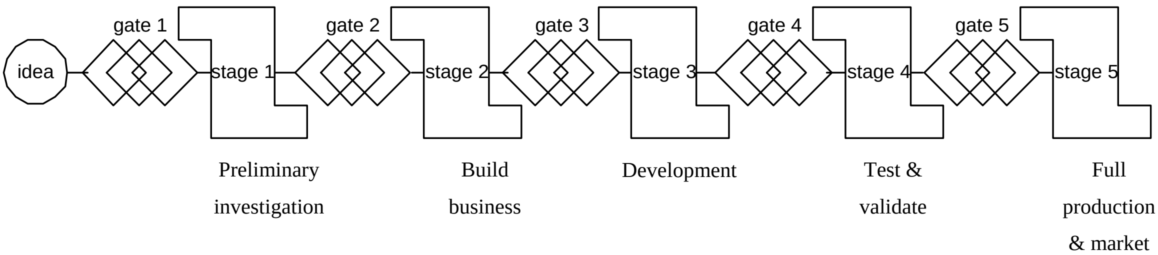


Figure 2.7: Third generation fuzzy stage gate overlapping NPD process (Kagioglou et al, 1998a)

2.5 Manufacturing ideals into construction

Manufacturing has developed and is developing solutions to typically improve its competitiveness (Howell, 1999). So while many construction researchers are at odds with the precepts of manufacturing, it is nonetheless felt that the business has much to learn from the manufacturing industry. There appears at first hand to be elements of the NPD process (see section 2.6.1) that can potentially be applied to construction. For example, Cooper and Kleinschmidt's (1988) description of the generic manufacturing activities; namely pre development, development and post development; can equally be used to describe construction. Further, the sequential over the 'brick wall' approach (see Figure 2.5) mimics that of the sequential construction project process, such as the RIBA's plan of works – the use of the third generation stage gate may help to improve the fragmented nature of construction.

However, Don Ward, the Chief Executive of the Construction Industry Board (CIB) in the UK (Building, 1999), recently reported that '…efforts to improve the industry have been met with mixed reactions …some construction organisations have risen to the challenge, reaping the business advantage …others resolutely maintain that any change in industry practices is impossible because of the apparently 'unique' nature of each construction project.' The products of construction tend not to lend themselves easily to the solutions devised by manufacturing, in that they are generally large and immobile, more complex in number, a greater range of components, and the final product is usually unique (Howell, 1999). Fortunately, these problems are not insuperable. For some particular types of construction, this direct transfer of knowledge from manufacturing to construction has been proved possible (Koskela, 1992). Many buildings, such as houses, are essentially repeated products that can be continually improved; the process of construction itself can be repeated from project to project (Egan, 1998). There are several notable examples of successful implementation; Schonberger (1990) reports on a Japanese factory producing prefabricated houses with a customer lead-time of forty days (from order to completion on-site), and production time (first to last operation) of one day; a Finnish window manufacturer provides delivery and installation of windows on site with a fifteen minute accuracy (Koskela, 1991); and an American industrial door manufacturer has gained a considerable competitive benefit from short cycle-times with Just-In-Time (JIT) production techniques (Stalk & Shulman, 1992). Indeed, it is true that manufacturing methods can be used to re-engineer construction's operational processes; 'pre-assembly is a very important issue in construction at the moment and is important because of the qualities of assembly in a factory are inherently better (Howell, 1999).

According to Howell (1999), it appears that the construction industry is sceptical to take on board the re-engineering of their core project process. However, process modelling should be used to improve the development efforts of construction, since major improvement can only be reaped from remodelling the underlying theories and practices rather than solely adopting production methods (Koskela, 1992), such as JIT and TQM (introduced in the 1980s from manufacturing).

British Airports Authority (BAA) led the way forward in the UK for design and construction project process reform (another leading UK client, London Underground, quickly followed their attempt). Therefore, in order to encroach towards a standard generic project process that would challenge the issues of fragmentation that would prevail if the leading construction organisations all developed their own standards; the Process Protocol (based on the NPD process) was developed.

2.5.1 The BAA project process

The theory behind the introduction of the BAA project process (BAA, 1995) was to have all of their construction projects following the same processes, so that best practice could be achieved. The process has seven major stages and eight major processes that combine to cover all areas of a construction project (see figure 2.8).

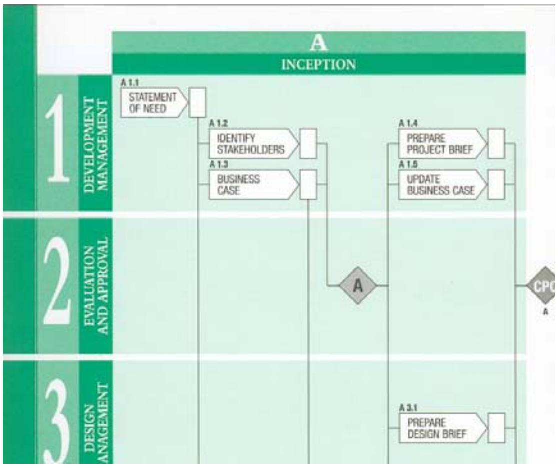


Figure 2.8: Snapshot of the BAA project process

The seven major stages of the model are (horizontal axis of figure 2.8): -

- Inception: brings together customer needs with the business strategy to address the question 'do we need a project?'
- Feasibility: explores the full range of options that could meet the needs and objectives identified, and determines the preferred solution
- Concept design: develops the solution in terms of architecture and interior design, also studies and selects major physical and engineering systems
- Co-ordinated design: using specialist input, it is predicted how the various elements of the design will fit together to ensure cost, safety and operational performance
- Production information: all the aspects of construction works are fully detailed and planed by suppliers and contractors
- Construction: the project is constructed to the specification that was agreed in the design, planning and consultation work
- Operation and maintenance: the facility is handed over and the information required for feedback is obtained

The eight major processes of the model are (vertical axis of figure 2.8): -

- Development management: to ensure that the right solution is used for the right problem and a business focus is maintained throughout the project

- Evaluation and approval: to ensure who needs to be consulted on various matters informed
- Design management: structuring the process of design to ensure the client knows what exactly what they are getting, how it will work and how it will be constructed
- Cost management: ensuring predictability of cost and controlling things so there are no surprises throughout the lifetime of the project
- Procurement management: to obtain the optimum solution by getting all the right people to do the right job
- Health and safety: to pan, co-ordinate and manage health and safety throughout all stages of the project
- Implementation and control: controlling the delivery of the project by following the process map and other associated documentation
- Commission and handover: to achieve a smooth transition from construction to operation by ensuring the client knows how to use and maintain the finished facility

2.5.2 Generic Design and Construction Process Protocol (GDCPP)

Using NPD as a reference, the University of Salford developed the Generic Design and Construction Process Protocol (GDCPP) in 1998 under the EPSRC's IMI fund (see Figure 2.9). The protocol is '…a common set of definitions, documentation and procedures that provides the basis to allow a wide range of organisations involved in a construction project to work together seamlessly' (Kagioglou et al, 1998b). It maps '…the entire project process from the client's recognition of a new or emerging need, through to operations and maintenance' (Cooper et al, 1998; Kagioglou et al, 1998c) by breaking down the design and construction processes into eight sub-processes (activity zones); namely Development, Project, Resource, Design, Production, Facilities, Health & Safety and Legal, and Process Management; into four broad stages; Pre-Project, Pre-Construction, Construction and Post-Construction stages; and ten phases.

Furthermore, continuous learning of both the process model and the project is facilitated by knowledge database development, the legacy archive (Aouad et al, 1999). In doing so, it aims to improve the design and construction process by providing the following, more commonly referred to as its six key principles (Sheath et al, 1996; Aouad et al, 1998; Kagioglou et al, 1998a; Cooper et al, 1998): -

- Whole project view
- Progressive design fixity
- A consistent process
- Stakeholder involvement/ teamwork
- Co-ordination
- Feedback

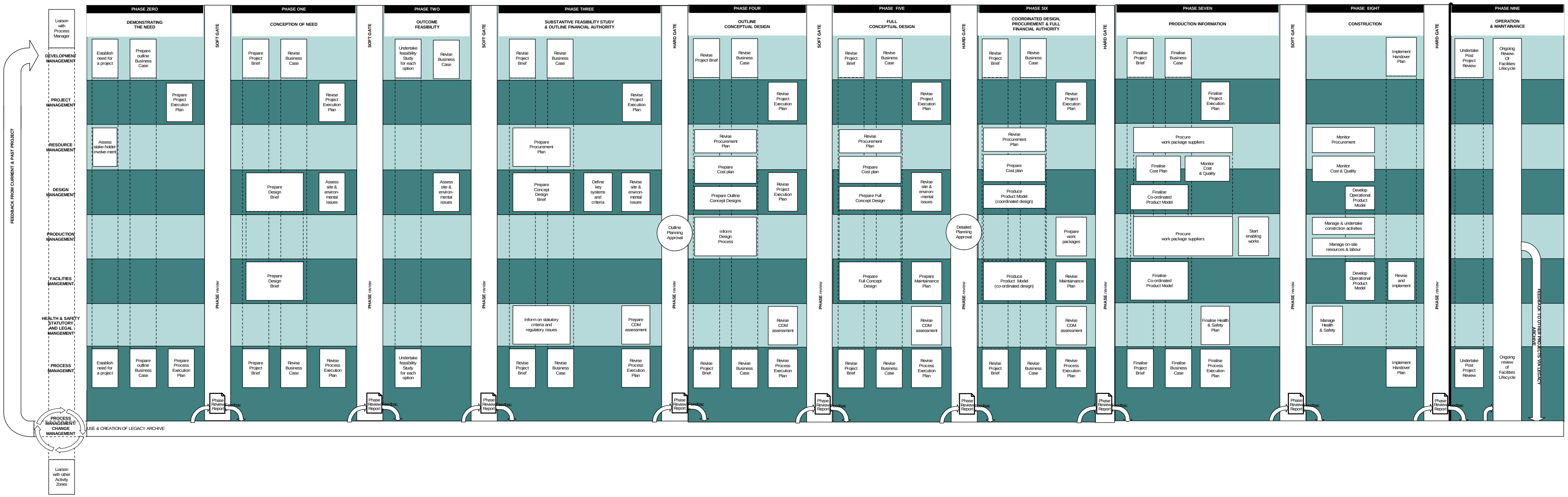


Figure 2.9: The Process Protocol high-level map (Kagiouglou et al, 1998a)

A detailed description of the Process Protocol can be found in Kagioglou et al (1998a and 1998b) or by visiting http://www.processprotocol.com

2.5.2.1 Whole project view

The separation between the design and production functions, as described in section 2.2, has been acknowledged as a key contributor to the inadequacies of construction (Harvey, 1971). Although several attempts have emerged to improve the situation, these have tended to concentrate upon changing the structures and processes to improve information flow and to reallocate risk through new mechanisms such as Design and Build, prime contracting, partnering, management of the supply chain and other novel procurement methods (Lee et al, 2001). The fundamental part of these initiatives is to bring together both the design and the construction activities by introducing those who do the building earlier into the design phase, into the front-end, or by improving the design-construction interface. This thus becomes the first principle of the Process Protocol.

Kadefors (1999) believes that to integrate constructability/ the contractor into the design phase is especially problematic, as current contractual arrangements shape interests in such a way that problem solving and value management are counteracted. Traditionally, contractors have not assisted in the design phase of buildings, nor have specialist subcontractors (e.g. mechanical or electrical) or large suppliers (e.g. steel merchants), as governed the process (such as RIBA Plan of Work). However, Gunaskaran and Love (1998) argue that their contribution will be invaluable. These specialist organisations have specific knowledge concerning the capability of the life cycle of materials, the overall performance of a product and the programming of site operations. Khurana and Rosenthal (1998) believe that the real keys to success can be found by forging a holistic approach, particularly whilst two thirds of the costs are committed during the design stage (Love and Gunesakaran, 1998).

The ramification for not considering the manufacturability/ constructability of a product when it is being designed affects the quality, efficiency and speed of its development, and research studies in manufacturing suggests that it is imperative that production should be moved to the front-end (Ettlie & Stoll, 1990; Charney, 1991; Smith & Reinerstein, 1991; Cooper & Klienschmidt, 1994). The whole project should be clearly planned out as far as possible allowing the production team to be appointed early in the process, and when required, to contribute to the design process to effectively utilise resources. Research concludes that machinery, labour requirements and materials should be considered in the detailed, or possibly the concept design phase (Riedel & Pawer, 1997). After all, the only way to improve a company's competitive position is by producing a design that is 'right first time' so that innovation and superiority can prevail, as changes here can be made efficiently and effectively, reducing cost and time (Milburn, 1992; Riedel & Pawer, 1997; Khurana & Rosenthal, 1998). Figure 2.9 illustrates that there is a particular concentration of processes during the front-end of the Process Protocol; phases 0 to 6. These processes focus attentively to the identification, definition and evaluation of the client's requirements. Comprehensive requirements capture is essential at the front-end of the process, focusing on the stakeholders and their requirements is seen as a contributor to effective design brief and specification development, and should also include production aspects.

2.5.2.2 Progressive design fixity

The stage gate approach found in NPD (Cooper, 1994; see section 2.6.1) applies a consistent planning and review procedure throughout the Process Protocol. It accommodates for the progressive fixing and/ or approval of information throughout the process, and allows the concurrent working of design and construction activities in order to reduce time. This is particularly useful for commercial clients who may have to change the design/ specification of the building project at a late stage of the project to accommodate for their changing market needs. The clients will have to pay for the additional risk and cost of progressively fixing the design elements, for example, the foundations for the project maybe over compensated for the potential of increasing the capacity, but greater flexibility is endorsed.

2.5.2.3 A consistent process

A successful company adopts a systematic and ordered process with logical steps that guides the development of an idea into a product (Cooper, 1994). While some companies use a variety of processes and approaches to develop new products, the most successful companies are those who have maintained one principal process (generic or high-level process) and adapted it to suit their specialist need in each individual project (specialist or secondary-level process). By using the same basic generic process, it uniformly yields the most productive results (Kuczmarski, 1992). Everyone involved in the process develops a comfortable and consistent level of working; they see why category analysis works and they understand the purpose of strategic roles better. However, that is not to say that the generic process is static (Thomas, 1995). It too is subjected to continuous improvement rather than totally re-engineering the whole process each time failure occurs; often management is all too often enamoured with changing the principal process. Rosenau (1990) believes that if the way new products are being developed changes, increased creativity will result. In fact, the exact opposite actually occurs. The art of managing a new product/ scheme is in itself a creative and flowing activity. A generic project process, such as the Process Protocol, allows just that.

The most important underlying factor to any development process is making it understandable and actionable by all people concerned. Consistency in the way the process is interpreted and followed is vital, as people need some anchor to hold onto - structurally sound and sturdy girders that even a new participant to the team can clearly identify with. It should be simple and straightforward as to be accomplished in logical steps. This in turn allows all employees to envision the progress of an idea through to the end product, a key component of success (Kucmarski, 1992). Crawford (1977b) reports that this has not always been the case. Even when management has made a thorough study and a firm decision for a new product, the result is frequently classified as confidential and shared with no one else beyond the board of directors or the executive committee. This inevitably leads to fundamental problems, and has more often than not resulted in failure of many new products. Many researchers have been appalled on discovering that the sales personnel or even the market researchers either don’t know whether their firm has such a strategy, or even think that strategy is something quite different to what it really is (Crawford, 1977a). Nonetheless, it is clearly no accident that the world’s most successful manufacturers are not secretive about their basic generic process (Neely, 2000).

2.5.2.4 Stakeholder involvement/ teamwork

The avid involvement of the client and all the stakeholders in a project is a prominent feature of the Process Protocol. It follows the clear consensus in manufacturing reports that full team participation improves the process by bearing all project input simultaneously, hence avoiding or reducing further revisions as to reduce time and money (Jassawalla & Sashittal, 1998). Furthermore, it allows an objective comparison of projects, providing the basis for both company and industry knowledge development.

Success is also very much a multidisciplinary, multifunctional effort (Cooper & Klienschmidt, 1995; Arditi & Gunaydin, 1998; Griffin, 1997). In order to achieve this, every step or phase has to be a multifunctional one, involving all the specialists that will inevitably influence that particular part of the project. Each cycle should involve framing the problem and generating alternative problems to suit all; the process is cyclic because typically the collaboration generates new understanding and leads to different alternatives, thus saving overall project time and costs. In short, it builds in different tasks and provides checks and balances that require the input and involvement of various functions. By cutting across functions and assembling all of the employees working on the same project into a 'team,' companies aim to reduce disputes among functions, pre-empt problems, and unleash the energy and effort that people give when contributing to a meaningful project (Griffin, 1997). No organisation can claim quality unless it operates in harmony – which it cannot do unless its departments and levels speak the same language (Donnellon, 1993). A poorly conceived and badly enacted team typically causes confusion, diverts energy and diminishes effectiveness, as measured by almost any indicator. More flexible teams are more capable of managing the intensifying competitive pressures and the inexorable acceleration of technology to produce the final output in a shorter time span and with reduced development costs. Further, every team member should have a strong consciousness of the need to eliminate waste and abnormalities from the process (Monden, 1993; Womack et al, 1990). This consciousness can only be achieved if people perceive a win-win situation, with a clear understanding of their role in the organisational network in order to achieve the business/ client's objectives (Jones, 1992).

2.5.2.5 Co-ordination

The separation between the designer and the contractor/ engineer in construction, as explained in section 2.2, is particularly deep as they are traditionally from widely divergent cultures. Therefore, by bringing these functions together in a cross-functional approach there will be a high risk of a cultural clash, possibly resulting in a negative impact on the project. Despite this difficulty, the increasing complexity and competitive pressures of the industry indicates that efforts at integration are necessary and will continue. The designer and contractor/ engineer do not differ as to appropriate conduct or project goals, but rather, they differ on firm-related priorities of surprises and profitability, and by bringing them together enables appreciation for the other's world. This can be envisaged through the use of processes (Cooper, 1987a).

Howell (1999) and Baxendale et al (1996) suggests that the '…conventional construction delivery processes cannot effectively handle the interactions and complexities of a multi-disciplinary team approach,' as current procurement methods exacerbate the division of tasks into functional disciplines that operate independently. Winch and Campagnac (1995) also share this common analysis in that contractual arrangements only establish roles and responsibilities and do not give much insight into how the different actors are to interact. Moreover, the functional disciplines develop their own objectives, goals and value systems, and become dedicated to the optimisation of their own function with little regard or understanding of its effect on the performance of the project (Gunasekaran & Love, 1998). A construction problem has to be agreed upon by the various disciplines that each have their own perceptions and objectives, so fundamentally the problem itself can possess multiple solutions (Li & Love. 1998).

Researchers have long argued that the employees are the critical building block of an organisation (Crawford, 1977b). When teams function properly, they become the glue that binds together the entire process. Co-ordination is an essential part of the job if conflicts are to be avoided and team players should push and pull in the same common direction. Successful teams bring together diverse information on every aspect that impacts customer satisfaction and they overcome the shortcomings of hierarchical structures and generate quality decisions (Hoffman, 1979). This sharing of common information and facilitation of real-time communication are linchpins for the success of this process. It is all too well to have a precise and accurate process in play, but if the participants do not interact to produce the set deliverables then there is no success.

2.5.2.6 Feedback

Expert knowledge and lessons learned in construction is currently not systematically incorporated back into the process, so the plethora of knowledge reaped has hardly been passed from project to project or even from person to person. According to Li and Love (1998), construction problem solving is reliant on experiential (empirical) knowledge, and that this knowledge is not codified in books and is weakly organised in memory. Furthermore, the ‘problem solvers’ perceive construction problems with different perspectives and the body of experiential knowledge may appear to be diverse or even disparate. Therefore, real benefits in cost, schedule, quality and safety for future projects can only emerge if only this wealth of construction knowledge can be effectively harnessed in planning and executing future work as to be incorporated into the process (Kartam, 1996; Kumaraswamy & Chan, 1998). The most apparent contributing factor to this cause is that team players rarely work together on the same project again, and so dissemination of aspirations is lost. Kartam (1996) suggests that the shortcomings be due to: -

- Unreliable communication channels between construction experts and less experienced individuals
- An unmanageable format that limits access, retrieval and updating of the potentially enormous volume of lessons
- The lack of a meaningful classification system

- Difficulty in integrating new systems into existing operations and procedures
- A primary focus on failures or incidents, rather that a balance of positive and negative experiences with constructed facilities

The Process Protocol actively encourages integrated learning by means of a legacy archive; a central repository or information spine (Hinks et al, 1997) that can take the form of an electronic information management system. Everyone in the project has access and contributes to the project data, thus enabling project co-ordination and communication to inform the latter phases and future projects. Furthermore, competitive advantage will effectively come from how such experiences are acted upon (Hinks et al, 1997; Aouad et al, 1999). The archive follows the notion of continuous improvement that is commonly associated with the PDCA cycle (see Figure 2.4).

2.5.3.7 Structure of the protocol

The Process Protocol uses a matrix network technique to model the design and construction process, similar to that of NPD's third generation fuzzy gate (see Figure 2.7). Matrix management has been actively studied and documented by many industrial and academic groups. According to Kmetovicz (1992), two-dimensional matrix representation has much strength, principally its ability of representation at the intersection of rows and columns This approach allows the processes to become the prime function rather than the actors in the process, as amplified in models such as the RIBA plan of work.

The matrix is constructed by arranging the work function (the activity zones) along the y-axis and time (the phases) along the x-axis. The stage gate (column) acts to clarify the structure and assess the roles performed by individuals within the team. Moreover, the phases of the design and construction process are restructured in the protocol to encompass the whole delivery of the project (see Figure 2.9) and by means of adopting the stage gate approach from manufacturing. The stage gates cut across functions and promote concurrency in the process, and provide a consistent planning and review procedure throughout the process by means of phase reviews, which ensures that the project is continuously co-ordinated and monitored. Within each cell of the matrix it becomes possible to identify the work that must be accomplished for each activity zone in the time segment, or phase, of the project life cycle. Once the necessary elements of each cell have been defined a network of executable items is apparent. This horizontal and vertical linking of nodes within and between matrix cells produces a complete network model of the entire project. Furthermore, the hierarchical organisation is still somewhat preserved within this matrix, which is widely advocated by the individual sectors within the industry, with the lower levels in the process mimicking groups or individual people.

The role of the cross-functional teams (activity zones) takes on relatively clear definition. They work to optimise themselves to be highly effective across the columns. They are multi-functional and may consist of a network of disciplines to enact the specific task of the project, allowing the ‘product’ to drive the process rather than the function as in a sequential approach. Luck and Newcombe (1996) argue that traditional roles and responsibilities change from project to project, often resulting in ambiguity and confusion; the use of zones potentially reduces this confusion and enhances communication and co-ordination (Cooper et al, 1998). The traditional building process promotes functional working, facilitating to the inherent problems of adversarial, functional relationships and fragmentation of the industry. The use of activity zones in the Process Protocol aims to encourage cross-functional team practice by grouping the participants of a project into core activities, thus overcoming the boundaries of project team segmentation. It is a structured set of processes that guide and support work towards the project's common objective from a multi-functional perspective.

It is anticipated that the generic Process Protocol will be customised for each individual project. Further, the processes may be enacted concurrently, which too has its origins in the manufacturing industry. Concurrent construction (CI) may be defined as an integrated approach to the planning and execution of all project activities, from the conceptualisation stage through to the hand-over of the built facility (Jaafari, 1997).

There are real opportunities to be harnessed by using CI; it can achieve major process efficiencies and savings on actual costs and delivery times (Jaafari, 1997). This is gained by integrating the whole project team into the process, including the designers, the client, the contractors, the government and other stakeholders. Everyone works towards a common goal, instead of aiming for a separate one (Kagioglou et al, 1998). Jaafari (1997) proposes that concurrent construction will provide an impetus to embrace new working philosophies (integrating all project phases into a single phase), as to revamp/ improve the industry. He also cites that through its application, it will be possible to achieve 25% savings on the overall project duration without additional resources, more evidence is needed to support of this assertion. In addition, by implementing concurrent construction it will possibly dismantle many barriers, and so will fully enforce cross-functional teams. A summary of the benefits of concurrency against serial/ sequential working can be found in Table 2.4.

Serial/ sequential	**Concurrency**
Traditional, thorough but takes too long	Able to reduce time-to-market by working in parallel
Small problem may disrupt all functions	Prevents delays in individual functions holding up the project
Can cause rivalry between functions	Promotes communication between functions
Risk of one function's solution causing problems for another function	Encourages cross-functional problem solving

Isolates functions	Promotes overall team working
Risk of tunnel vision from individual functions	Requires coherent control under overall Project Management
Risk of parochialism and 'not my job' attitude	Promotes understanding of other functions and opportunities for improvement

Table 2.4: Serial/ sequential working against concurrency

2.6 Conclusion

In chapter 1, the aims and objectives of this research investigation was presented. This chapter intended to refine the research area, namely the use of project processes with the aim of transferring manufacturing ideals to improve construction. The UK construction industry is under increasing pressure for transformation as it has been continuously criticised for its inadequate performance by many governmental and institutional reports. It has one of the worst public images among the industrial sectors and is often perceived as dirty, dangerous, with adversarial relationships and great environmental insensitivity (Ball, 1988; CIB, 1996). Therefore, it must undergo organisational, structural and cultural transformations (Jaafari, 1997). Framed in these terms, the design and construction process can no longer be left to chance. Process innovation was suggested by Egan (1998) as a route to corporate survival and prosperity, as exemplified in section 2.2. The process must be integrated to deliver quality, value for money, speed, high productivity and satisfaction.

The limitations of current construction project process models were exposed in section 2.2. Methods (i.e. CI and re-engineering) of improving the performance of processes were subsequently introduced in section 2.5.2, and guidelines on how to implement process change were discussed in section 2.5.3. As manufacturing was also suggested as a reference point for process innovation (Latham, 1994), the

NPD process was illustrated in section 2.6 as a basis for improving the design and construction project process. Finally, new process models that have adopted manufacturing principles were described in section 2.7 (i.e. the BAA project process and the Process Protocol) in an attempt to improve construction performance. The Process Protocol translates many the mechanisms of the manufacturing NPD process by fostering an integrated holistic manner. Further, the launch of the Process Protocol formed the impetus for construction companies to consider their practices; some companies adopted the protocol whilst others used it as a basis for developing their own process.[2] In the next chapter, the topic of performance management will be investigated, concentrating on the measurement of new project process models.

[2] Examples of companies who have used the Process Protocol, either by adoption or inference, include: Taylor Woodrow, Property Techtonics, Alfred McAlpine, Marconi, Tilbury Douglas, BIW Technologies, British Nuclear Fuels Ltd (BNFL), British Telecom, Citex, Tarmac, CRISP, IAI, John Mowlem, Schal, P3 Knowledge Technology, CIRIA, Christiani & Nielsen, British Aerospace, Amec, WSP Group and Teamwork 2000.

CHAPTER 3: PERFORMANCE MANAGEMENT

3.1 Introduction

Chapter 2 identified the need for process reform in the construction industry (Egan, 1998). Learning from other industries was suggested as a reference point for improvement initiatives (Latham, 1994); this contributed to the development of a number of new design and construction project processes. This chapter reviews the topic of performance management, in particular, how to measure the effectiveness of a new project processes. The application of existing performance frameworks are reviewed, and the lack of such a guideline in the literature is made profound. Thus confirming the unique nature of this research investigation.

Research in the performance management field has been, and is being, undertaken by a diverse group of people from a variety of different disciplines. These include business strategy (Simons, 1995), human resource management (IPM, 1992), manufacturing and operations management (Dixon et al, 1990; Neely et al, 1996) and organisational behaviour (Meyer & Gupta, 1994). Formoso (1997) reports that the subject is also essential for construction. According to Mohamed (1998), it is an invaluable tool to address the '…ever-rising customer requirements and expectations …for improvements in the cost, timing and quality of construction output.' However, the transference of research from the various industries into construction has not been apparent, principally because of the functional boundaries, such as language and the structure of the industry.

Historically, performance management refers to measuring an organisation's performance and is a fundamental part of any management process. There are many roles of measurement in the management process, but in general, any activity that has a data requirement will inevitably involve measurement. These roles are summarised by Butler (1994), and Bonsdorff and Andersin (1995): -

- Improve organisational performance
- Assist in decision-making

- Provide visibility of results
- Improve understanding
- Compare absolute performance
- Improve motivation
- Improve individual performance
- To show employees how they contribute to the organisation's performance
- To communicate performance expectations
- To provide management information
- To identify performance gaps

A typical measurement process defines what to measure, how to collect the data, process the data and then evaluate it to provide the facts needed for making changes related to improvement (Formoso, 1997). Moreover, recent research has shown that this process is more complex in nature, and Neely (1999) reports that the following issues also have to be addressed when determining measures: -

- The changing nature of work
- Increasing global competition
- Specific improvement initiatives
- National and international quality awards
- Changing organisational roles
- Changing external demands
- The power of IT

Collectively, these factors have fundamentally caused many changes in the manner in which organisations compete. Chandler (1997) and Lockamy (1998) intrinsically agree that firms can no longer compete solely on the basis of cost, but must formulate competitive strategies. Furthermore, this need of 'rethinking' performance management in the construction industry has also been highlighted by the growing number of new process methods and techniques that have been introduced over the last two decades that aimed to shift the traditional paradigms in order to improve performance. These 'initiatives' have primarily been from manufacturing and have led to an array of new philosophies such as concurrent engineering/ construction, lean production/ construction and many others such as

JIT and TQM (Koskela, 1992; Kagioglou, 1998; Nelson et al, 1999). The main driver behind these philosophies was to optimise an organisation's performance, both internally and externally, and inevitably their implementation has to be assessed. Therefore, the industrial and academic need for guidelines or examples of how to approach the topic of measuring construction project process is high and timely (Driva, 1997).

3.1.1 Definitions

There are a wide range of definitions for performance related terms in the literature, and these dialogs have to be framed towards a common baseline for the rest of this review before further factors can be discussed: -

- Performance management: is the process by which a company manages its performance in line with its corporate functional strategies and objectives. Bitici et al (1997) cites that it is a '…closed loop control system, where the corporate and functional strategies are deployed to all processes, activities and tasks, and feedback is obtained through the system to enable appropriate management decisions'
- Performance measurement: Bitici et al (1997) differentiates performance management and measurement by describing measurement as '…the information system that is at the heart of the performance management process and it is of critical importance to the effective and efficient functioning of the performance management system.' Furthermore, Sinclair and Zairi (1995b), Neely et al (1995) and Evangelidis (1992) state that it is the process of determining how successful organisations or individuals have been in attaining their objectives
- Performance measures: are the numerical or quantitative indicators that show how well each objective is being met (Pritchard et al, 1991; Fry, 1995)
- Performance measurement system: is the systematic way of evaluating the inputs, outputs, transformation and productivity of an organisation's performance (Globerson, 1985)

- Target: is the predetermined level of performance against each measure (Sinclair & Zairi, 1995a)
- Critical success factors, CSFs: are the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance of the organisation (Rockart, 1979)
- Key performance indicators, KPIs: are the actual measures used to quantitatively assess performance against the critical success factors, moreover, Sinclair and Zairi (1995b) also state that there should be at least one KPI for each CSF

3.2 The history of performance measurement

Various aspects of performance measurement have been extensively discussed in the literature. Atkinson et al (1997) identified that there are three roles in performance measurement, namely co-ordinating, monitoring and diagnostic. Cameron (1986), Keegan et al, (1989), Maskell (1991), Bevan and Thompson (1991), Lockamy and Cox (1995), and Kaplan and Norton (1996) provide sets of guidelines for design of performance measurement systems that will lead to excellent performance. Moreover, in reviewing the literature, the developments in performance related issues appear to have progressed in two distinct phases, and its emergence may be of interest to construction researchers and practitioners. The first phase began in the late 1880s and carried on through into the 1980s. Ghalayini and Noble (1996) report that this phase typically concentrated upon financial measures such as profit, profit per unit of production, return on investment, return on sales, sales per employee and productivity. These financial measures were heavily criticised by both researchers and practitioners in that they were inadequate for contemporary business. Their arguments are summarised below: -

- Financial measures alone encourages short-termism which delays capital investment (Hayes & Abernathy, 1980; Neely, 1999)
- They lack strategic focus and fail to provide data on quality, responsiveness and flexibility (Skinner, 1974; Neely, 1999)

- They encourage managers to minimise the variances from the standard rather than to seek continuous improvement (Turney & Anderson, 1989)
- They fail to provide information on what customers wanted and how competitors are performing (Camp, 1989; Kaplan & Norton, 1992)
- Financial measures are historically focused (Sanger, 1998; Dixon et al, 1990)

In summary, Sanger (1998) suggests that '…financial measures are useful - but they tend to measure the past – and they tend to measure the easy-measurable.' Ghalayini and Noble (1996), in retrospect, see these financial measures as 'lagging metrics,' which report on results and decisions made in the past and therefore have no little use in improving an organisation's current performance.

The second phase of performance measurement started in the late 1980s and involved non-traditional or non-financial measures. The shift was in reaction to the growing concern of the inadequacy of financial metrics alone, as highlighted earlier, and the changes in the world market when companies began to loose their arena to overseas competitors who were able to provide higher quality products with lower costs and more variety (Letza, 1996). Tsang et al (1999) believe that financial measures focus on short-term results. As a result, very few managers will choose to make capital investments or pursue long-term strategic objectives that will jeopardise quarterly earnings targets. Neely et al (1997) promote that an organisation should ideally adopt multiple measures to achieve balanced perspective and should include internal and external, financial and non-financial, and performance drivers and outcome measures.

Therefore, in order to regain competitive edge, companies not only shifted their strategic priorities from low-cost production to quality, flexibility, short-lead times and dependable delivery, but they also implemented new technologies and philosophies such as TQM, JIT etc (Ghalayini & Noble, 1996). These changes led to the need for a broader, cross-functional perspective of how organisations operated, as compared to the traditional, functional driven approaches that had already arisen; to provide the empirical evidence that the process adopted functioned appropriately (Gadd, 1995). Both Deming and Senge (Beckford, 1998), amongst others, described the need to adopt a holistic view of the organisation and its environments, therefore requiring an understanding of the interaction and linkages between criterion parts of the process/ system. The need to address these issues led to the increasing development of new costing and performance measurement systems that provided information not supplied by traditional systems (Zairi, 1994). Moreover, the implementation of these changes revealed also, that traditional performance measures had many limitations and the development of new performance measurement systems was required if the organisation was to achieve success (Neely, 1999). The focus therefore shifted towards 'leading' indicators of performance, rather than 'lagging' metrics, and related to non-financial, or operational, measures (Hayes et al, 1988; Maskell, 1992; Dixon et al, 1990). Further, McNair and Mosconi (1987), Drucker (1990) and Russell (1992) promote that both financial and non-financial measures are needed within an organisation's strategic framework.

A comparison between the traditional and non-traditional measures is displayed in Table 3.1. Lingle and Schiemann (1996) highlighted the success of adopting the types of measures as listed in the non-traditional part of the table. They concluded from a survey that by '…having agreed measures that the managers understood, balancing financial and non-financial measures, linking strategy measures to operational ones, updating what is measured regularly, and by communicating measures and progress to all employees' is what distinguishes a successful from a unsuccessful company.

Traditional	**Non-traditional**	**Source**
Based on outdated systems	Based on company strategy	Globerson, 1985; Dixon et al, 1990; Kaplan & Norton, 1992
Mainly financial measures (lagging)	Financial and non-financial measures (leading)	Globerson, 1985; Lynch & Cross, 1991; Maskell, 1991
Intended for managers	Intended for all employees	Takeuchi &Quelch, 1983; McKinnon & Bruns, 1992; Sinclair & Zairi, 1995b

Intended for mainly monitoring performance and are difficult, confusing and misleading	Intended to improve performance and are simple, accurate and easy to use	Lynch & Cross, 1991; Schmenner & Vollmann, 1994; Bauly, 1994
Hinders continuous improvement; does not change over time	Helps in achieving continuous improvement; changes over time as needs vary	Dixon et al, 1990; Ghalayini & Noble, 1996; Neely et al, 1997

Table 3.1: Traditional versus non-traditional measures

3.2.1 Characteristics of performance measures

Following the move in the late 1980s towards non-traditional or non-financial measures, many researchers began to expound upon the fundamental characteristics of metrics. These characteristics are summarised in Table 3.2.

Characteristic	Reference
Continuously revised/ relevant	Relevant measures should be derived from the process that is being monitored or improved (Griffin, 1993). Measures should focus attention on the issues that are relevant to current strategies (Lynch & Cross, 1991). Upton (1998) reports that outdated measurement systems may inhibit success, and so must change in accordance with the business strategy
Measures should be derived from strategy	A company's performance must be measured on the criteria derived from the overall strategy that has been set for the business (Goold, 1991). When measures are no longer strategically relevant they should be eliminated (Lynch & Cross, 1991). Measures derived from objectives ensures and effective link between strategy and operations by translating strategic objectives from top-down (based on customer priorities) and measure from bottom-up (Lynch & Cross, 1991). Performance measures must change to reflect new strategies (Dixon et al, 1990). Relationships must exist between the firm's strategies, organisational actions and performance measures (Dixon et al, 1990). Sustainable world-class performance will not occur if there is a misalignment between a firm's strategic objectives and actual market requirements (Adam, 1992). The translation of mission statements into a set of integrated performance measures to control, monitor and reward performance, which is consistent with the mission statement, is fundamental (Fitzgerald & Moon, 1996; Simmonds, 1981). Strategy in its wider context

	is a mixture of knowledge and assumptions about the organisation, its goals, objectives, action, milestones, budgets and plans (Kuwaiti & Kay, 2000). Strategic alignment is based on two fundamental assumptions: 1) economic performance is directly related to the ability of management to create a strategic fit between the position of an organisation in the competitive market, and the design of an appropriate structure and systems to support it; and 2) that this strategic fit is inherently dynamic (Kuwaiti & Kay, 2000)
Encourage behaviour	Measures are a very powerful motivation too and therefore will have a direct bearing on the motivation of the user (Lynch & Cross, 1991). To improve a users motivation, the relevance of the measures to their job is important (Maskell, 1991). Provides information for management control, decision-making and as a powerful motivational tool (Tsang et al, 1999)
Improvement tool	Performance improvement is critical to the economic well-being of companies (Dixon et al, 1990) a company philosophy of continual improvement must be supported by a system that encourages improvement (Turney & Anderson, 1989). Measures should improve performance on a continuous cycle (Banard, 1962). Measuring should facilitate improving an organisation's performance and the metrics should help with project steerage (Bauly, 1994). Regular feedback loops, which are short, should be introduced in order for organisations to be more responsive so that they can continuously improve (Cobb, 1993). To achieve continuous improvement, specific goals need to be set during a predetermined time horizon (Ghalayini & Noble, 1996) and need to be reviewed periodically to allow changes and improvements to be made (Neely et al, 1997). These goals need to be carefully selected, if they are set too low the company will under achieve relative to its ability, and if they are too high the company will under perform relative to expectations leading to low morale in some instances (Neely et al, 1997)
Clear and simple	Measures should be as simple as possible, unnecessary complexity should be eliminated (Turney & Anderson, 1989). Information should be conveyed through as simple set of measures as possible (Dixon et al, 1990). Targets should be clearly stated (Goold & Quinn, 1990). Measures should be user-friendly, that is simple, easy to use and be available promptly (Neely et al, 1997)
Acceptable	Acceptance of measures is increased by participation in goal setting (Ward, 1996) and its design and implementation (Sink & Tuttle, 1989)
Timely	Feedback can only be effective if it is received at the appropriate time (Maskell, 1989; Kaydos, 1991). If measurement is performed too often it over-consumes resources and becomes counterproductive, hence timing is

	of prime consideration. Conversely, under-measurement can lead to vital indicators being missed and therefore the optimal solutions for addressing each failing to be implemented (Love & Holt, 2000)
Effective	Measures should accommodate change, whether they are internal or external, otherwise they will be ineffective, or more likely counter-productive (Meyer, 1994)
Integrated	Measures should not operate in isolation; they have to be balanced with the needs and requirements of other systems in the organisation (Clarke, 1994). Performance measures should relate to the needs and goals of the organisation and become tightly linked through the elimination of non-value adding activities so that timely and relevant feedback is achieved (Green et al, 1991)
Objective	An objective measure is easily understood and quantifiable (Muckler & Seven, 1992) and is unbiased (Neely et al, 1995). Performance measures influence what people do (Lockamy & Cox. 1994)
Coherent	Coherent sets of measures are balanced, providing a comprehensive view (Kaplan & Norton, 1992)
Specific	Targets should be precisely and clearly expressed leaving nothing to implication (Neely et al, 1995)
Accurate	Measures should be accurate (Lynch & Cross, 1991)
Demanding	A demanding target is associated with better performance than compared to easy goals (Goold & Quinn, 1990). Targets should be ambitious but yet achievable (Harvey-Jones, 1991)
Involve and reward employees	Full employee commitment and involvement in formulating strategies and identifying the related performance measures ensures success (McKinnon & Bruns, 1992; Neely et al, 1997). Performance management is "…the management of individuals and teams on a frequent and ongoing basis, and …that this may be in terms of rewards (financial consequence) or recognition (non-financial consequence) (Sinclair & Zairi, 1995b). The way to people's hearts and minds is not through their ears but through their wallets (Hammer & Stanton, 1995). Systems, especially those involving humans, respond to performance measures (Neely et al, 1997). People modify their behaviours in an attempt to ensure a positive performance outcome even if it means pursuing inappropriate courses of action (Hopwood, 1984; Neely et al, 1997)
Incorporate targets	Targets for performance can be set by comparison with a variety of benchmarks including customer expectations, competitor performance, best-in field, past performance or comparison with other business units internal or external to the organisation (Robbins, 1996). Human performance is

	greatly determined by the motivation of the individual or team operating in the process (Hofstede, 1968). The ability and acceptance the user has on the target will determine the achievement of the target. If the user accepts a difficult and demanding target, he or she will apply a high level of effort until it is achieved, lowered or abandoned (Robbins, 1996). Goal clarity and participation have been shown to contribute to higher levels of motivation to meet targets, providing managers accept those targets (Hofstede, 1968)
Flexible	Measures must be flexible (Beamon, 1999). Slack (1991) identifies two types of flexibility. Firstly, range flexibility which describes the extent the operation that can be changed, and secondly response flexibility, which is the ease in cost and/ or time in which the operation can be changed. Slack (1991) indicates that flexibility measures potential behaviour and it does not have to be demonstrated by the system for it to exist

Table 3.2: Characteristics of performance measures

Furthermore, when defining performance metrics that encompass balanced and coherent characteristics, it is equally important to consider the barriers to implementation during the design process (Lewin, 1938). The barriers emphasise on peoples' fears and perceptions of effective performance measurement, to which training and education is the ideal means to overcome these inhibitions (Bourne & Neely, 1998). These impediments are summarised below (Lewin, 1938; Sink &Tuttle, 1989; Zairi, 1996): -

- Fear of exposing poor performance
- Fear of exposing good performance
- Perception of more time, effort and/ or paperwork
- Fear of loss of autonomy
- Information overload (data rich/ information poor) – the perception that this will worsen the prevailing situation
- Previous misuse and abuse of measurement
- Fear of failure
- Lack of skill and/ or lack of measurement masters
- Fear of unknown outcomes and consequences of measurement
- Paradigms regarding measurement techniques, measurement users and abusers

- Incompatible reward system – no incentives for those who perform well
- Failure to define performance operationally
- Failure to relate performance to process
- Fear of distorting performance priorities
- Misunderstanding and misusing measures
- Measuring the wrong things

3.3 What to measure

In considering the characteristics of performance measures in Table 3.2 and the barriers to implementation, the question remaining to practitioners and researchers in the field is, what to measure? The process of deciding which measures of project or business performance to adopt is a valuable one (Neely et al, 2000), because it forces management teams to be very explicit about their performance priorities and the relationship between them. Generally management are inundated with too many, not too few data (Bond, 1999). Selectivity is essential for guiding the management process, to filter out extraneous data and report at an appropriate level of aggregation (Rockart, 1979). Peters and Waterman (1982) explain this succinctly, '…what gets measured gets done.' However, it is equally important to measure the 'right' things as inappropriate performance measures are claimed not only to misrepresent, but also undermine efforts and resources (Green et al, 1991; Schmenner & Vollmann, 1994; Ghalayini & Noble, 1996; Upton, 1998). Letza (1996) stressed that there are also additional dangers in measuring the '…wrong things right,' which Neely et al (1997) suggests is dysfunctional behaviour. This is particularly apparent when a large number of performance metrics is present in an organisation and everything is measured but little that matters. Brown (1994) who argues, '…measuring more things does not guarantee quality' captures this stance.

Cameron (1986) finds that measures of organisational performance are still often selected on the basis of convenience. Typically, the measures used are either too narrowly or too broadly defined and this is a problem effects the success of the analysis. Moreover, measures of individual, group, and organisational performance are also not necessarily the same. Other common features of performance measures identified in the literature include: -

- Proxies of measures are selected on the basis of convenience and are often unrelated to organisational performance (Flapper et al, 1996)
- A single measure is commonly used to assess performance despite the fact that it is a multidimensional construct (Rummler & Bache, 1990; Johansson et al, 1993)
- Outcome measures are the dominant type of indicators for evaluating performance, and are usually financial. Their effects are most frequently used in policy decisions, though these merely reflect short-term results. Sustainable performance, however, depends on the long-term effects of strategies pursued by the organisation (Tsang et al, 1999; Neely, 1999)

3.3.1 Performance measurement frameworks

In response to calls for improved performance measures, several measurement frameworks emerged in the management literature (Letza, 1996). These frameworks involved specifying a formula, including the purpose of the measure, the measurement system, the frequency of the measurement and the re-evaluation of the measurement system (Neely, 1997; Harper, 1984). However, different metrics purposes pose different demands on a measurement system and that a system developer should consider why performance measurement is actually required before defining and implementing one (Sink & Tuttle, 1989; Kerssens van Drongelen, 1998; Neely, 1998).

According to Lingle and Schiemann (1996), those companies who adopt performance measurement systems perform better than companies who do not. Performance measurement systems can be described in many ways, they can be single or complex, general or specific (Johnson, 2000). There is no common definition of a system, Fitzgerald and Moon (1996) state that '… there is a broad agreement that some form of performance measurement system is an important component of organisational control, and furthermore, that there is no general model that conveys a precise constitution of such a system.' Some frameworks prescribe methods of monitoring the whole organisation to guard against sub-optimisation (Kaplan & Norton, 1996), whilst others develop audits to help organisations identify the strengths and weaknesses of their measurement systems (Dixon et al, 1990). Their importance, it seems, has never been greater as they can either inhibit or enhance the success (Young & Selto, 1991; DeLuzio, 1993; Swenson & Cassidy, 1993). Examples include the performance measurement matrix (Keegan et al, 1989), the performance pyramid (Lynch & Cross, 1991), the balance scorecard (Kaplan & Norton, 1996) and the Business Excellence Model (Anon, 1999). These models not only provide a means of measuring overall organisational performance but they also provide a common baseline for benchmarking. Generally, they provide the means for (Lockamy, 1998): -

- Maintaining an alignment between strategic objectives and market requirements
- Co-ordinating the effective use of company resources
- Monitoring progress toward the achievement of pre-determined strategic objectives

The most popular frameworks, their objectives and misgivings are discussed in the following section.

3.3.1.1 The balanced scorecard (BSC)

Undoubtedly, one of the most widely recognised performance measurement frameworks of today is the balanced scorecard (BSC; Kaplan & Norton, 1992). Developed by Robert Kaplan and David Norton, it provides a '…balanced presentation of both financial and operational measures' by translating the business mission and strategy into a set of objectives and quantifiable measures built around four perspectives' as outlined below (Kaplan & Norton, 1992; see Figure 3.1): -

- Financial: investor's views
- Customer: the performance attributes valued by customers

- Internal processes: the long and short-term means to achieve the financial and customer objectives
- Learning and growth: capability to improve and create value

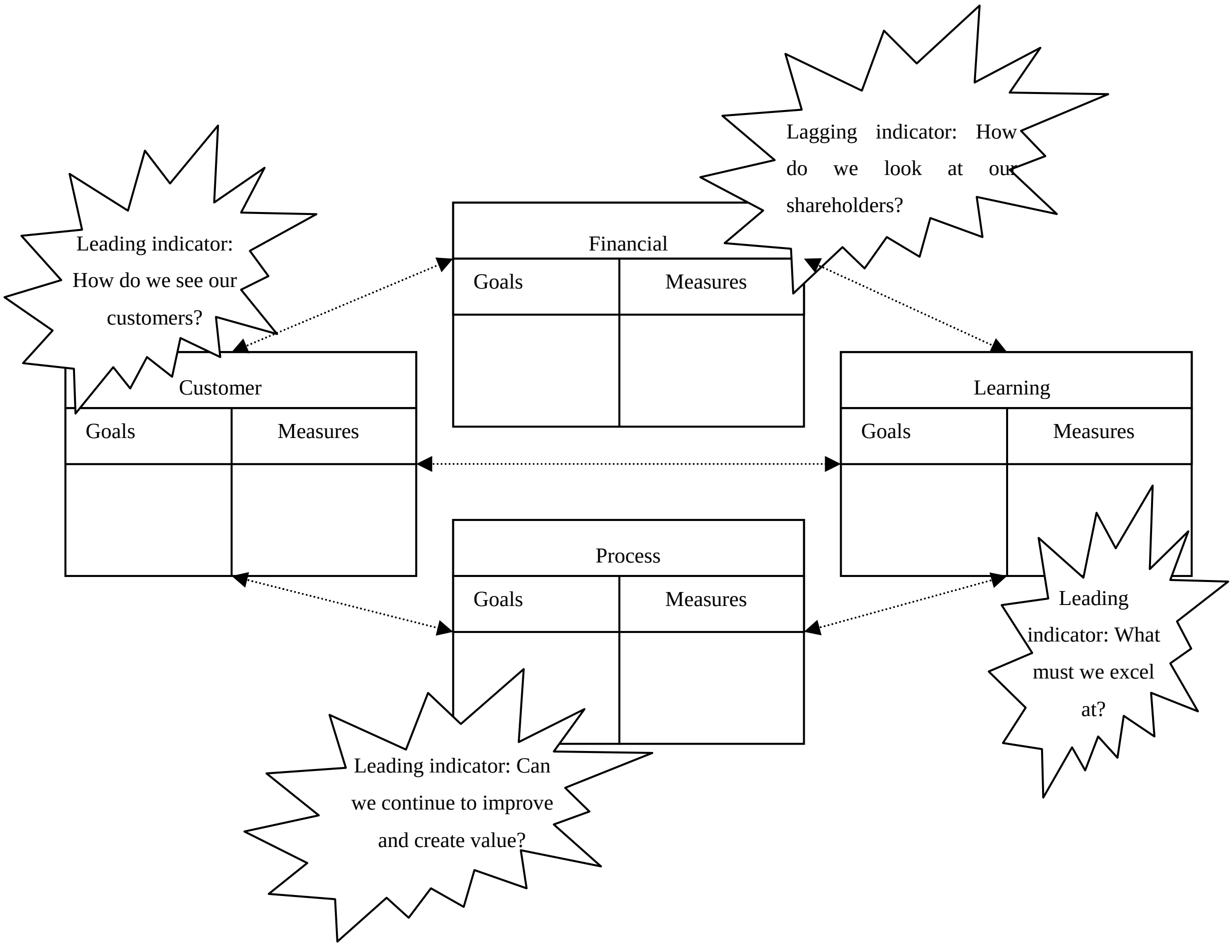


Figure 3.1: The BSC (Kaplan & Norton, 1992)

Tsang (1999) believes that the BSC's success lies in its balanced approach in assessing the seemingly disparate elements of a company's competitive agenda. Ghalayini and Noble (1996) also believe that it prevents sub-optimisation by forcing consideration of all measures at the same time. However, it too has weaknesses. It has been heavily criticised for its simplicity (Brignall, 1992). Gregory (1993) denotes that '…clearly much work would be need to go on below the level of the scorecard to provide systems which could deliver these …rather aggregated measures,' and in particular, a mechanism for specifying which objective should be met in a specific time horizon (Ghalayini &Noble, 1996). Sinclair and Zairi (1995a) declare that it is not complete as a performance measurement system as it is primarily designed for mangers to gain an overall view on performance, and maybe not apparent for all employees. Furthermore, it doesn't consider suppliers (Neely, 1997), which is particularly apparent for the construction industry.

3.3.1.2 Performance measurement matrix

In 1989, Keegan et al developed the performance measurement matrix (see Figure 3.2). As with the balanced scorecard, the strength of the performance measurement matrix lies in the way it seeks to integrate different classes of business performance – financial, non-financial, internal and external. The matrix, however, is not as well packaged as the balanced scorecard and does not make explicit the links between the different dimensions of business performance (Neely et al, 2000), which is arguably one of the greatest strengths of Kaplan and Norton's system.

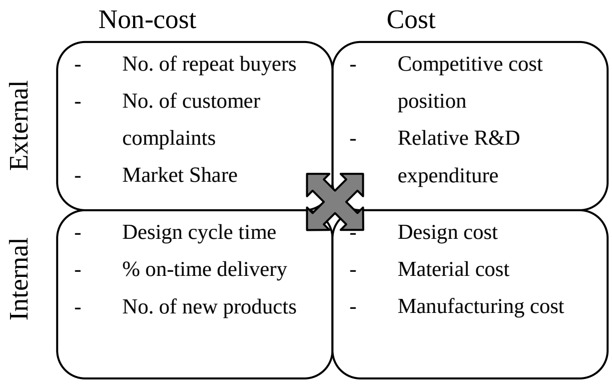


Figure 3.2: Performance measurement matrix (Keegan et al, 1989)

3.3.1.3 The results and determinants framework

An alternative, which overcomes the criticism of the linkage between the different dimensions, is the results and determinants framework (see Figure 3.3). This framework, which was developed by Fitzgerald et al (1991) following a study of performance measurement in the service sector, is based on the premise that there are two basic types of performance measures in any organisation. That is, those that relate to results (such as competitiveness, finance) and those that focuses on the determinants of the results (for example, quality, flexibility, resource utilisation and innovation). The appeal of this distinction is that it highlights the fact that the results obtained are of past business performance with regard to specific determinants, i.e. results are lagging indicators, whereas determinants are leading indicators.

Results	Financial performance
	Competitiveness
Determinants	Quality
	Flexibility
	Resource utilisation
	Innovation

Figure 3.3: Results and determinants framework (Fitzgerald et al, 1991)

3.3.1.4 Brown's framework of process metrics

The performance measurement frameworks discussed so far in this literature review have tended to be hierarchical in orientation. One of the most popular performance frameworks dealing with the horizontal flows of materials and information within the organisation, or the business processes, is the one developed by Mark Brown, a US management consultant (Bond, 1999). Brown's framework is useful because it highlights the difference between input, process, output and outcome measures, and it encourages the checking of micro processes (Neely, 1997). He uses the analogy of baking a cake to explain this more fully: -

- Input measures: quality and quantity of input e.g. the volume of flour, quality of eggs etc
- Process measures: cycle time and process parameters e.g. oven temperature, baking time etc
- Output measures: monitors quality and dependability of output e.g. quality of the cake etc

- Outcome measures: tracts the impact of the output e.g. satisfaction of the cake eaters etc

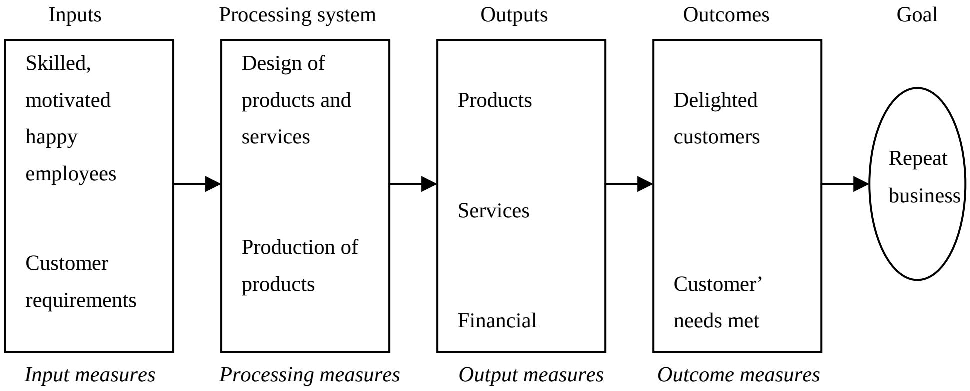


Figure 3.4: Brown's framework of process metrics (Brown, 1996)

3.3.1.5 Performance pyramid

Lynch and Cross's (1991) performance pyramid falls in the same continuum as Brown's framework (see Figure 3.5). The strengths of this particular framework are that it ties together the hierarchical view of business performance measurement with the business process view (Neely et al, 2000). It also makes explicit the difference between measures that are of interest to external parties (customer satisfaction, quality and delivery) and the primary internal interests of the business (productivity, cycle time, waste). However, Neely et al (2000) believe that this framework is difficult to operationalise.

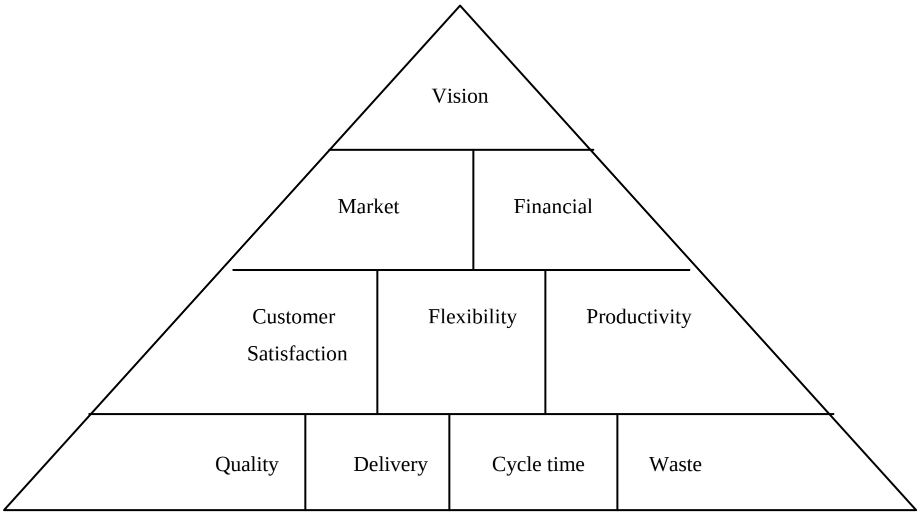


Figure 3.5: Performance pyramid (Lynch & Cross, 1991)

3.3.1.6 The EFQM Excellence Model

Another wide-ranging and currently popular measurement framework is the European Foundation for Quality Management's Model (EFQM; USA), or its counterpart European version, the Business Excellence Model that was launched in 1992 (see Figure 3.6). This framework consists of two distinct subsets of performance factors, broadly classified as enables and results. It is a non-prescriptive framework, which recognises there are many approaches to achieving sustainable excellence in all aspects of performance, based on the premise that '…excellent results with respect to performance, customers, people and society …are achieved through partnerships, resources and processes' (EFQM, 2001). The model's 9 boxes, shown below in Figure 3.6, represent the criteria to assess an organisation's progress towards excellence. The theory underpinning is that the enablers are the levers that management can pull to deliver future results. However, the terms used in framework are so open and can be interpreted in so many ways, that a single organisation could decide to capture any of the several dozen different measures of performance under each of the headings (Neely et al, 2000).

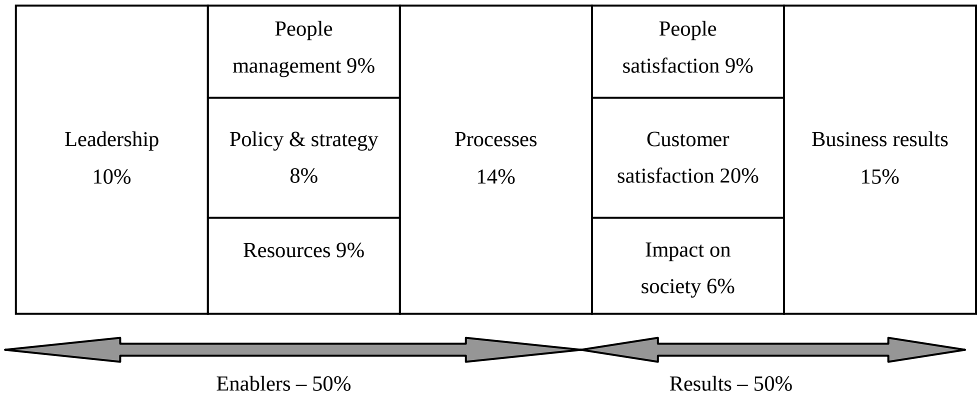


Figure 3.6: The business excellence model (EFQM, 2001)

3.3.2 Critique of performance measurement frameworks

Although such frameworks are undoubtedly valuable, their adoption is often constrained by the fact that they are all simple frameworks (Neely et al, 2000). They suggest some areas in which measures of performance might be useful, but provide little guidance on how the appropriate measures can be identified and designed (Medori & Steeple, 2000). This brings us back to the original problem of what to measure. Good measurement systems don't just happen. They are designed, human factors engineered, developed, implemented and constantly improved. This issue has become topical in recent years, with several authors discussing it, albeit often at a rather superficial level. Keegan et al (1989), for example, argued that the process of deciding what to measure should consist of three main steps. The first involves looking at strategy, defining the strategic objectives of the company and determining how they could be translated into divisional goals and individual management actions. The second encompasses deriving an appropriate set of measures by populating a performance measurement matrix. The third focuses on instilling the performance measurement system into management thinking. Critical here, is closing the management loop and ensuring that the measurement system actually drives day-to-day decisions and actions, thereby ensuring the firm's strategy is implemented.

The first and third of these steps, while difficult in practice, are relatively self-explanatory. The second, of actually deciding what to measure, is much more involved. Keegan et al (1989) goes on to suggest that the best approach is to start with five generic measures – quality, customer satisfaction, speed, product/ service cost reduction, and cash flow from operations – and then simply derive the rest, ensuring that each of them is: -

- Integrated, both hierarchically and across the business functions, and
- Based on a thorough understanding of the organisation's cost drivers

A suggestion on how to do this in practice, however, is not offered. Therefore in 1991, Wisner and Fawcett proposed a slightly more detailed process for performance measurement system design. This is presented in a diagrammatic format (see Figure 3.7). The nine-step process is similar to Keegan et al's (1989) in that it assumes that measures should be derived from strategy, but has the advantage that it makes explicit the fact that the measurement system itself should be periodically refreshed.

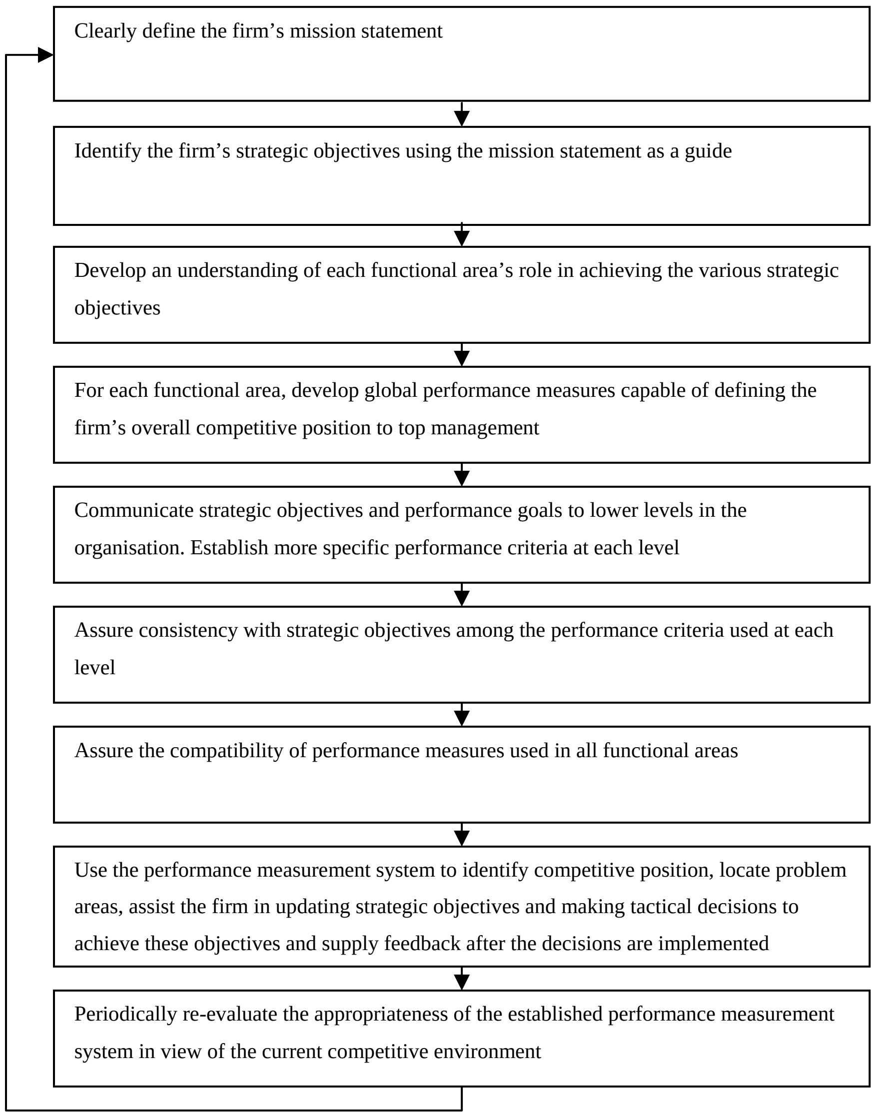


Figure 3.7: Performance measurement system design (Keegan et al, 1989)

Sink and Tuttle's (1989) attempt to describe the process of performance measurement system design in their book, 'Planning and Measurement in your Organisation of the Future' is listed below, is perhaps the most detailed method. However, the question of how to decide upon what to measure is still not explicit in either Wisner and Fawcett's or Sink and Tuttle's work.

1. Organisational systems analysis: -
   - Define the target system
   - Define the purpose of measurement

- Conduct audience analysis
- Review up-line strategic plans
- Review target system strategic plans
- Define, operationally, performance for target system
- Conduct an existing measurement system audit
- Identify and/ or develop measurement ‘master’
- Confirm accepted guiding principles for measurement within the organisation and target system
- Conduct force-field analysis and design communication plan

2. From the performance improvement plan (PIP) identify strategies developed for performance improvement for the target system
3. Decide what to measure. Identify what information the management team of the target system need/ wants to confirm that (a) the target system is performing, and (b) the target system is improving
    - Develop consensus measures for performance
    - Audit to improve measures
    - ‘Operationalise’ the measures, determine the operational definitions for the measures
4. Identify data required, sources and collection devices
5. Identify how to convert the data into the needed information, address the storage, retrieval, processing and portrayal question. Select approached, methods, tools and techniques for processing
6. Finalise and document your measurement system development plan
7. Develop and maintain the visibility system for the performance measurement system, and recycle the design and development process as an integral part of the PIP each year
8. Constantly and continually improve the performance measurement system

In their preliminary writings about the balanced scorecard, Kaplan and Norton paid little attention to the process of performance measurement system design (Kaplan & Norton, 1992; Neely et al, 2000). By 1993, they too had recognised the importance of this topic and therefore included a brief description of an eight-step process, which involved various rounds of interviews and workshops, to enable managers to design balanced measurement systems in their 1993 Harvard Business Review paper ‘Putting the Balanced Scorecard to Work.’

Since then, there have been numerous attempts to document performance measurement system design processes, nearly all of which ended up open-ended and vague statements (Dixon et al, 1990). Conclusively, despite the widespread interest in the topic of performance measurement, little detailed attention has been paid to the question of how managers can decide which performance measures they should adopt (Neely et al, 1997). Neely et al (2000) suggests that for any performance measurement framework to be of practical value, the process of populating the framework has to be understood. Indeed, even those authors that have discussed this issue have tended to offer superficial and rather generic guidelines as opposed to specific and actionable advice. This lack of guidance applies to measuring the project process; although some of the frameworks advise measuring the process, the question still remains on how to measure it. Thus contributing to the research aim of this thesis.

3.4 Performance management in construction

The subject of performance management in the UK construction industry is encountering increasing interest in both the academic and managerial ambits. Mohamed (1998) supports this growing trend by reporting ‘…to improve construction performance, it is essential to have accurate and representative measurements reflecting current practice, trends and productivity.’ For the most part, this interest is due to the broadening spectrum of performances required by the present-day competitive environment and the need to support and verify the introduction of new design and construction processes (Toni & Tonchia, 2001).

Previously, construction performance measurement has adopted a narrow focus, typically failing to respect the profoundly complex and interdependent nature of what is essentially a dynamic social system capable of infinite variation (Love & Skitmore, 1996; Nesan & Holt, 1999). Construction projects are usually evaluated by the '…extent in which the client's objectives like cost, time and quality were achieved' (Ward et al, 1991). These metrics are traditionally seen as the three indicators of construction performance and are predominately project specific and profit orientated (considering 'tangible' or 'hard' factors), failing to take account of the broader stakeholder issues (namely, 'intangible' or 'softer' issues) that encroaches upon the phenomena (Love & Skitmore, 1996). According to Ward et al (1991), it is wholly inappropriate to evaluate projects, suppliers and procurement methods solely on the extent in which they meet the client's objectives and goals, without considering the nature of the business environment. Although these measures provide an indication as to the success or failure of a project, they do not in isolation provide a balanced view of the project's performance (Mohsini & Davidson, 1992). Understanding why some projects are more successful than other requires broad knowledge of their contextual, technical, structural and human factors – from different perspectives. The success or failure of a project is also credited by memories of the people involved, such as impressions of harmony, goodwill and trust or, conversely, of arguments, distrust and conflict (Ward et al, 1991). These are, however, sometimes more easily recollected than intrinsic data, though is not formally reviewed or measured. Hence, to acquire a holistic perspective of project performance calls for the examination beyond the traditional narrow and reactive measures, requiring focus on the broad considerations of the project team's corporate strategy and processes.

Moreover, this narrow focus of measurement may be decremented in part to the nature of the industry. Construction projects, unlike manufacturing, are commonly measured against only one 'level' of objectives, that is, those defined by the client (Mohamed, 1998). Furthermore, the traditional indicators of time, cost and quality, may be all that is immediate to the client (Ward et al, 1991). However, this practice induces a concept that for the duration of the project, the client 'owns' the project team. Therefore, the objectives of the project team become those of achieving the client's objectives. This, even to a casual observer of the construction industry, cannot be apparent. The adversarial nature of the industry would suggest that the discrete objectives of each of the project team members be maintained and conflict with her project's primary objectives.

In addition, the primary concern of new construction processes is to overcome functional organisation rigidity where single functions or units often have different and contradictory performance objectives. This fragmentation is one of the main criticisms against the construction industry (Latham, 1994). Most often, the processes are executed and treated as if they were stand-alone processes; the interfaces are not systematically managed and the result is a less than optimal performance. Traditionally, each function or unit tries to maximise its own performance and considers good local performance as the only condition for good overall performance (Fry & Cox, 1989). Therefore, there is great need to co-ordinate the efforts so several performances are achieved simultaneously. The objectives can be reached by a harmonic composition and integration of sub-tasks, with functional responsibilities but co-ordinated by the process logic: the performances are the result of the synergetic and synchronous effects of the single contributions along the operations value chain (Rummler & Bache, 1990; Johansson et al, 1993). Mohsini and Davidson (1992), who define two levels of organisational objectives common to most constructional projects, support this argument: -

- The temporary objectives of the project and the organisation that is set up to build it
- The collective set of permanent objectives of the participating organisations

In this way, to encompass the broader performance issues of the project team, the construction process can be considered as a chain of activities; each phase is characterised by a customer/ suppler (internal or external) logic (Schonberger, 1990) and implies that everyone has a customer – even those far from the downstream activities – and everyone is served by someone else. Once the customer is satisfied with the outcome the work proceeds to the next activity. So a poor performance in a single link in the chain is sufficient to spoil the overall performance. Adopting such a sequence will not only ensure systematic customer involvement, but will substantially simplify the task of project benchmarking as it will give rise to simple and clear measures for the organisation to meet.

Furthermore, it should cover both quantitative and qualitative issues, that is in addition to the well-known time, cost and quality measures, there should also be a number of queries raised by the customer, design variations to suit site conditions (De Toni & Tonchia, 1996).

Several research studies have been conducted which identify critical factors affecting construction productivity (Motwani et al, 1995; De Toni & Tonchia, 1996). In 1990, Herbsman and Ellis classified these as technological and organisational influence factors. Technological factors include specifications, design, location and materials. While organisational factors comprise of production, labour and social issues. However, since most construction companies do not track formally historical productivity data, it makes it difficult for researchers to formulate any statistically significant observation/ trends (Motwani et al, 1995). Moreover, one of the most common holes that exist in construction practice is rework (Mohamed, 1998). This undesirable feature puts considerable pressure on the organisation in the form of direct additional costs and loss of time, which could have been avoided if things were done correctly in the first place. Therefore, any set of measures should be simple enough to be 'built-in' within the process allowing accurate and representative measures to be taken. These measures would initially help detect the errors leading to rework and ultimately lead to their prevention in similar future projects.

Following such interest in performance field and the move towards learning from other industries (principally manufacturing), the UK construction industry has started to implement some of the new performance initiatives (Johnson, 2001). These include the balanced scorecard, the business excellence model, measuring broader aspects of construction projects and the introduction of key performance indicators (KPIs). However, these models and initiatives have failed to take into account the measurement of new construction project processes.

3.4.1 Construction KPIs

In 1999, in an attempt to improve the performance of the UK construction industry, the government launched its ‘Key Performance Indicators’ (KPIs) under its Construction Best Practice Programme (CBPP, 1999). The indicators were designed to enable the measurement of project and organisational performance throughout the construction industry, by initially providing firms with a means of measuring and comparing their own performance with the rest of the industry, and collectively, to assess improvements in the industry overall through benchmarking (CBPP, 1998). Clients, for instance, can assess the suitability of potential suppliers for a project, by asking them to provide information about how they perform against a range of indicators, so they can see how potential suppliers compare with the rest of the industry in a number of different areas. Construction companies will also be able to benchmark their performance to enable them to identify strengths and weaknesses and assess their ability to improve over time. The indicators cover the following issues: -

- Client satisfaction: product
- Client satisfaction: service
- Defects
- Predictability: cost
- Predictability: time
- Profitability
- Productivity
- Safety
- Construction cost
- Construction time

A casual observation of the results of the national benchmarking indicators raises a number of issues. It is inappropriate to assess the success or failure of projects based on the KPIs alone. For instance, client satisfaction, of both the product and service, is quite high (eight out of ten) but the productivity is very low. This result questions whether clients really know what the productivity levels in projects are, and hence clarifies the importance of not only using the ‘right’ measures but also the significance of the relationships between them (Kagioglou et al, 2000). Further, it may be incongruous to compare one project against another by the KPIs alone. For example, to a commercial client construction time may be more important than construction cost, whereas a client who has a fixed budget may perceive that construction cost is more important than construction time. Perhaps, therefore, what is needed is a more integrated measurement system for the construction industry. Further, the construction process should also be encompassed in any measurement system. More recently, CBPP (2002) have also launched a series of ‘respect for people’ indicators that aim to examine stakeholder perspectives/ culture on the project. The indicators include: -

- Employee satisfaction
- Staff turnover
- Sickness absence
- Safety
- Investors in people
- Working hours
- Pay
- Training
- Diversity
- Travelling time

CBPP also plan to extend these indicators in the coming period. Although these are assisting organisations to measure various aspects of construction projects, they have thus yet considered the project process itself. In particular, the measurement of new design and construction project processes that are emerging post Latham (1994) and Egan (1998) reports.

3.4.1.1 Benchmarking

Benchmarking involves comparing one company’s current performance against the world leader in any particular area (Compton, 1992). During the 1990s, there was considerable interest in benchmarking in the manufacturing and other service industries. Its successful implementation is reflected in the large number of publications that address its concept, application and limitations (Voss et al, 1997; Ramabadron et al, 1997). Moreover, as manufacturing has been a reference point and source of innovation for construction over the years, it is no wonder that construction researchers are now adopting such practice (Mohamed, 1998) such as through CBPP's KPIs.

According to McNair and Leibfried (1992), Venetucci (1992), Voss et al (1997), Elmuti and Kathawala (1997) and Beamon (1999), any company should benchmark if it wants to attain world-class competitive capability, prosper in a global economy, and above all, if it wants to survive. Companies today are competing in an international area and to survive they must be the world-champion (Rolstadas, 1998). Therefore, in order to understand what practices are necessary to reach world-class standards, many organisations have begun to use benchmarking as a way of acquiring knowledge (Camp, 1989). There are four types of benchmarking: -

- Internal: where an organisation aim towards identifying improvement areas within its structure through comparing its business operations with those of others that do it better (Elmuti & Kathawala, 1997)
- Project/ competitive: where an organisation assesses the performance of projects in which it is involved in with and direct compares with its competitors in the same market which have competing products, services or work processes (Mohamed, 1998; Beamon, 1999)
- External /industry: where the organisation attempts to increase productivity through developing tools and techniques, developed and successfully used by other industries that are similar to that of their own (Mohamed, 1998; Beamon, 1999)
- Process/ generic: this focuses on the best work processes. Instead of directing the benchmarking to the business practices of a company, the similar procedures and functions are emphasised, and possibly against dissimilar organisations. Although it is thought to be extremely effective, it is difficult to implement and requires a broad conceptualisation of the

entire process and careful understanding of the procedures (Matters & Evans, 1997)

However, benchmarking in construction is not a straightforward task due to the very nature of the industry in that it traditionally lacks solid data gathering, and there exists a remarkable fluctuation in productivity due to the economic climate (Mohamed, 1998). Ball (1988) and Howell (1999) add that due to its temporary nature of the construction process, where a number of organisations get involved in designing and constructing a single project, adds to the complexity of the task in transferring practices from other industries. Therefore, benchmarking attempts would face certain difficulties such as incomplete or non-existent data, and even if data were well recorded and retrievable, it would be highly dependent on the special characteristics of the project, size, type and budget. Moreover, Mohamed (1998) cites further factors in why the construction industry is reluctant to adopt benchmarking: -

- There appears to be a general misunderstanding of concept: for many practitioners it means measuring everything
- There is confusion in its requirements: what and how to measure in addition to what to compare to
- The data is usually unavailable: due to structure of the construction process, it does not allow data associated with field-based operations to be collected readily
- Application issues: it seems to require radical changes to the industry
- There is a lack of conceptual models: to support and guide data collection in construction

Mohamed (1998) concludes that due to the current nature of the industry, benchmarking would difficult as an effective basis for comparison and would only work if there were a consistent method of measuring the performance of operations. Currently, such a presiding national method does not exist, and as Peer (1986) reports, that this may be a result of the relatively limited number of studies devoted to construction productivity. Furthermore, any performance measurement studies are usually concerned with the identification of sources of delays rather than with the analysis of measuring systems and techniques. Benchmarking can be an effective tool to achieve best practice and construction organisations should be effectively taking up internal benchmarking to gain a thorough understanding of how they do business and how their customers evaluate their services (Mohamed, 1998). Also, organisations have to be more open to benchmark what has been successful in other industries and assess if it is adaptable to construction. Finally, it should be seen as an integrated part of an ongoing process aiming at improving productivity. A fully implemented benchmarking environment within the industry will significantly improve the quality of decision making related to design and construction processes. The benchmarking process is modelled in Figure 3.8 (Elmuti & Kathawala, 1997).

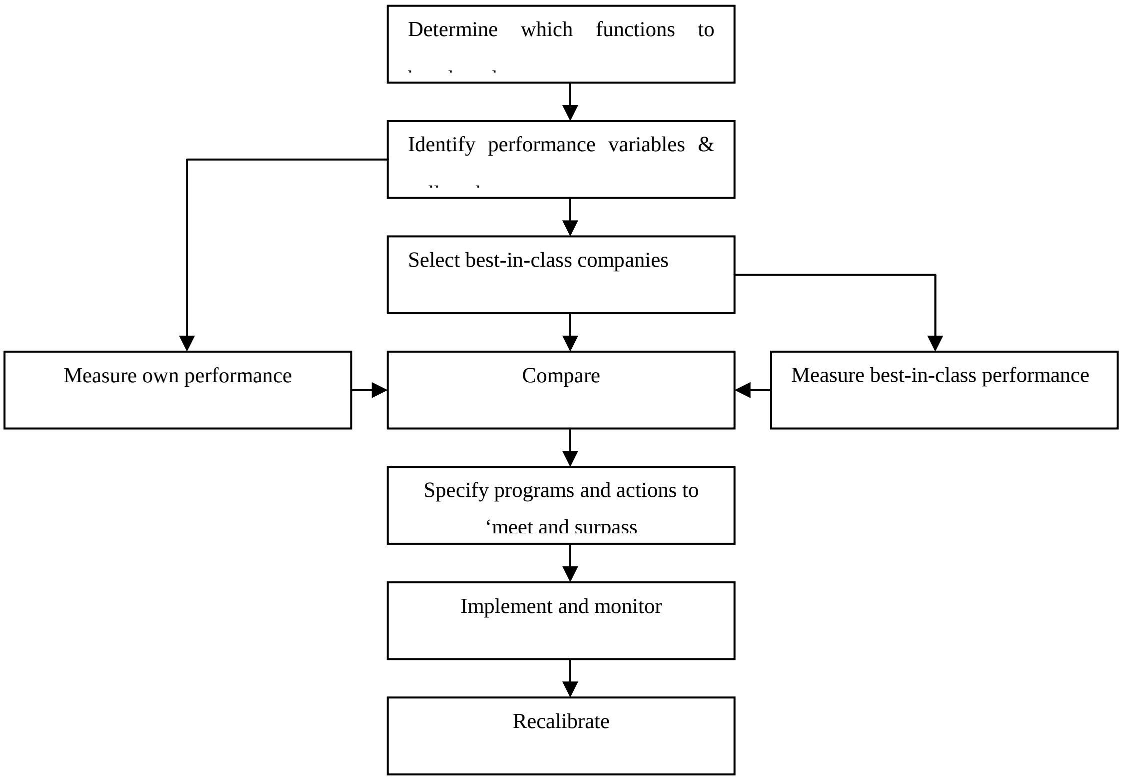


Figure 3.8: The benchmarking process (Elmuti & Kathawala, 1997)

3.4.2 Measuring the project process

The reasons offered by organisations for implementing one process over another are varied, but the main drivers include an increase in bottom-line profit, effective risk management, assurance of product and/ or service quality to the customer and implementation for opportunity (Debenham, 2000). Therefore, once a process has been selected, it is important to measure its delivery/ implementation in addition to its output since it is an integral part of the planning and control cycle of the project (Barnard, 1962). Hibberd and Djebarni (1991) go on further to suggest that assessment should also be made on how well the process achieves its proposed performance as project performance is not directly attributable to process performance, and this is clearly evident in construction projects.

Some companies, though perhaps mistakenly, believe and operate a new project without the conviction of a fully planned process, and have been triumphant in doing so. While successful results are the obvious payoffs, many practitioners and academics alike advocate it is unwise to constantly rely on luck to salvage the success of the project. However, a structured, clear and transparent process, all attributes of a successful process, may not always lead to a successful project. There are a whole host of internal and external factors to a project that can significantly hinder the enactment of the process. No construction project exists in a vacuum (Child, 1972; Mintzberg, 1979). It is subject to an array of influences from regulatory control to political and industrial intervention (Sidwell, 1990) and these may prohibit the full implementation of the process. Therefore, it is unwise to assess the effectiveness of a project process on the success of the implementation project. Moreover, the key is to devise the exact correlation of the two. If a process dictates certain advantages, then assessments need to be made to evidence its value. Bond (1999) suggests that performance measures should be used in three identifiably distinct phases when governing processes: -

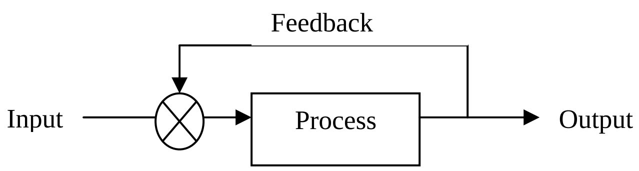
- Maintaining process status quo: to ensure a smooth flow of output according to the process/ schedule
- Process improvement: to continuously monitor and improve the process to produce the desired output

- Achieving process stability: less changes to the process enhances quality and productivity

3.4.2.1 Results and process measures

The construction industry involves bringing together information and resources to create a built facility. It therefore involves systematic conversion of 'raw materials' into finished 'products.' When viewed in this way, the concept of a process cannot be avoided. A process is any system where entities (people, materials, information etc) are made to interact and to transform each other. However, as in any project or business process, there are a number of non-value activities embedded within the process, i.e. activities that consume time and/ or cost without adding value to the process (Koskela, 1992; Mohamed, 1998). Through measurement, these activities can be identified and later eliminated, leading the way to a more efficient business practice (Koskela, 1992). According to Tutesigensi (1999), and Dorf and Bishop (1995), in order to measure the process the associated inputs, outputs and interaction mechanisms/ feedback needs to be defined (see Figure 3.9): -

- The inputs to the process are the performance targets the process has to achieve (Dorf & Bishop, 1995)
- The output to the process is the point where the measurement of the process is realised. The pursuit for a better output is a firm’s challenge (Otley, 1987)
- Feedback is an essential element to the learning and improvement of the process (Globerson, 1985; Otley, 1987; Maskell, 1991; Hanna & Burns, 1997)



<u>Figure 3.9: Definition of a process</u>

3.5 Conclusion

Chapter 1 reported on the problems of the UK construction industry; Latham (1994) suggested learning from other industries such as manufacturing, and Egan (1998) recommended process improvement as methods of augmenting improved performance. Chapter 2 reviewed the use of project processes, and presented a solution that applied manufacturing process initiatives into construction, namely the Process Protocol. Other UK construction companies followed the initiative to improve their existing practices through process modelling. Moreover, the question on how to measure the effectiveness of these new process models emerged. This chapter investigated the topic of process management and in particular, how to measure the project process.

There is currently considerable interest in construction performance measurement. The researcher gauged this interest from the high levels of attendance and number of industrial conferences on the subject, and academic interest manifested itself through the considerable number of research papers and Internet discussion groups on the topic. However, the interest is not new, as evidenced in section 3.2. In the late 1970s and 1980s, both researchers and practitioners expressed a general dissatisfaction with traditional backward looking accounting based performance measurement systems, identifying their shortcomings and arguing for change. In the late 1980s and early 1990s, this dissatisfaction led to the development of 'balanced' or 'multi-dimensional' performance measurement frameworks. These new frameworks placed emphasis on non-financial, external and future looking performance measures.

To date various performance measurement frameworks and methods of analysing the appropriateness of the measurement systems that exist in specific organisations were proposed in section 3.3.1. The frameworks all have their relative benefits and limitations, with the most common being that of little guidance given to the actual design and selection of the metrics. Furthermore, there is sparse consideration on the measuring of the project process, in particular, the efficiency and effectiveness of the process. The next chapter will investigate process, IT and performance measurement trends in both manufacturing and construction industries, to further support the research direction as identified thus far in this thesis.

CHAPTER 4 - SCOPING SURVEY

4.1 Introduction

The context of this research investigation was described in Chapter 1. The research need was affirmed in chapters 2 and 3; chapter 2 examined the use of project processes in the UK construction industry and subsequently borrowed ideas from manufacturing to improve upon productivity; and chapter 3 evaluated the field of performance management and highlighted that there was little guidance available on how to measure the effectiveness of new project processes. This chapter reports on the development and findings of a scoping survey. The survey questionnaire aims to achieve a general understanding of the industries' views on process, performance and IT related issues in both manufacturing and construction. It was anticipated that the results would support the research direction and build upon the knowledge already established in the previous literature reviews (chapters 2 & 3).

4.2 Sample of survey companies

In order to capture an internal and external perspective of each industry, the sample of manufacturing and construction companies included organisations directly within the industry, such as contractors and architects for construction, and also those who are usually considered as not directly involved, such as clients and suppliers. Conversely, the manufacturing sample included companies from various sectors of the industry, such as pharmaceutical, engineering and food producers, to establish sector wide perspectives. The spectrum of disciplines in each sample was to reduce the chances of creating a survey questionnaire that would be discipline-biased and thus limiting the generalisability of the results. Furthermore, this also reduced any chances of any specific product bias (i.e. building type) from the desired generically applicable results.

As a scooping study, it was felt that 200 companies were sufficient as the sample audience in each industrial sector, largely due to resource issues. The survey questionnaires were sent to a selection of the 'top' 170 UK companies and a random sample of 30 SMEs (small and medium sized enterprises) in order to ascertain a representative response of each industry. However, due to the nature of the construction industry, it was difficult to determine a common characteristic as a basis of selection for the 'top' construction sample. Common characteristics such as number of employees, turnover or profit, cannot be applied as they vary significantly across each discipline. For example, a successful architectural practice usually only consists of around 100 architects with a turnover of £10 million, whereas a contractual firm has 30,000 employees and an annual turnover of £3,100 million. The disciplines cannot be directly compared against each other. Therefore, the researcher personally selected the construction sample from the various sources. Table 4.1 illustrates all the sources sought and those that were used to nominate the sample. (In addition, a large number of construction organisations now operate in more than one field, for example a contractor firm may have an architectural and engineering division). The validity of the survey questionnaire can be questioned here, as the selection criterion was not consistent across the sample, however, the researcher perceived that there was no other way of selecting companies from various disciplines across the industry. Further, as the purpose of this survey questionnaire was to inform and support the direction of this research investigation, rather than to make inferences about the industry, it was deemed adequate.

Sources explored	Source used
National Federation of Builders	
RIBA	
Construction Industry Board	
Construction Clients Forum	The list of the 32 UK members as of 07/05/99
Construction Industry Council	
Construction Confederation	
Major Contractors Group	
Confederation of British Industry	

Stock Exchange	
Construction Best Practice Programme	
The Architects' Journal	The top 20 UK architectural practices by turnover as of 29/04/99
Construction News	The top 100 UK contractors by turnover as of 19/04/98
Building	The top 200 UK consultants by number of UK chartered employees as of 02/10/98
Fame	
CBI/ Kompass 1998	
Trafford Park Development Corporation Manchester	Random sample of SMEs from the local vicinity as of 1997

Table 4.1: Sample of construction sources sought and used

The selection of manufacturing companies, on the other hand, was simple in comparison. The Department of Trade and Industry (DTI) supplied a detailed ranking list of each discipline in terms of research and development (R&D) expenditure (see Table 4.2); R&D expenditure is usually related to an organisation's success (DTI, 1998). Again, as the criterion cannot be used to directly compare companies of different disciplines, as pharmaceutical companies spend much more than and plastics companies in R&D for instance. The researcher again selected the final sample but was fully aware of the discrepancies caused by the varied sample selection criteria and against that of the construction sample.

Sources explored	Source used
DTI	The UK R&D Scoreboard 1998
Trafford Park Development Corporation Manchester	Random sample of SMEs from the local vicinity
Fame 2000	
CBI/ Kompass 1998	
Dun & Bradstreet Business Register	
Kelly's Business Directory	
Key British Enterprises	

Virgin Fastrack Times 100 1999

Table 4.2: Sample of manufacturing companies sought and used

In both industrial samples, 30 SMEs were also selected at random using information supplied by the local authority. This, it was anticipated, would encourage a greater response since the results would benefit a local researcher. Only 30 SMEs were chosen as they are usually less readily to participate in survey questionnaires and are rarely involved in the whole building process, which the survey aimed to investigate.

4.3 Development of the scoping survey

The issues identified in the literature review were used to develop the scoping survey questionnaire for each industry in an attempt to further justify the research need. The questions are similar in each survey to enable a direct comparison between the practices of manufacturing and construction in process, performance and IT related issues. The following section details its development.

4.3.1 Scoping survey questionnaire design and layout

As the survey questionnaire respondents were going to be asked for their opinions on process, performance and IT related issues, it was felt that the Likert scale approach was the most appropriate to ascertain responses. The five-point scale (strongly disagree, disagree, uncertain, agree or strongly agree) is commonly used in attitude assessment to indicate the respondent's level of agreement or disagreement with each statement. Further, they were supplemented with some open-ended questions that would require more time and thought to complete.

A cover sheet for each survey questionnaire was designed incorporating a statement of its purpose and it indicated that all the responses would be confidential and no individuals would be identified in the subsequent reports. In addition, instructions on how to complete the questionnaire were included at the head of each section. The questions were wide ranging and covered topics in more depth than were eventually taken forward with the main part of the research, due to its scoping and informing-the-research nature. The questions were divided into six sections, which will be discussed in the following section: -

- General background information
- Project strategy
- Project definition
- Process execution
- Performance measurement
- Information technology

4.3.1.1 Section 1: background information

The first section in each survey questionnaire sought fundamental information on the interviewee, the company and the markets in which it operated. The primary intention of this section was to acquire important details that would allow later responses to be put into context when analysing the completed questionnaire. The questions covered the following topics: -

- The respondent's name, company and position
- The approximate number of employees in the company
- The formal project development processes that are used and the percentage of projects that went through a consistent project process
- Who were involved in the generation of a new project proposal
- The activities that are undertaken before a new project are determined
- The criteria used for reviewing new project proposals

4.3.1.2 Section 2: project strategy

This section aimed to examine the importance, nature and influence of the company's business strategy on the project process. The areas covered were: -

- A clear business strategy for developing new projects
- The consistency of new project proposals with the overall business strategy
- The use of the business strategy to inform the project process
- The issues included in the business strategy
- The business criteria for making approval decisions in the project process

4.3.1.3 Section 3: project definition

This section examined how a new project is defined within the company, detailing how it was formulated, evaluated and resourced during the project process. It questioned: -

- The main project elements identified in the project proposal
- The criterion of reviewing new project proposals
- The issues included at the front-end of the project plan
- Sufficient allocation of resources
- The project members involved in capturing the project
- A clear plan for capturing the project requirements
- The clear identification of project requirements and subsequent timescale
- The clear identification of project requirements before moving to detailed design
- The issues identified at the front-end of the project and assessments performed
- The benchmarking of project specifications against competitors

4.3.1.4 Section 4: process execution

This section focused upon the respondent’s perceptions of the execution of the project process. It addressed the areas of: -

- The existence of a consistent project process
- The number of changes to the consistent project process

- The adaptation of the project process for each individual project
- The ease of changes to the project process
- The identification of the project process at the beginning of the project and the omission of any predetermined steps
- The management of the project process and its review
- The use of cross-functional teams in the project
- The introduction stage of the project manager
- The presence of a process manager and stage they should be introduced
- Who changes the project process
- The sufficient communication and collaboration between the project team members
- The sufficient allocation of project responsibilities at the outset
- The changes to the design specification before and during production

4.3.1.5 Section 5: performance measurement

This section examined the performance measurement system in operation in the project. The areas covered were: -

- The agreement of the critical success factors at the outset
- The criteria for taking measures of the project
- The alignment of the measurement system with the business strategy
- The stage in which measures were collated and by whom

4.3.1.6 Section 6: information technology

This section was used to address the positioning and use of IT in each company's project processes, questioning specific detail upon: -

- The use of an integrated IT system to support communication
- The advanced technologies used to improve the project process
- The use or ideal use of IT within the project

4.3.1.7 Section 7: additional information

As suggested by the Oppenhiem (1992), the final section was left free for the respondents to comment about the survey questionnaire, to add any additional points that were not included, or to reinforce any particular attitudes or perceptions questioned that could be used in the subsequent analysis.

4.4 Testing of scoping survey questionnaires

In order to test the validity of the questionnaires, they were each given to six nominated practitioners in each industrial sector for verification on their applicability. This was to check for clarity and consistency of the questions/ topics covered. The list of recommended changes made by the nominated practitioners and subsequent amendments to the questionnaires can be found in section A.1 in appendix A.

4.5 Dissemination of final scoping survey

The final version of the survey questionnaires can be viewed in section A.2 and A.3 of appendix A. They were distributed to the sample audience, as identified in section 4.2, and were accompanied by a covering letter (see section A.4 and A.5 of appendix A) and a return self-addressed-envelope to encourage response. Thus following the guidelines of good questionnaire design as suggested by Hague (1994) and Oppenhiem (1992).

4.6 Response of scoping survey

Table 4.3 illustrates the number and percentage of the sample population who were sent and subsequently responded to the scoping survey questionnaire in each industrial sector. In total, the number of construction respondents was 68 (34%) of which only 61 (30.5 %) were usable, and for manufacturing there was 55 (27.5%) respondents, again only 38 (19%) were usable.

	No. of sample	% of sample	No. of respondents	% of respondents	No. of usable responses	% of usable responses
Manufacturing Sectors						
Pharmaceutical	20	10	3	1.5	1	0.5
Engineering	59	29.5	24	12	20	10
Plastics	12	6	2	1	2	1
Electronics	58	29	10	5	7	3.5
Food	18	9	8	4	4	2
Fuel	12	6	5	2.5	3	1.5
Chemical	21	10.5	3	1.5	1	0.5
Total	*200*	*100*	*55*	*27.5*	*38*	*19*
Construction Sectors						
Contractor	80	40	34	17	31	15.5
Architect	17	8.5	3	1.5	3	1.5
Consultant	35	17.5	10	5	8	4
Engineer	32	16	7	3.5	7	3.5
Surveyor	16	8	6	3	6	3
Client	20	10	8	4	6	3
Total	*200*	*100*	*68*	*34*	*61*	*30.5*

Table 4.3: Manufacturing and construction survey questionnaire sample and responses

4.6.1 Analysis

The data from the survey questionnaires was entered into the SPSS application for analysis. Using the software, a descriptive analysis was compiled for every question. This incorporated a frequency count of the possible responses, the percentages, mean, standard deviation and variance. This degree of statistical analysis of the results was primarily adopted and deemed appropriate due to the survey questionnaire's scoping nature, and for ease of relaying back the findings to practitioners. The results of each section are summarised this section, a full copy of the results can be found in section A.6 – A.11 of appendix A.

In addition, one company returned 12 questionnaires as an individual took the initiative and distributed the survey to his colleagues. Their responses were assessed against that of their particular discipline (contractors) at the outset of the analysis to see if the results were biased and if they could be used for the purpose of this investigation. The t-test and Levene's test was used to establish the validity of their responses. Table 4.4 details the response to 'the percentage of projects that went through a consistent project process' and Table 4.5 illustrates 'there even is a consistent project process.' It is clear from the results that there were no significant differences between the responses of the 12 individuals and the rest of the contractors; both variances were not assumed in Levene's test (0 being highly probable). Therefore, the researcher could conclude that the additional responses from one contractural company would not hinder the assessment of the construction survey questionnaire.

Sector	N	Mean	Std. Deviation	Std. Error mean
Contractor	16	3.25	1.29	0.32
Company Z	15	3.07	1.03	0.27

	Levene's test for equality of variances		**T-test for equality of means**						
	F	**Sig.**	**T**	**Df.**	**Sig. (2-tailed)**	**Mean difference**	**Std. Error difference**	**95% confidence interval of the difference**	
								Lower	**Upper**
Equal variances assumed	1.671	0.206	0.435	29	0.667	0.18	0.42	-0.68	1.05

Equal variances not assumed	0	0	0.438	28.32	0.665	0.18	0.42	-0.67	1.04

Table 4.4: T-test and Levene's test to compare the result of Company z against the contractors to 'there is a consistent project process'

Sector	N	Mean	Std. Deviation	Std. Error mean
Contractor	16	3.88	1.45	0.36
Company Z	15	3.20	1.42	0.37

	Levene's test for equality of variances		T-test for equality of means						
	F	Sig.	T	Df.	Sig. (2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
								Lower	Upper
Equal variances assumed	0	0.996	1.304	29	0.202	0.67	0.52	-0.38	1.73
Equal variances not assumed	0	0	1.305	28.904	0.202	0.67	0.52	-0.38	1.73

Table 4.5: T-test and Levene's test to compare the result of Company z against the contractors to 'the percentage of projects that go through a consistent project process'

4.6.1.1 Summary of section 1 results - background information

This section summarises the key findings in the background information part of the survey questionnaire; a full copy of the results can be found in section A.6 of appendix A. The types of formal project development processes that were used by each respondent company in both manufacturing and construction industries was firstly investigated. The results, as illustrated in Table 4.6, suggest that both industries organisations usually adopt a phase review approach. However, the construction response is far more varied and inconsistent, concluding that there is no standard development process for construction. However, the construction response can be questioned as the most notable project process in construction, the RIBA plan of work (see section 2.3.1) was refuted by the questionnaire respondents; only 6.6% confirmed that it was being utilised within their organisation.

	Frequency	Percent
Manufacturing response		
No response	6	15.8
Phase Review	21	55.3
Stage-Gate	7	18.4
In-house NPD	2	5.3
ISO 9000/1	2	5.3
Total	*38*	*100.0*
Construction response		
No Response	24	39.3
Phase Review	18	29.5
Risk/ In-house	4	6.6
Financial	3	4.9
ISO 9001	2	3.3
Quality Management System	6	9.8
RIBA/ Design	4	6.6
Total	*61*	*100.0*

Table 4.6: Formal development processes used in manufacturing and construction companies

In recognition that that there is no industry-wide formal development process in construction, according to the survey results, organisations do tend to operate under the same project process conviction. The bar chart in Figure 4.1 clearly shows that the construction industry's response to the percentage of projects that go through a consistent project process is similar to that of manufacturing. Both industries agree that 80-100% of their projects follow a constant process.

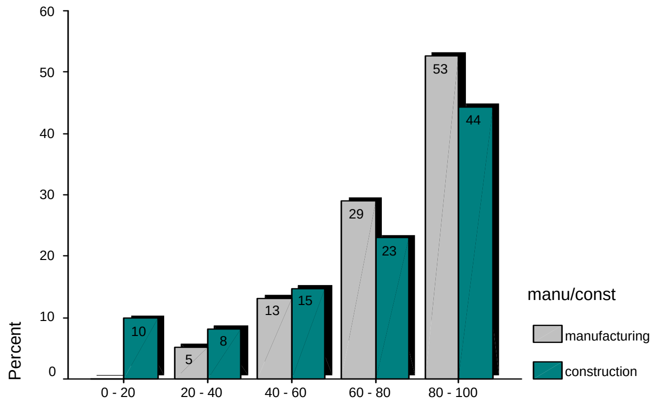


Figure 4.1: Manufacturing and construction industry response to the percentage of projects that go through a consistent project process

4.6.1.2 Section 2 results - project strategy

The key responses regarding the project strategy in both manufacturing and construction companies is discussed in this section; a full copy of the results can be found in section A.7 of appendix A. Both industries agreed that 'the business strategy is the main criteria for making approval decisions in the project process,' as illustrated in Figure 4.2, although there was also a certain degree of uncertainty particularly in the construction response.

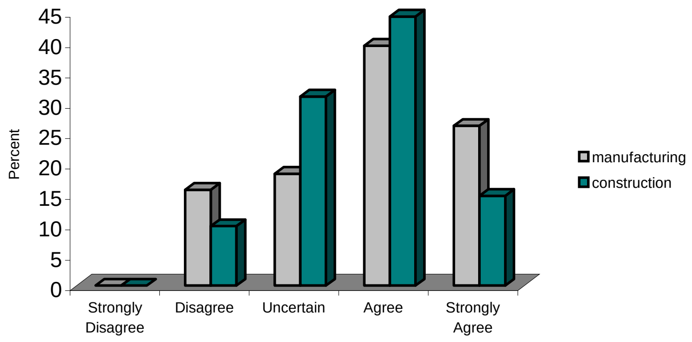


Figure 4.2: Manufacturing and construction response to 'the business strategy is the main criteria for making approval decisions in the project process'

Further, the criteria used for making decisions in the project process in both manufacturing and construction companies is detailed in Table 4.7. The results are not conclusive, as the question was open-ended, and are varied across each industry. The respondents were asked to list their own answers and may not have thought of all the relevant criteria. It is not surprising that the two industries relayed finance as important, as both are usually heavily dictated by finance/ the client's budget.

Criteria		Listed
Finance	Man.	68.4%
	Con.	57.4%
Pay Back Time	Man.	57.9%
Safety	Con.	13.1%
Market Conditions/ Product Technology/ Definition	Man.	57.9%
Quality/ Market Conditions	Con.	27.9%
Risk/ Time to Market	Man.	44.7%
	Con.	36.1%
Resources/ Manufacturing Capability	Man.	39.5%
Resources/ Repeat Business	Con.	49.2%

Table 4.7: Manufacturing and construction list of business criteria for making decisions

4.6.1.3 Section 3 results - project definition

This section details the manufacturing and construction response to questions related to project definition. A full copy of the results can be found in section A.8 of appendix A. Figure 4.3 shows that both manufacturing and construction respondents are generally unsure as to whether there is a clear plan for capturing project requirements within their organisation. Although the majority of manufacturing respondents either agree or strongly agree to the statement, 26% are uncertain. Moreover, the construction response is fairly uniform across disagree, uncertain and agree criteria, equating to 59% of the responses.

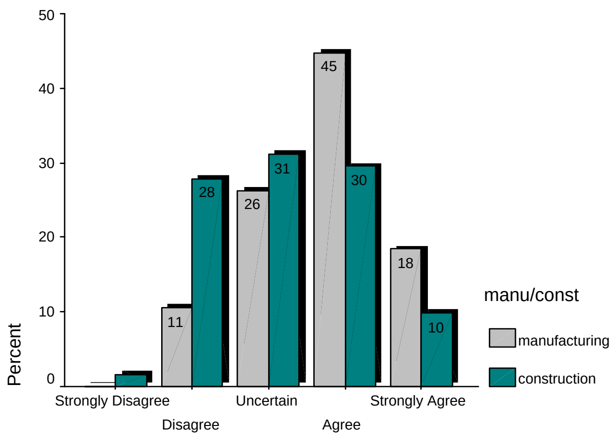
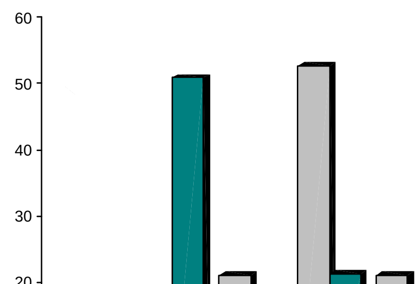


Figure 4.3: Manufacturing and construction response to 'there is often a clear plan for capturing project requirements'

If there is no clear plan for capturing the project requirements, are the requirements sufficiently identified? The basis of the subsequent question relates the integrity of selecting an appropriate project process for the task at hand. Figure 4.4 displays both the manufacturing and construction response. The majority of manufacturing companies agree that the project requirements are always clearly identified, however, this is not the consensus of construction companies. The construction respondents disagreed to the statement, mirroring typically the response to 'there is a clear plan for capturing project requirements,' as in Figure 4.3.



<u>Figure 4.4: Manufacturing and construction response to 'the project requirements are always clearly identified'</u>

4.6.1.4 Section 4 results - process execution

The key findings to the set of process execution related questions by both manufacturing and construction respondents are discussed in this section. A full copy of the responses can be found in section A.9 of appendix A. This section questioned whether there was a consistent project process in operation. Figure 4.5 illustrates the manufacturing and construction response; 90% of the manufacturing respondents agreed to the statement, compared to that of 59% of construction. This result can be viewed against Figure 4.1 whereby respondents were asked the percentage of projects that go through a consistent project process. The manufacturing response is mimicked in both questions unlike that of construction. Therefore, Wilcoxon signed rank test was used to compare the two construction responses for their consensus (see Table 4.8); the large deviation from the construct 0 value (z) confirms that there is inconsistency.

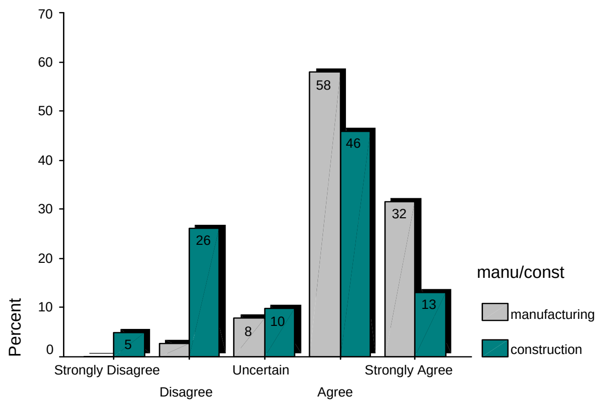


Figure 4.5: Manufacturing and construction response to 'there is a consistent project process within our company'

Ranks	**N**	**Mean rank**	**Sum of ranks**
Negative ranks	32a	21.94	702.00
Positive ranks	11b	22.18	244.00
Ties	18c		
Total	*61*		

a There is a consistent project process < consistent process percentage

b There is a consistent project process > consistent process percentage

c There is a consistent project process = consistent process percentage

There is a consistent project process > consistent process percentage - test statistic b	
Z	-2.901a
Asymp. Sig. (2-tailed test)	0.004

a Based on positive ranks

b Wilcoxon signed rank test

Table 4.8: Wilcoxon signed rank test results comparing manufacturing and construction response to ‘there is a consistent project process’ against ‘consistent process percentage’

Figure 4.6 details the manufacturing and construction response to 'there are often changes to the consistent project process.' The two industries are at complete opposites here and the bar chart clearly shows that their responses are mirrored; the majority of manufacturers agree to the statement whereas the constructors disagree. However, the responses reflect typically as what would be expected. Manufacturers usually produce repeat products or vary slightly the operation of their production line to manufacture similar products. Constructors, on the other hand usually produce different types of facilities that are also procured in different ways.

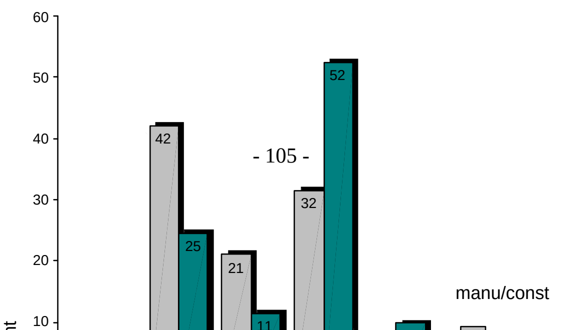


Figure 4.6: Manufacturing and construction response to 'there are often changes to the consistent project process'

The manufacturing and construction respondents were similar in response to the statement, 'we adapt the consistent project process for each individual project.' Figure 4.7 illustrates that although both industries generally agreed, however the manufacturing respondents results were more widespread. Manufacturing companies tend to manufacture the same or similar products, and so only sometimes do they have to adapt the consistent project process. Whereas, the construction industry has to change their consistent project process in accordance to the building type, environment, procurement method etc.

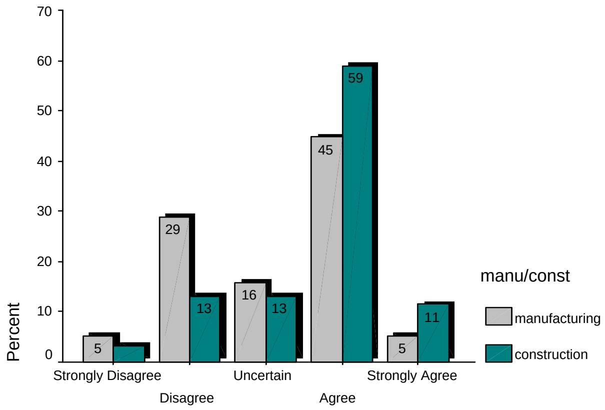


Figure 4.7: Manufacturing and construction response to 'we adapt the consistent project process for each individual project'

Figure 4.8 illustrates that the manufacturing and construction industry are not aligned in defining their project process at the beginning of a project. Typically the responses are at opposite ends of the scale. The majority of the manufacturing respondents agree to the statement, and although a high proportion of construction respondents also agree, the majority disagreed or were uncertain (57%). This result is alarming; companies should plan the whole process of a new project at the outset. Further, the result somewhat refutes the findings of Figure 4.5 whereby respondents were asked their response to the statement ‘there is a consistent process within our company;’ the project process is not always defined at the beginning of the project although there is a consistent process. Also, how can the process be succinctly defined if the project requirements are not fully identified, as displayed in Figure 4.4.

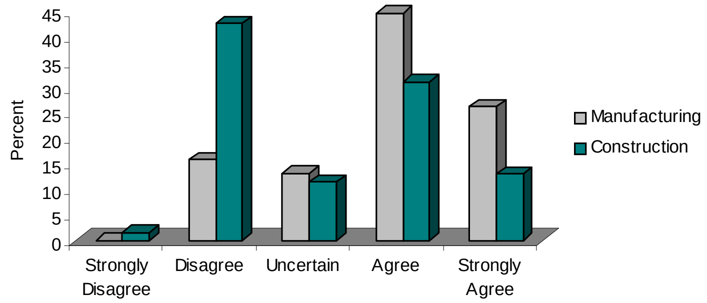


Figure 4.8: Manufacturing and construction response to 'the project process is always defined at the beginning of a project'

Once the project process is defined, both industries were aligned in disagreement to the statement 'we never omit any steps from the pre-determined project process' (see Figure 4.9). The disagreement to the statement signifies that there are often a number of changes to the determined project process – steps often become obsolete. This result again is as expected. Manufacturing companies have to change their business in response to the changing market conditions, as do the construction industry, but who also have added factors such as the weather leading to delays/ changes to the project process. This factor was exemplified earlier in chapter 1.

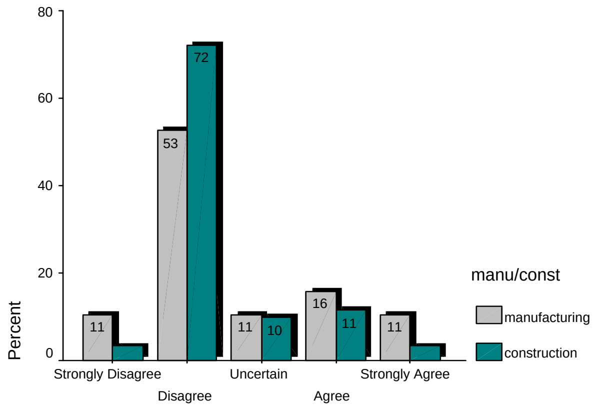


Figure 4.9: Manufacturing and construction response to 'we never omit any steps from the pre-determined project process'

The two industries were not aligned in the way in which they managed their project process at the front-end (see Figure 4.10). Manufacturing companies, having usually planned the complete design and production of a product at the outset, agree that they know how the project is going to be managed. On the other hand, the construction response is much more varied. The majority of respondents disagreed to the statement, particularly if the procurement of the project is not defined during the front-end; but there is also a degree of agreement, perhaps with respect to essentially repeated projects such as house building.

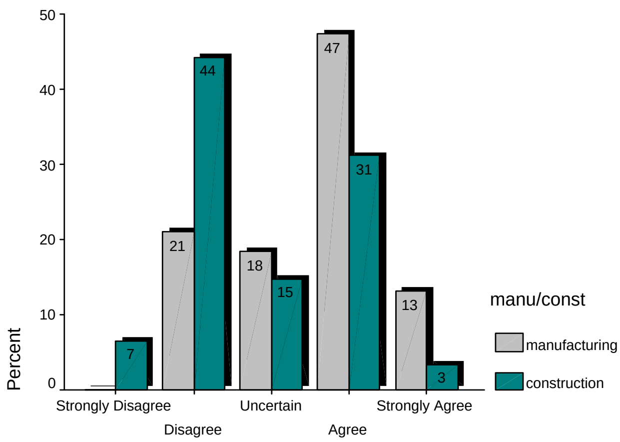


Figure 4.10: Manufacturing and construction response to 'it is always clear at the front-end how the project process will be managed'

A good communication channel between the project team is essential for any process to be successful (Kelly et al, 1997). However, this is not reflective across the construction industry, as illustrated in Figure 4.11. The manufacturing response was almost paramount in agreement, but the response in construction was typically uniform across disagree, uncertain and agree criteria. This result may be a reflection on the nature of the industries. A project team within manufacturing is usually well developed with well-established methods of working, whereas in construction the team is usually constructed on a temporary nature only for the duration of the project, requiring time for working practices to develop.

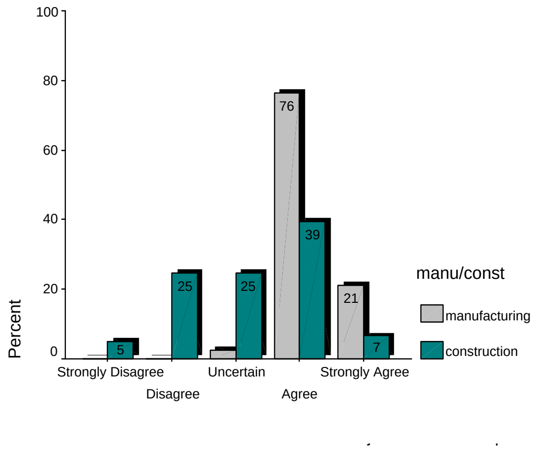


Figure 4.11: Manufacturing and construction response to 'there are good communications between the project team participants throughout the project process'

Likewise, the proposition that the nature of the industries affects the enactment of the project process is again reflected in the response to the statement 'the necessary project responsibilities are not being allocated at the outset.' The result is detailed in Figure 4.12. Again the industries are not aligned in their response. The manufacturing respondents disagreed to the statement, signifying that the responsibilities are detailed at the start of a project unlike that in construction. Further, this result is thus reflected in Figure 4.10 whereby respondents were asked to detail their agreement or disagreement to the statement 'it is always clear at the front-end how the project will be managed.'

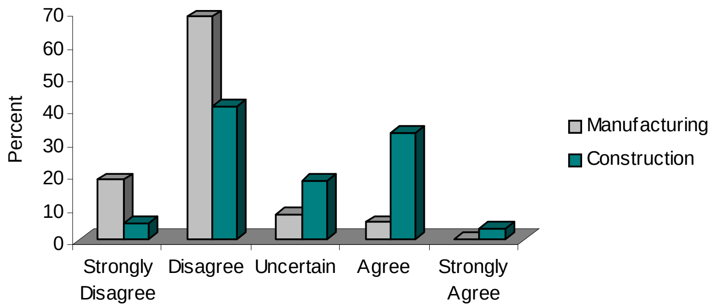


Figure 4.12: Manufacturing and construction response to 'the necessary project responsibilities are not being allocated at the outset'

4.6.1.5 Section 5 results - performance measurement

The following section details the survey questionnaire response to performance management related issues. A full account of the results can be found in section A.10 of appendix A.

The majority manufacturing and construction respondents both agreed that the principal reason for taking performance measures was to inform the client/ customer, benchmark the project and to manage resources (see Table 4.9), although there was a significant number of manufacturing respondents who believed that measurement was not used to 'inform the client/ customer,' and not to 'benchmark the project' in construction. The results were what were expected. Manufacturers usually produce products in anticipation that there will be a market threshold, and therefore it is not usually apparent to inform the customer of the production performance of the product. Moreover, the recent introduction of the governments KPIs (key performance indicators) in 1998, over a year after this survey questionnaire was conducted, has contributed to a furry of benchmarking in the construction field (CBPP, 2001), and this may be reflected in the results in Table 4.9. According to Ball (1988), construction projects are still often considered as a unique and therefore it is difficult to directly compare them against each other, as supported by 24.6% of negative and 19.7% of uncertainty response to the statement. More investigation needs to be conducted in this area in order to achieve a more conclusive response.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Inform the Client/ Customer	Man.	2.6%	39.5%	13.2%	44.7%	0
	Con.	0	11.5%	19.7%	54.1%	14.8%
Benchmark the Project	Man.	0	7.9%	18.4%	68.4%	5.3%
	Con.	1.6%	23.0%	19.7%	47.5%	8.2%
Manage Resources	Man.	0	0	5.3%	78.9%	15.8%
	Con.	0	4.9%	16.4%	62.3%	16.4%

In addition, 3 (7.9%) of manufacturing respondents stated that feedback was a reason for taking measures, and 4 (10.5%) stated that monitoring and controlling risk was a factor; 7 (11.5%) of construction respondents stated that feedback was a reason for taking measures, and 10 (16.4%) stated that it is to monitor and control risk.

Table 4.9: Manufacturing and construction response to the reason for taking measures

The alignment of the measurement system to the business strategy is critical for project success (Globerson, 1985; Dixon et al, 1990; Kaplan & Norton, 1992), however, the results in Figure 4.13 do not follow this trend. Nearly half of construction respondents (44.7%) were uncertain as to whether this factor was in practice, which is alarming since commercial construction projects would have nearly all emerged as a direct result from the need determined in the client's business case. Clearly, this is a key area for consideration/ improvement for both industries.

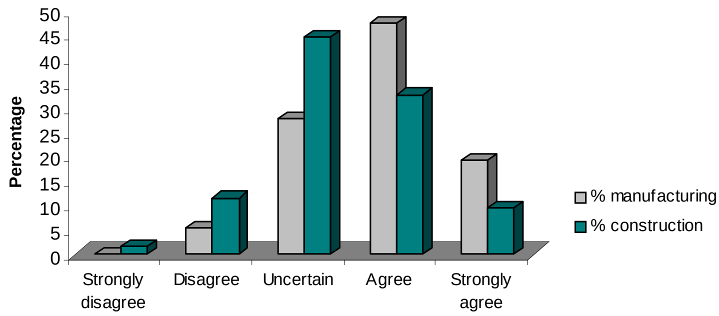


Figure 4.13: Manufacturing and construction response to 'our measuring system is aligned to our business strategy'

Table 4.10 illustrates that the manufacturing and construction company responses are aligned in terms of when they collect particular measures. Time is measured every week. Cost every month. Quality every phase review, although the construction respondents were quite widespread in this response and seemed to be uniform over collating quality measures every week, month and phase review. Manufacturers assessed the time-to-completion of a project at each phase review, whereas construction did so every month, and likewise this similar pattern emerged with the metrics of time through each phase of development, total cost against estimated cost, and phase cost against estimated cost. The client/ end-user/ customer satisfaction was always collated at the end of the project in each industry, and 40% of manufacturing respondents claimed that the project team's satisfaction was never assessed and 33% in construction.

The process effectiveness/ execution was measured at the end of the project or at the phase review, and the number of changes in the process was never measured although virtually equal construction respondents stated that it was done every month. However, this seems contradictory to a statement elsewhere in the questionnaire that asked respondents if there was a consistent project process within their company (Figure 4.5). Although 45.9% of construction respondents agreed, it seemed somewhat questionable against the general belief that there is a consistent construction process and this is highlighted in the 31.1% of respondents who were in disagreement or strong disagreement to the statement. Manufacturers were all in agreement or strong agreement in terms of having a consistent project process. Innovation within the process is again hardly ever measured, and is a possible area to consider for improvement in both industries as highlighted by Kaplan and Norton's balanced scorecard (1992; 1993; 1996). Conclusively, most construction companies assessed the success of their tender submissions every month but what is more alarming, 13.1% never rated their performance in respect of what was perceived against a common metric.

The following data is collected every:		**Week**	**Month**	**Phase Review**	**End of Project**	**Never**
Time	Man.	50.0%	39.5%	10.5%	0	0
	Cons.	52.5%	41.0%	3.3%	3.3%	0
Cost	Man.	7.9%	52.6%	36.8%	2.6%	0
	Cons.	14.8%	73.8%	9.8%	1.6%	0
Quality	Man.	7.9%	28.9%	60.5%	0	2.6%
	Cons.	31.1%	29.5%	31.1%	8.2%	0
Time-to-Completion	Man.	13.2%	13.2%	50.0%	23.7%	0
	Cons.	31.1%	54.1%	4.9%	6.6%	3.3%
Time through each phase of development	Man.	5.3%	18.4%	71.1%	2.6%	2.6%
	Cons.	26.2%	42.6%	24.6%	3.3%	3.3%
Total Cost against	Man.	5.3%	36.8%	39.5%	18.4%	0

Estimated Cost	Cons.	8.2%	72.1%	8.2%	9.8%	1.6%
Phase Cost against Estimated Cost	Man.	2.6%	21.1%	57.9%	10.5%	7.9%
	Cons.	4.9%	65.6%	24.6%	4.9%	0
Client Satisfaction	Cons.	4.9%	11.5%	36.1%	44.3%	3.3%
End-User Satisfaction	Cons.	3.3%	3.3%	18.0%	49.2%	26.2%
Customer Satisfaction	Man.	2.6%	5.3%	34.2%	42.1%	15.8%
Team Satisfaction	Man.	2.6%	7.9%	26.3%	23.7%	39.5%
	Cons.	1.6%	6.6%	27.9%	31.1%	32.8%
Process Effectiveness/ Execution	Man.	5.3%	2.6%	31.6%	52.6%	7.9%
	Cons.	1.6%	11.5%	32.8%	34.4%	19.7%
Commercial Success	Man.	0	7.9%	15.8%	68.4%	7.9%
Number of Changes in the Process	Man.	0	2.6%	21.1%	18.4%	57.9%
	Cons.	16.4%	31.1%	9.8%	16.4%	26.2%
Innovation within the Process	Man.	2.6%	0	23.7%	31.6%	42.1%
	Cons.	3.3%	11.5%	27.9%	26.2%	31.1%
Tender Awards against Tenders Submitted	Cons.	6.6%	39.3%	31.1%	9.8%	13.1%

In addition, 6.6% of construction respondents stated that they collected measures relating to safety and environmental issues.

Table 4.10: Manufacturing and construction response to the time of data collection

4.6.1.6 Section 6 results - Information Technology

The following section details the manufacturing and construction responses to the survey questionnaire relating to IT; a full copy of the results is detailed in section A.11 of appendix A. Table 4.11 illustrates the manufacturing and construction response to the use of advanced technologies. Both industries agreed that integrated databases, document management systems and inter/ intra/ extranet applications would assist in project success. However, the response to the use of artificial intelligence was rather bewildered for both industries, and this may be attributed to a lack of understanding of the technology.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Integrated Databases	Man.	0	2.6%	5.3%	63.2%	28.9%
	Con.	0	3.3%	1.6%	55.7%	39.3%
Document Management Systems	Man.	0	5.3%	2.6%	60.5%	31.6%
	Con.	0	1.6%	1.6%	47.5%	49.2%
Artificial Intelligence	Man.	7.9%	21.1%	39.5%	18.4%	13.2%
	Con.	0	13.1%	55.7%	21.3%	9.8%
Inter/ Intra/ Extranet Applications	Man.	2.6%	5.3%	5.3%	52.6%	34.2%
	Con.	1.6%	3.3%	13.1%	52.5%	29.5%

Table 4.11: Manufacturing and construction response to the use of advanced technologies

4.7 Conclusion

The aim of this chapter was to inform and contribute to the research direction of this investigation. The need for a framework that would measure the effectiveness of a new project process (PPE) was identified in chapter 1. Chapter 2 illustrated this need by firstly defining the problems of the construction industry, and suggesting that learning from manufacturing (Latham, 1994) and process modelling (Egan, 1998) could improve the prevailing situation. Moreover, chapter 3 highlighted that there was very little guidance on the measurement of the performance of processes, and in particular, new project processes in lieu of the growing trend of new construction process practice. This chapter presented the results of a scoping survey questionnaire that compared the position of the manufacturing and construction industry in terms of process, performance and IT related issues. The development of the survey questionnaire was described and the major findings discussed.

The findings of the survey provide further justification for linking performance measurement with new project process implementation. However, the results are, as discussed, very inconclusive. In general, the manufacturing responses are more consistent in their attitudes towards process, performance and IT related issues. In construction, however, the responses are more random and somewhat puzzling at times, although there are a lot of intervening variables that may govern the results. The size and breath of the sample may contribute to its diversity, as it was difficult to find a common category to select companies from the various disciplines. The results seem to suggest that the construction industry is still grappling with process and to some degree IT, and are also trying to address the topic of performance measurement. This chapter, by its very nature is a scoping study, has gone beyond purely performance measurement. There is an emerging need to prove the value of change – in order to substantiate the benefits of the newly adopted project process. Therefore, the researcher believes that in order to focus this study, one core aspect should be addressed. The results from the preceding chapters suggest the opportunity for the performance measurement of new design and construction project processes in lieu of the growing number of process improvement initiatives that are emerging in the UK.

CHAPTER 5: RESEARCH METHODOLOGY

5.1 Introduction

"Research is a learning process…perhaps the only learning process."
Richard Fellows and Anita Liu, 1997.

The literature reviews conducted thus far, chapters 2 and 3, exemplified the research need of this thesis; the lack of guidance in performance measurement of new design and construction project processes. This research need was supported by the findings in a scoping survey questionnaire (chapter 4). Therefore, the aim of this chapter is to discuss the research strategy to be used in the development of a framework for measuring the effectiveness of implementing a new construction project process, and to justify the decisions made in the development of the research design.

Any substantial research investigation must be based on a rigorous scientific methodology, and although research is central to both business and academic activities, there is no consensus in the literature on how it should be defined. One reason for this is that research means different things to different people. However, from the many definitions offered, there appears to be agreement that (Denzin, 1984): -

- Research is a process of enquiry and investigation
- It is systematic and methodical
- Research increases knowledge

Several steps in the process of building theory from research have appeared in the literature. For example, Yin (1994) and Eisengardt (1989) describe the design of case study research, Miles and Huberman (1984) outline specific techniques for analysing qualitative data, Bettenhausen and Murnoghan (1986) discuss the conversion of theory testing research, and Denzin (1984) summarises the triangulation of data types. However, at the same time, there is substantial confusion as to how to use them, how to combine them, when to conduct a particular type of study and how to evaluate it. According to Frankfort-Nachmias and Nachmias (1996), a research methodology is a system of explicit rules and procedures upon which research is based and claims for knowledge are evaluated. Lee (1989) suggests that there is no single universally accepted scientific methodology, but rather a combination of methodological paradigms is used to form the methodology. Therefore, in such a way, every methodology is unique and applicable only for its intended purpose.

In considering the above issues, it is clear that the research methodology of this investigation has to be sympathetic to the issues being investigated, or rather, to suit the method to the problem and not the problem to the method (Linstone, 1978; Robson, 1993). The methodology should describe the path of the research, embodying a particular style and employing different methods, being dependent upon the type of questions posed, the extent of control the researcher has over actual behavioural events, the degree of focus on contemporary events and the nature of the enquiry (Yin, 1994). Therefore, under this philosophy, where a number of different issues are encountered in the research objective, a selection of research methods is required since no single study can accommodate the need. This chapter discusses the research methods depicted in Figure 5.1 (developed from the research design model of Figure 1.1) on the basis of which they were chosen and their appropriateness.

	Explanation	Method
Identify the research need	*Identification of the problem statement for the research*	*Personal involvement on the Process Protocol project; review of the literature; consultation with other academics and industrialists*
Develop the outline research design	*Identification of the initial research strategy to substantiate the problem statement*	*Review of the literature on how to approach research*
Conduct a review of the existing literature	*Review to establish the gaps in the literature and to affirm the research need*	*Extensive literature reviews in both project processes and performance management; identified research 'gap'*
Informing scoping survey questionnaire	*Empirical evidence to support the research need as identified previouslly in the literature reviews*	*Scoping survey questionnaire to confirm the positioning of process, performance and IT related issues; sent to both UK construction and manufacturing companies*
Develop detailed research methodology	*Identification of the most appropriate strategy to address the research aims and objectives*	*Conduct a more extensive study on how to approach the research; explore methods including interviews, case studies etc*
Develop the PPE framework	*Synthesis of the findings of the literature reviews and results of the diagnostic survey questionnaire*	*Combine findings of previous literature reviews and diagnostic survey questionnaire to develop framework*
Validate the PPE framework	*Testing of the PPE framework*	*Test framework using case study projects that have adopted the Process Protocol; use both quantitative and qualitative research methods to gather data*
Draw conclusions	*Summary of the findings of the research*	*Analyse findings of the case studies and draw conclusions regarding the validity of the framework and research method. Establish recommendations for improvement and future work*

Figure 5.1: Graphical design of the research design and methodology

5.2 Research strategy and methods

Although terms 'research strategy' and 'research method' are often used interchangeably, there is a considerable difference between the two. Galliers (1992) and Weick (1984) have defined research strategy as the way of going about research, embodying a particular style and employing different research methods, a way of collecting evidence that indicates the tools and techniques used for data collection. This section will describe the research strategy that was used to satisfy the research design model (see Figure 5.1) and the justification behind the chosen research methods. According to Creswell (1994), the guiding principle for developing any research methodology is that it must completely address the research question. Therefore, to meet these objectives, the research method should be a blueprint for directly collecting observations and data connected to the research, and should (Simister, 1995): -

- Make explicit the questions the researcher should answer
- Develop a data collection methodology
- Discuss the data in relation to the initial research questions

This investigation aims to follow Simister's guidance. Research studies in the built environment have been criticised for their anecdotal approach when interpreting real world phenomena (Johnson, 2000). In this sense, it is argued that the clear definition of a research strategy is a fundamental and necessary requirement for a sound empirical study in such a field. According to Amaratunga and Baldry (2001), construction research has reached a stage that demands the validation of its heuristic principles with different 'real world' situations in order to refine and integrate them.

Table 5.1 outlines the main phases of the research strategy of this thesis in terms of qualitative and quantitative approaches, each of which will be discussed in detail in the following section. Historically, research has followed these two courses (Creswell, 1994), the former being the more prevalent and the latter providing statistical support for the qualitative findings.

Research phase	Output
Literature reviews	Qualitative research objectives
Phase one analysis	Literature findings will form the scoping survey questionnaire
Scoping survey questionnaire	Quantitative support from the literature reviews that will inform the case studies
Case studies	In-depth qualitative, quantitative and causal investigations of the performance of a new project process on two construction projects
Phase two analysis	In-depth analysis of the qualitative and quantitative research to theory building followed by verification

Table 5.1: The main phases of the research strategy of this investigation

5.2.1 Quantitative and qualitative methodology as research traditions

Data collection is an integral part of an enquiry. Without data there is no enquiry (Easterby-Smith et al, 1991). As stated earlier, research may be categorised into two distinct types: quantitative and qualitative (Creswell, 1994). 'Quantification means to measure on some numerical basis… whenever we count or categorise, we quantify… a qualitative approach by contrast emphasises meanings, experience, descriptions etc' (Coolican, 1990). The former grows out of a strong academic tradition that places considerable trust in numbers that represent opinions or concepts. In contrast, the qualitative approach concentrates on words and observations to express reality and attempts to describe people in natural situations. Over the past fifteen years, the debate over the relative virtues of quantitative and qualitative methodologies has gained considerable impetus. While the exact constitution of the two methodologies varies somewhat from author to author, or it is defined with varying degrees of specificity, there is substantial agreement about the fundamental antinomies and their practical implications for the conduct of research (see Table 5.2; King, 1996).

Quantitative	Qualitative
Inquiry from the outside	Inquiry from the inside
Underpinned by a completely different set	An attempt to take account of differences

of epistemological foundations than in qualitative research	between people
Involves the following of various states of the scientific research	Aimed at flexibility and lack of structure in order to allow theory and concepts to proceed in tandem
The results are said to be 'hard generalisable data'	The results are said to be through theoretical generalisation, 'deep, rich and meaningful'
	Inductive – where propositions may develop not only from practice or literature, but also from ideas themselves
	An approach to the study of the social world, which seeks to describe and analyse the culture and behaviour of humans and their groups from the point of view of those being studied

Table 5.2: Features of quantitative and qualitative research methods

5.2.1.1 Quantitative research

The quantitative research approach is the preferred method by researchers adopting a positivist stance (Bryman, 1993). Its research designs are characterised by the assumption that human behaviour can be explained by what may be termed 'social facts' that can be investigated by methodologies that utilise '…the deductive logic of the natural sciences' (Horna, 1994). This process has a logical, linear structure in which theories determine the hypotheses that are generalisable across settings, and is concerned with how rich, complex description of the specific situations under the study will evolve (Gable, 1994). These take the form of expectations, about likely causal links between the constituent concepts of the hypotheses. The determination of the causal links will result in its acceptance or rejection. Hence, quantitative research places great emphasis on methodology, procedure and statistical measures of validity (Chadwick et al, 1984).

Quantitative investigations look for 'distinguishing characteristics, elemental properties and empirical boundaries,' and tend to measure 'how much' and 'how often' (Nau, 1995). They are appropriate to examine the behavioural component of the built environment in that its strengths are (Easterby-Smith et al, 1991): -

- Comparison and replication is allowable
- Independence of the observer from the subject being observed
- Subject under analysis is measured through objective methods rather than being inferred subjectively through sensation, reflection or intuition
- Reliability and validity may be determined more objectively than qualitative data
- Strong in measuring descriptive aspects of the built environment
- Emphasises the need to formulate hypothesis for subsequent verification
- Helps to search for causal explanations and fundamental laws, and generally reduces the whole into the simplest possible elements in order to facilitate analysis

These strengths however, are not the sole prerogative of quantitative designs. Indeed, many of the arguments for the use of quantitative research, especially in an academic environment where resources are limited, have pragmatic origins in terms of allowing large-scale data collection and analysis at a reasonable cost and effort, as well as providing statistical 'proof.' Examples of such a method includes experiments or survey questionnaires for instance; experiments measure the effect of manipulating one variable on another variable for finding casual relationships between variables (Keppel, 1991), and survey questionnaires use cross sectional and longitudinal studies to collect data (Babbie, 1990).

The weaknesses of such quantitative research designs lies mainly in their failure to ascertain deeper underlying meanings and explanations of the built environment, even when they are significant, reliable and valid (Bryman, 1993). Quantitative research is strong in measuring variables such as a quantitative assumption regarding construction process capability in that '…processes can be reduced to a set of variables which are somehow equivalent across construction projects, persons involved and across situations,' and if this measurement is one of the focuses of the research, and then a quantitative approach may be justified (Amaratunga & Baldry, 2001). However, factors such as physiological factors, motivating factors, employee's capability etc are important in most of the built environment concepts. Although quantitative methods can be used to measure such factors, their appropriateness in explaining them in depth is more limited. Chadwick et al (1984) recognises this weakness, as quantitative research tends to take a 'snapshot' of a situation that is to measure variables at a specific moment in time. Some construction related aspects might be affected by temporal changes that cannot always be identified within a single quantitative study. Bryman (1993) explains that this is due to its apparent orderliness and linearity and their lack of concern over the influence of resource constraints.

Furthermore, Gable (1994) considers quantitative research alone as relatively weak when used during the process of discovery; once the research is underway there is little the researcher can do upon realising that a crucial item has been omitted from the questionnaire, or discovering that a question is ambiguous, or is being misunderstood by respondents. Gable (1994) goes on to suggest that the researcher should have a good idea of the answers sought before stating the study. In this way, quantitative survey research would appear to serve as a methodology of verification rather than discovery. However, this could lead to even further misgivings. Chadwick et al (1984) identified the inability of researchers to observe something without changing it, either knowingly or unknowingly, as such a factor. In this case, observable changes in those being studied are attributed to the subject's awareness that they are part of an experimental group, rather than to any variations in the conditions that were the intended factors under investigation. The researcher can also never be sure whether the interviewee is giving a true factual insight to the phenomenon under investigation, or being given answers that the interviewee perceives the investigator wants. Researchers are also not able to observe something with complete consistency and therefore often misinterpreting it as human perception is selective: you cannot interpret an observation without misrepresenting it, and you cannot communicate an interpretation of an observation without an additional misrepresentation.

5.2.1.2 Qualitative research

Qualitative research, on the other hand, embodies strategies such as grounded theory or case studies. A grounded theory attempts to derive a theory by using multiple stages of data collection and the refinement of information (Strauss & Corbin, 1990), and a case study explores a single entity, the 'case,' by using a variety of data collection methods during a sustained period of time (Yin, 1989).

Qualitative researchers consider that it is not possible to assign meaning to a phenomenon, or behaviour, without describing its context and understanding of the position of the people who affect, or are affected, of the phenomenon (Miles, 1979). Researchers carry out their investigation within the natural setting of the phenomenon (Cohen & Manion, 1994). Hence, direct and in-depth knowledge of a research setting through an intense and/ or prolonged contact is necessary to achieve contextual understanding. These situations are reflective of the everyday life of individuals, groups, societies and organisations (Miles & Huberman, 1984). As a result, qualitative research methods are associated with face-to-face contact with persons in the research setting, together with verbal data and observations. Further, in the built environment discipline, there are distinct signs of a growth in the application and acceptance of the use of qualitative approaches (Amaratunga & Baldry, 2001).

Marshall and Rossman (1989) have identified the premises that form the underlying rationale of qualitative research. Firstly, human behaviour is significantly influenced by the setting in which it occurs, therefore, it is necessary to study this behaviour in these settings. This is particularly apparent when investigating the application of a new construction project process. The method provides a systematic, empirical strategy for answering questions about people in their own bounded social context, with the researcher interfering as little as 'humanly' possible during the enquiry. In this sense, people make sense of their own experiences and create their own reality (Locke et al, 1993), a researcher cannot understand human behaviour without understanding the framework in which subjects interpret thoughts, feelings and actions. According to Cohen and Manion (1994), this method gives a clear view on what 'real life' is like, and is rich and holism, with strong potential for revealing complexity. Furthermore, the fact that such qualitative data are typically collected over a sustained period makes it powerful for studying any process and its inherent flexibility (data collection times and methods can be varied as a study proceeds) gives further confidence that what has been going on is really understood (Bryman, 1993). In this way, it has often been advocated as the best strategy for discovery, exploring a new area and developing hypotheses, and is particularly useful when one needs to supplement, validate, explain, illuminate or reinterpret quantitative data gathered from the same setting (Remenyi & Williams, 1996). These features are summarised by Bryman (1993) below: -

- A commitment to viewing actions and values from the perspective of the people being studied
- Providing a detailed description of the social setting they investigate
- Understanding events and their behaviour in their context
- Viewing social life as a process rather than static; i.e. longitudinal
- Avoiding the imposition of inappropriate ‘frames of reference’ on the subjects being studied by using a relatively flexible research approach
- An appreciation of the impact of biases on the research findings
- The formulation and testing of theories in tandem with data collection

In spite of the strengths of qualitative research, it does have its weaknesses (Miles, 1979; Miles & Huberman, 1984). The collection and analysis of data is time-consuming and demanding because many types of data are collected, and they come in many forms. As a result, this large variety of data may inhibit data analysis (Chadwick et al, 1984). Qualitative data analysis techniques are considered ‘not easy,’ as the methods are considered to be not well established (Cavaye, 1996). However, the relative difficultly of analysing qualitative data does not invalidate the data, or the conclusions drawn from them, because rules of logic applied to verbal data enable the researcher to make sense of the evidence and to analyse the data appropriately.

Furthermore, Chadwick et al (1984) have identified a number of contentious issues regarding the use of qualitative research, and must be considered when carrying out the analysis for this thesis: -

- The inability of the researcher to interpret events from the subject’s point of view

- The extent to which the results can be generalised beyond the confines of the particular case
- Research may be too unstructured as to be meaningless
- The loss of detachment of the researcher
- Poor reliability, since a single researcher often observes single events

5.2.2 Combining quantitative and qualitative research

There is a strong suggestion within the research literature that both quantitative and qualitative research are best thought of as complementary and should therefore be mixed in application (Gable, 1994; Cavaye, 1996). Das (1983) states that they '…are not antithetic or divergent, rather, they focus on the different dimensions of the same phenomenon.' This emphasis has developed with the growing attention focused upon 'triangulation' in research (Yin, 1984) and will be used during the course of this thesis. This will be detailed in section 5.2.4.2.4.1.

5.2.3 Literature reviews

A literature review reveals the established and generally accepted facts of the situation being studied (Cohen & Manion, 1994), and enables the identification and understanding of the theories or models that have been used by previous researchers in the field (Yin, 1994). This assists the researcher in identifying an unsolved problem in the field being studied, which will later become the focus of the research study. For this thesis, a wide review of primary, secondary and tertiary sources was carried out in the field of the research including books, journals, conference proceedings, newspapers, PhD theses, CD-ROMs and the Internet to produce the following literature reviews: -

- Chapter 2 examined project processes in both manufacturing and construction industries and identified the need for reform for construction
- Chapter 3 investigated the field of performance management and highlighted the inhibitor of new design and construction project process performance measurement

5.2.4 Survey questionnaires

According to Oppenheim (1992), there are two broad types of questionnaires. The first is the descriptive/ enumerative survey that prepossesses inferences about a whole population from a representative sample, for instance censuses and opinion polls; and the second is the analytic/ relational survey, which is used to examine differences between variables and is used to test specific hypotheses. Both are used within this thesis. The findings that emerged from the initial analysis of the literature reviews formed the basis of the principal scoping survey questionnaire (chapter 4). It aimed to highlight any inter-industry differences that existed in process and performance related issues between UK manufacturing and construction companies as there was very little or no direct up-to-date empirical evidence positioning the two. The purpose of this survey questionnaire was to support the research need. The latter type of survey questionnaire was used within each individual case study context (see chapters 7 and 8).

The survey questionnaire approach is a popular way of collecting data for theory testing and is usually conducted for subject matters that are difficult to study by either direct observation or experimental manipulation (Atkinson et al, 1990). Ackroyd and Hughes (1983), and Rubenstein and Haberstroh (1966) support the use of survey questionnaires as a means of understanding and generating factual and attitudinal information. This research method was deemed the most appropriate manner to facilitate the support of the qualitative research by the quantitative research, the research strategy of this thesis. The literature reviews of this investigation laid the grounds of the building theory, and the quantitative scoping survey questionnaire (chapter 4) was to provide further evidence to support and sharpen the emergent theory.

5.2.4.1 Types of questionnaires

The two most commonplace approaches of data collection are survey questionnaires and interviews (Galliers, 1992). The difference between the two lies in the administering of the questions. With a survey questionnaire the questions are self-administered, whereas in an interview, the researcher administers the written questions. Both methods were used to undertake the research described in this thesis in the case studies.

In terms of the pilot scoping survey, data was to be collected from many companies, rather than just one, and from two different industries. If interviews had been employed, a very large number would have been necessary in order to generate the quantity of data required. Personal interview questionnaires are more poignant in terms of the time required to conduct the interview and the expense of travelling to the location. Therefore, it was decided that a survey questionnaire would be more appropriate for the quantity of data required. The completion of postal survey questionnaires is faster and cheaper, requiring the cost of postage rather than travel, and respondents who live a great distance from the questionnaire administrator can also complete them. They can be completed in the participant's own time rather than being restricted to the time of the interview, although, with postal survey questionnaires, there is also the time and expense of reminders following non-return of survey questionnaires. However, Oppenheim (1992) emphasises the lower response rate for postal survey questionnaires over interviews, and that such survey questionnaires may be unsuitable for certain groups of people, for example those with literacy, language problems or those who are very young. These factors were considered in the choice of the research strategy.

Moreover, with survey questionnaires it is not possible to correct misunderstandings that may occur at the time of completion, to probe the answers given or offer explanations (Galliers, 1992), and to oversee the order of question completion or to record observational data (Bryman, 1993). Interview questionnaires, on the other hand, are more suited to responses to open-ended questions, but are more difficult to replicate. During an interview, the researcher may exert a subtle influence on the interviewee in the direction of his or her own expectations/ wishes regarding the response (Sayer, 1984). For example, if the researcher nods his or her head at a crucial time, he or she may be capable of influencing the experimental result (Greenspoon, 1955). This may be avoided through postal questionnaires, although as Oppenhiem (1992) points out, the respondent may imagine or apply a stereotype to the interviewer or to the interviewer's organisation, and may be bias in their response. There is also the risk of participant bias with interviews as the interviewee frequently forms beliefs about what they are expected to say or do (Rosenhan & Seligman, 1989). Participants may wish to tell the interviewer what they believe he or she wants to hear. That is, they may wish to be 'good' participants by confirming the researcher's hypotheses (Rosenhan & Seligman, 1989).

However, it must also be noted that survey questionnaires are usually completed remotely and without supervision or control, and this can bring its own set of problems in terms of data validity (Greenspoon, 1955). It can be difficult to know whether the respondent was filling in the questionnaire seriously, had the necessary knowledge, or understood the questions and terms. This can therefore lead to a large degree of variability in the results. Consequently, to minimise this problem in this thesis, the most appropriate candidates were selected. The researcher also acknowledges that the validity of the findings from the survey questionnaires in this thesis are very much dependent upon the quality of its design and the subsequent analysis. In response, the findings were triangulated as much as possible, as within the case studies of this investigation.

5.2.4.2 The sample

The sample audience chosen for the survey has to be appropriate for what is being measured (Oppenheim, 1992). More too, the quality of the response is related to the motivation to participate in the research. Oppenheim (1992) suggests that several measures can be employed to achieve such. Participants may be enthused by a preliminary postcard, the promise of a reward, sponsorship, expenses, or by the belief that important changes will occur following the survey. Response rates may also be increased with the use of an advance warning letter, inviting participation, denoting why they were selected, and personally addressed envelopes and the promise of confidentiality and anonymity.

For the purpose of this research, motivation was encouraged by the promise of a free copy of a summary report based on the findings, which the respondents may consider to be useful or interesting. An initial telephone call was used to establish the most appropriate person in the case of the principal survey questionnaire and top management support was granted in the context of the case studies to relinquish a personal approach. Moreover, confidentiality and anonymity was assured throughout.

5.2.4.3 The design of survey questionnaires

Ackroyd and Hughes (1983), and Oppenheim (1992) suggest that during the design of survey questionnaires, careful consideration needs to be given to the order in which the questions are asked, perhaps by using filter questions in order to exclude some respondents from a particular group of questions if they are not relevant to them. The types of questions that are asked should also be considered carefully. Open or free-response questions allow respondents to reply using their own words, but responses may be constrained by the amount of space provided for the written response. However, these types of questions are difficult to analyse and code. Closed questions, in which respondents choose from a set of answers, are easier to analyse and less time consuming to both complete and code. Nonetheless, providing potential answers may introduce bias in the response, and the choices offered might not correspond with the respondent's preferred answer (Greenspoon, 1955). Hague (1994) suggests that it is ideal to begin with easy questions, probably those that involving ticking boxes, and then eventually moving on to those that require more thought as to encourage a response. Therefore, in the case of the scoping survey questionnaire design for this investigation, closed questions were mainly used and space was allowed for additional responses at the end of the document, and sometimes at the end of each question. These, in addition to a mixture of both question types were used to reduce bias.

Oppenheim (1992) also states that the questions need to be carefully worded in order to avoid misinterpretations through alternative meanings. Double-barrelled/ double negative and hypothetical questions should be avoided, along with long sentences, proverbs, loaded words, over-taxing of respondents' memories and leading questions. Hague (1994) suggests a number of steps to take to reduce this bias and ambiguity: -

- Ensure that the question is without bias – e.g. avoid 'you agree that the company has an excellent product range?'
- Jargon or shorthand may not be understood by the respondent
- Steer clear of sophisticated or uncommon words
- Avoid ambiguous words
- Make the question as short as possible
- Make the question as simple as possible – e.g. avoid 'when you buy both butter and margarine, do you use a different supplier?'
- Make the questions very specific
- Make sure that the question and answer do not conflict - e.g. avoid 'do you care what brand you buy or would you buy any brand?'
- Keep the number of meaningful words to a minimum – e.g. avoid 'what motivates and inspires you in the selection or specification of a new supplier?'
- Avoid negative questions – e.g. avoid 'do you never buy shampoo?'
- Avoid hypothetical questions
- Keep questions within the respondent's capabilities
- Make it easier for respondents to answer questions
- Allow for 'others' in fixed response questions
- Ensure that fixed responses do not overlap

The above steps were followed in all survey questionnaire designs within this thesis. Further, once the wording of the questions has been addressed, Hague (1994) goes on to describe the importance of categorising them within the main headings into a semi logical order so that the overall survey questionnaire is more coherent, easier to complete and to analyse. However, although a sense of continuity between subjects was maintained throughout the survey questionnaires that were used in this thesis, in order to encourage concentration, the individual statements did not necessarily always flow directly from the one before. In addition, some questions were replicated, reversed and the tense changed to enhance this, as recommended by Ackroyd and Hughes (1983). This approach was adopted to ensure that the respondents paid attention to the statements and to enable a degree of cross checking of the completed survey questionnaire, to assess the consistency of individual's responses and so that respondents read the statements carefully and did not, for example, simply agree with every statement. Several academics and industrialists vigorously validated the wording and sequence of all survey questionnaires used in this thesis to reduce any ambiguity.

In addition to the design of the survey questionnaire, Hague (1994) points out that the covering letter is as important as the questionnaire itself and must be considered at the outset, as it becomes the first root for a response. His suggestions of what it should include were also fully recompensed in all the survey questionnaires that were administered in this thesis: -

- Explain the purpose of the survey and why the respondent has been selected
- Give the respondent a reason for wanting to complete the questionnaire
- Give clear instructions as to what should be done, i.e. how to fill it in and how to send it back
- Give assurance that completing the questionnaire is easy
- If possible, give assurance that replies will be confidential
- Thank the respondent

5.2.4.4 Survey questionnaire response recording

One of the most widely used methods of recording responses in survey questionnaires is the Likert Scale (Yin, 1994). According to Oppenheim (1992), Likert Scales are usually reliable due to the range of responses they are able to record for closed-questions and usually adopt a five-point scale, the points of which represent varying responses; strongly agree, agree, neither agree or disagree, disagree and strongly disagree. The central point represents a neutral response. However, Oppenheim (1992) openly criticises the central neutral response. He states that this point does not always represent the centre between the scale extremes, but rather would provide respondents with an easy option when faced with difficult or contentious statements that, if selected, would fail to identify the particular characteristics that the questionnaire was intended to highlight. This response could signify a host of responses, including a lukewarm response to the question, a lack of the relevant knowledge or attitude, or the revolt against strongly positive or strongly negative attitudes. Either instance is unclear. This factor was carefully considered during the survey questionnaire development and the most common alternative, ‘uncertain,’ was finally selected. The inclusion of this option would, it was felt, enable any statements that were inapplicable or understood to the particular respondent to be easily identified.

5.2.4.5 Statistical analysis

Analysis of data generated by survey questionnaires can take one of two forms, descriptive statistics or statistical inference (Oppenheim, 1992). Atkinson et al (1990) concludes that descriptive statistics summarise the data using several methods; measures of central tendency describe a central representative point (e.g. mean, mode, median); measures of variation describe the spread of scores around the average score (e.g. standard deviation). Further, statistical inference procedures (e.g. tests of statistical significance) attempt to assess the relationships or association revealed by the data. There always exists a degree of uncertainty from sampling errors, if a statistical test suggests a large magnitude, that effect is likely to hold for the population from which the same was chosen (Atkinson et al, 1990).

Descriptive statistical analysis was primarily used to report the findings in this investigation since an industrial approach was adopted; the respondents of the survey questionnaires were keen to have access to the results and expressed that they would prefer them to be simple to understand. Statistical inferences were used to describe particular relations between the data sets.

5.2.4.6 Reliability, validity and uniform procedures

For a survey questionnaire to be reliable, it must be consistent, reproducible, and be administered and scored in the same way (see section 5.2.3.3; Atkinson et al, 1990). In short, a test cannot be considered reliable if it contains confusing or ambiguous items which may be interpreted in different ways, be of insufficient depth to assess what is being tested, if the scoring is subjective, or if the results were obtained on different occasions or scored by the wrong people (Atkinson et al, 1990). Moreover, Oppenheim (1992) argues that reliability and validity are not always related to each other, in that reliability is necessary but not sufficient for validity, and that invalid measures may be very reliable. In light of this, the reliability and validity of surveys should not be considered in isolation, and procedures employed must be uniform in order for both conditions to exist.

Nevertheless, certain procedures can be followed to ensure such reliability. For factual questions, internal checks, such as asking the same question twice but worded differently can be employed, or by including bogus responses on multiple-choice questions (Oppenheim, 1992). However, questions that require the expression of an attitude or opinion cannot be asked twice using different wording as they are sensitive to wording, as if the wording is changed it becomes a different question (Oppenheim, 1992). Reliability can instead be increased here by using sets of questions relating to an attitude to maximise the more stable components of the attitude being measured, whilst at the same time, reducing the instability arising from both emphasis and mood changes. In addition, external checks involving secondary information source, such as official records or a second informant, can be used to check the validity of factual questions, but this is still difficult for attitudinal responses. There are complex links between attitudes and behaviour; attitudes are not always a predictable form of behaviour and behaviour does not always mirror attitudes (Atkinson et al, 1990).

The survey questionnaires used in this thesis fully consider and adopt all the issues regarding reliability, validity and uniformity. They were all administered and scored in the same way.

5.2.5 Case studies

In order to gain the depth of understanding necessary to develop a framework to assess the effectiveness of implementing a new design and construction project process, the case study approach was used as the primary research methodology. According to Yin (1989), a case study is an '…investigation into a contemporary phenomenon within its real-life context …where the boundaries between phenomenon and context are not clearly evident …and in which multiple sources of evidence are used.' Babbie (1986), Roberts (1996) and Eisenhardt (1989) define it as in-depth understanding of the dynamics present within single settings. Or quite simply, it is the preferred strategy when trying to answer 'how' and 'why' questions when there is little control over events Yin (1989).

The case study uses a variety of data collection methods during a specific period in an effort to study a single research 'case.' This research method is highly pertinent for this thesis since data collection of the built environment has to be carried out in 'real world' conditions. The kind of control present in a laboratory is not feasible and is not even ethically justifiable (Miles & Huberman, 1984; Yin, 1994; Remenyi et al, 1998). This research strategy can therefore deal with varying sources of evidence and experimental design allowing the researcher to examine contemporary events by direct observation and interviewing. Further, it is unlike quantitative research methods, as it can be viewed as an 'experiment' to test a specific theory. In a typical survey questionnaire, an inference can be made about a larger population on the basis of empirical data collected about a sample, and in case studies, the researcher uses a theory as a template to guide the research development. By subsequently using analytical generalisation, the empirical results can then support or refute the theory. In this way, a case study acts like an experiment that is used to test the validity of a specific hypothesis and it also often involves a smaller sample of participants than a survey.

There are many advantages to the case study approach (Miles & Huberman, 1984; Lincoln & Guba, 1985). Case studies are useful when an '…investigator has an opportunity to observe and analyse a phenomenon previously inaccessible to scientific investigation' (Yin, 1989). They are also useful for studying phenomena that are experiencing rapid change. According to Simister (1995), a case study's flexibility allows issues to be explored as they develop in the data collection phase. Moreover, Lincoln and Guba (1985) note that this type of enquiry allows the research findings to be intrinsically linked to the data, and is generally more effective when describing complex relationships between a number of variables, as well as enabling the building of theoretical frameworks (Roberts, 1996).

However, there are also many criticisms of this method. The main criticism is that it suffers from a lack of rigour and it can be bias (Yin, 1989). Yin (1989) cites that '…the case study has long been stereotyped as a weak sibling …investigators who do case studies are regarded as having deviated from their academic disciplines; their investigations as having insufficient precision (quantification), objectively and rigor.' Simister (1995) suggests that this perception is the result of the flexible nature of a case study's research design. Summarising the work of others, he concludes that the strength of a case study is dependent upon the development of an explicit research design, and the use of several methods for data collection (Lincoln & Guba, 1985; Yin, 1989; Simister, 1995).

Case studies also rely to a greater extent than survey questionnaires on the interpretation of the data that is generated, and so is more prone to equivocal evidence biased views to influence the direction of the findings and conclusions (Miles & Huberman, 1984). With case studies, the danger of ad hoc theorising and neglecting to test data becomes greater (Simister, 1995). Failing to develop a sufficiently operational set of measures and the use of 'subjective' judgements during data collection stages usually renders construct validity poor. According to Bromley (1986), researcher bias has an impact on the internal validity of the data.

Becker (1986) agrees with this in that researchers may have ‘feelings’ for the subjects and conclusions that are drawn suffer from a lack of reliability. A further problem is that of external validity which is very difficult to measure in the case study setting (Berger, 1983). It is impossible to generalise findings to different settings as phenomenon and context is necessarily dependent. They often also require a greater length of time both to conduct and analyse, as well as providing little basis from which generalisability to a population from only a single or a small number of cases (Yin, 1989; Gable, 1994). Therefore, to reduce the bias in data collection, the author used the multiple case study method.

The evidence from multiple case studies, however, is often considered more compelling and the overall study is regarded as more robust. Further, in the context of this research, perhaps the most critical aspect is that it provides a limited bias for the traditional ‘scientific generalisation’ (Yin, 1994; Remnyi et al, 1998), as whether external (validity) conditions are thought to produce variation in the phenomenon being studied. Notwithstanding, like all experimental observations, case study results can be generalised to theoretical propositions (analytical) but not to populations (statistical). Thus, the aim of case studies cannot be to infer global findings from a sample to a population, but rather to understand and articulate patterns and linkages of theoretical importance. In support of the above, Santos (1999) stated that it is important to emphasise that case studies deal with unique situations and, because of that, it is not possible to elaborate detailed and direct comparisons of the data. Therefore, to overcome the limitations in case study research methods, the researcher proposes the use of triangulation techniques (see section 5.2.4.2.4.1).

5.2.5.1 Multiple case studies

Case studies can be single or multiple (Herriot & Firestone, 1983). This thesis uses the multiple approach to test the PPE framework; although the single approach is used to examine the success of the Process Protocol (see section 5.2.5.1.1). Multiple cases strengthen the results by replicating the pattern matching and increasing the robustness of the theory as it allows analysis of data across companies and projects. Furthermore, it also allows the researcher to test and crosscheck research findings during and after the development of PPE framework (Irani, 1998); the objective of this research. Herriot and Firestone (1983) describe this approach as an enabler to the identification of differences in context to be related to constants in the process and the outcome. Yin (1983) supports the use of multiple sources of data stating that the case studies that adopt such methods are rated more highly than those that rely on only single sources of data.

The number of case studies needed when a multiple case study approach is adopted is not pre-defined in the literature (Eisenhardt, 1989; Dyer et al, 1991). Dyer et al (1991) suggests that the decision on the appropriate number of case studies is intuitive and depends on what new information can result from studying further cases.

5.2.5.1.1 Case study selection

To gain access to construction case studies alone is intrinsically difficult for a researcher, and projects usually outlast the duration of the research investigation. This factor was increased with the research requirement of adopting of a new construction project process.

The Process Protocol was used through case studies in this investigation as a basis to test the PPE framework. This process model was selected because firstly, it is a 'new' design and construction process; although some commercial companies to date have used it, it has never been fully implemented nor has its proposed benefits (six key principles) verified. Further, the protocol is particularly apt since there is relatively no new project process currently available for investigation in the UK construction industry that isn't company-biased. These factors fit entirely with the researcher's involvement in the development of the Process Protocol II project; it became apparent during the research project that such a model would be timely and useful to support the uptake of the protocol.

Determining numerous projects that would adopt the Process Protocol as to test and validate the PPE framework during the timescale of this research investigation proved problematic. Unfortunately, there is seemingly somewhat a reluctance of deployment of new project processes in construction. This is perhaps, in part, due to the inherent instability of the industry and the subsequent lack of funding available to construction professionals (usually from clients who are inexperienced in the process) to adopt new methods of working.

The Castle Vale and Britannia Walk projects (chapters 7 & 8) were finally identified as the only valid projects that had adopted the Process Protocol and could be subsequently used to test and implement the PPE framework during the period of this doctoral thesis. Therefore, two case study projects were deemed as adequate as there was no other alternative project that could be examined. However, the two case studies investigated had only implemented differing parts of the Process Protocol (hence, multiple case studies are used in this investigation to examine the framework; see section 5.2.5.1). The Process Protocol is a new construction project process and at the time of investigation, it had not been fully implemented on a single project, therefore, it remained impossible for the researcher to measure the protocol’s full benefits using the PPE framework. The Castle Vale project adopted what can be viewed as the legacy archive of the protocol, and the Britannia Walk project employed only particular deliverables of the protocol.

5.2.5.2 Case study protocol

Yin (1994) suggests the use of a study protocol for reliability during the investigation of multiple case studies. Robson (1993) suggests that one of main the problems with case study research is its inherent ‘looseness’ and Yin (1989) suggests that one way to combat this looseness is to establish a protocol that outlines the procedures and general rules that will be used during data collection. According to Kidder (1981), it becomes a ‘…major tactic in increasing the reliability of the case study research and is intended to guide the investigator in carrying out the case study,’ and ‘…a well designed protocol insures that the operations of the study can be repeated with the same results.' Therefore, a case study protocol was developed for this study to establish a framework for collecting and analysing the data for each case study. This is outlined in Figure 5.2 (Eisenhardt, 1989).

Step 1: Project identification	Step 2: Identify supervisors; gain commitment	Step 3: Interviews/ workshops/ questionnaires; collect data	Step 4: Data analysis and validation	Step 5: Write up case studies	Step 6: Verification

Figure 5.2: Case study protocol framework

5.2.5.2.1 Step one: identify suitable projects

The first step of the case study protocol was to identify construction projects that could be used for the research. Castle Vale and Britannia Walk were identified as the most appropriate; in both instances, the project team approached the researcher for assistance to measure the success of the Process Protocol. Moreover, both projects met the following criteria: -

- The project's duration was suitable to that of the researcher
- Each project encompassed one or more than one of Process Protocol's key principles
- Each project enabled flexibility of the researcher to fully test all or part of the PPE framework

5.2.5.2.2 Step two: identify front-line supervisors to gain commitment

Once a suitable project had been selected, the front-line supervisors were identified. Most construction projects consist of a well-defined group of front-line supervisors, who are closely associated with the project, including the project manager, lead-architect or client. Typically, Barrie and Paulson (1992) suggest that these can be easily identified using a project roster or organisational chart. This step was primarily to ensure tentative commitment for full collaboration in the case study work, and in particular, to determine benefit to both parties involved.

5.2.5.2.3 Step three: collect data through interviews, workshops and survey questionnaires

The type of data collection method used on each case study included a series of interviews, workshops and survey questionnaires. These methods were used to understand the processes and culture present to capture and gather information. Burgess (1993) describes that there are several types of field roles; Gill and Johnson (1997) presents a taxonomy of the roles in Figure 5.3 and concludes that the type of role an observer takes while observing will strongly determine the types of data collection techniques applied.

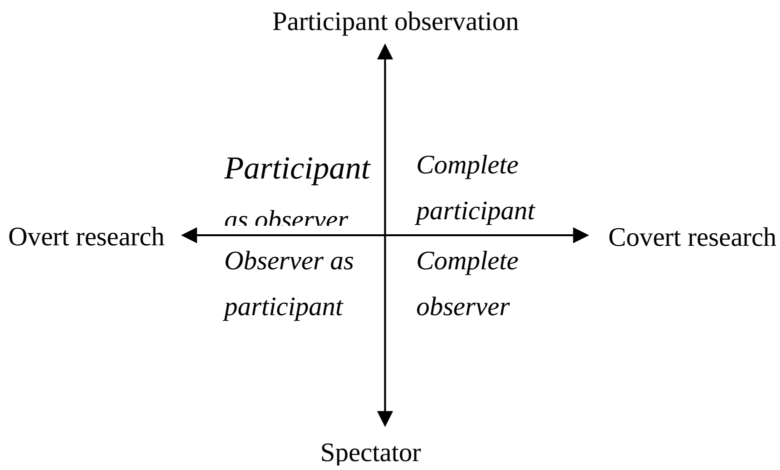


Figure 5.3: Types of roles an observer can take (Gill & Johnson, 1997)

A complete observer is that of a spectator who looks on events and processes, and avoids becoming involved in interactions with the subjects. Participant observation is opposite from this adopting a fully participating role in the everyday lives of subjects being completely immersed in the social setting (Gill & Johnson, 1997). The subject's knowledge of the role of the observer is seen as all-important and having an effect on the relationship between the observer and subject. If the subject(s) know about, or are aware of, the presence of the observer, then they may behave differently. This is described as overt research. The opposite of overt research is convert research, where the observer is concealed from the subject(s) and attempts to have the least affect on subject behaviour.

The researcher adopted the role of observer as participant during the course of this investigation. This is particularly appropriate for performance measurement in the built environment. Steier (1991) and Gill and Johnson (1997) both believe that an observer's interaction will cause the subject(s) to behave differently and that the researcher should develop a means to be 'reflexive,' i.e. the researcher should attempt to understand his or her affect on the subject(s) in the social setting. This may include direct observation where the observer is directly watching and listening to the subject(s) and or events. Or, access to data may be through indirect observation of an event, not personally witnessed but which an informant may report either orally or in writing. Observation enables a researcher to get access to what people actually do as opposed to what they claim to do and what the company procedures impose on them (Mintzberg, 1973). The main advantage of this type of research compared to other types is its greater ecological validity because it entails studying phenomena in their natural contexts. Its drawback was that the researcher never felt sure she was observing everything. However, it did allow the researcher to keep abreast of both case studies which were being conducted concurrently, this became the most important factor due to the time limitations of this thesis.

Within this method of data gathering, the interviewing method was used in some instances, along with workshops where time was limited. These methods allowed the researcher to focus and gain more detailed data on events of interest that were observed. The type of interviews carried out at the case study were as Burgess (1993) describes as 'conversations with a purpose.' They were also generally semi-structured in nature to allow the interview to have an overall purpose, but also be sufficiently flexible to explore issues as and when they arose during the discussions. The workshops were central to fruitful pre-understanding and understanding progression. All interviews and workshops were taped and transcribed, with the participants' consent. They included project participants from all areas of the project as suggested by Flynn et al (1994), as constituents other than the senior management may be the best source to overcome the potential bias. This factor was also considered whilst conducting survey questionnaires, which were described in section 5.2.3.

5.2.4.2.3.1 Action research

Observer as participant research has some grounding characteristics as that of action research. Hasley (1972) defines action research as '…the small-scale intervention into the functioning of the real-world …together with the close examination of the effects of such intervention,' thus Cohen and Manion (1994) summaries it features as collaborative, participatory and evaluative. Although the researcher intervened/ implemented the PPE framework on the case study projects for the purpose of evaluation, she did not intervene the course of the project or the process. Framed in these terms, the participatory of action research was not holistically undertaken during this research investigation.

5.2.4.2.4 Step four: data analysis and validation

Data analysis in each case study will consist of examining, categorising, tabulating or recombining the evidence to address the initial propositions of the study (Yin, 1989). Yin (1989) notes that case study research is often stymied by a lack of analytical rigor and without a well-defined data analysis strategy, a researcher can often be overwhelmed by the large quantities of data that are collected during the case study process. As such, it is important to develop a strategy that sets priorities on what to analyse and why. One approach is to use the theoretical propositions of the study to shape the data collection and analysis and to ensure that the data is collected and analysed in an appropriate statistical manner, as previously highlighted in section 5.2.3.6. Each of the results collected from the various methodologies were then triangulated as to draw conclusive conclusions.

5.2.4.2.4.1 Triangulation

The researcher fully acknowledges that the case study approach can be criticised on the basis of a lack of measurability. The data gathered is generally based on perceptions and subjective interpretations of the researcher. Therefore, this often makes quantification and the manageable summary of findings very problematic and ambiguous (Glaser & Backer, 1973). In response to these methodological weaknesses, the researcher triangulated the data collection process as much as possible, by carrying out interviews, using questionnaires, presenting and debating the findings with practitioners in workshops and meetings. This aims to reduce the bias inherent in data sources (Creswell, 1994; Simon et al, 1996; Trellis 1997a; Trellis 1997b; Trellis 1997c). Moreover, the use of a variety of research methods in this thesis is ideal to achieve triangulation of the data. According to Green et al (1989), Yin (1989) and Morse (1991), it allows researchers to observe the empirical evidence in different ways to seek a convergence of the results through the overlapping of data sources, adding scope and breadth and supporting the construct validity of the research design. It is in fact a method of crosschecking the existence of certain phenomena and the veracity of individual accounts, by gathering data from a number of informants and through a variety of channels (Open University, 1988).

Triangulation is the combination of methodologies in a study of the same phenomenon and is applied to develop a deeper understanding of the hypotheses (Rossman & Wilson, 1991). More importantly, it is not used merely to prove that the hypotheses are correct, but rather, it is used to try to develop a deeper understanding of the subject. Its need rose from the ethical need to confirm the validity of the process and its origins. Campbell and Fiske developed the method in 1959 (Jick, 1979) through the idea of 'multiple operationism.' They argued that more than one method should be used in the validation process to ensure that the variance reflected is that of the trait and not of the methods. This is illustrated by Fellows and Lui (1997; see Figure 5.4).

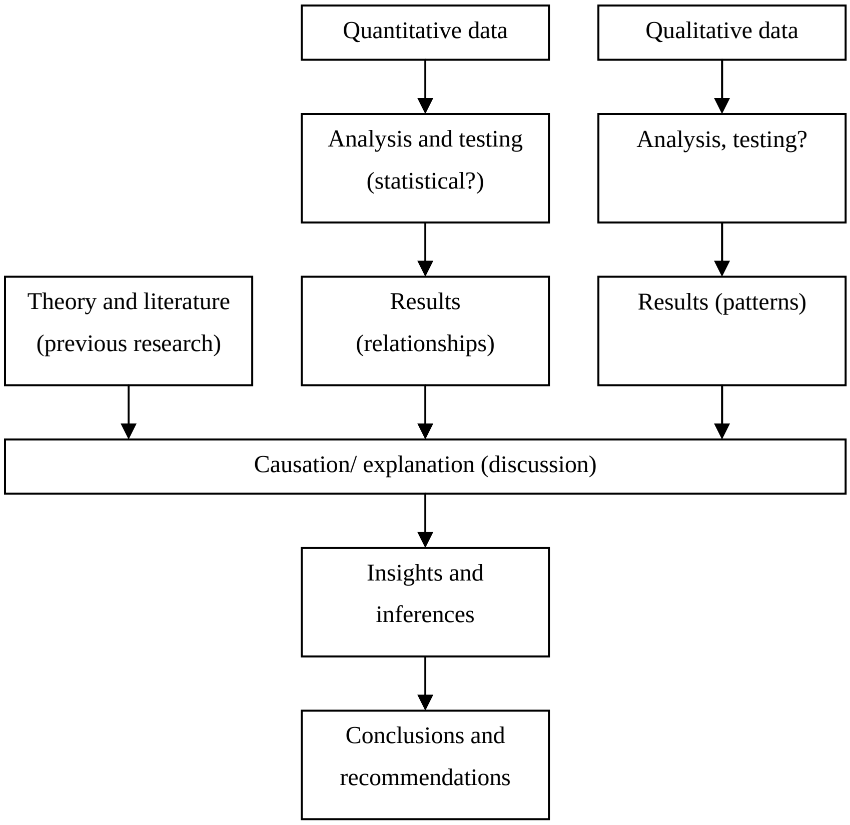


Figure 5.4: Triangulation of quantitative and qualitative data (Fellows & Lui, 1997)

Nau (1994) describes the success of this methodology is its premise that the weaknesses in each single method will be compensated by the counter-balancing strengths of another. That is, it is assumed that multiple and independent measures do not share the same weaknesses or potential bias. Further, it assists in making inferences and in drawing conclusions. Rossman and Wilson (1991) describe triangulation as: -

- To enable confirmation of corroboration of each other
- To elaborate or develop analysis, providing richer details
- To initiate new lines of thinking through attention to surprises or paradoxes, ‘turning ideas around,’ providing fresh insights

Triangulation or multiple methods were used in the case studies for two purposes. Firstly, quantitative methods (measurement of constructs) were used to support the findings of the qualitative research (attitudinal survey questionnaires), and secondly, the quantitative findings were used to uncover formal relationships between the constructs, to which the qualitative research validated. According to McCutcheon (1993), triangulation tests the degree of external validity and this is particularly apparent in this thesis since much in unknown. Nau (1994) suggests that the researcher should aim to achieve a situation where 'blending quantitative and qualitative methods should produce a final product that supports explicitly the meaning for the research.' Therefore, by adopting the following assumptions in the analysis of the data generated within each case study, the researcher should ensure that the final outcome maximises the strengths of the approach (adapted from Jones, 1978): -

- Quantitative analysis may be more appropriate to assess the behavioural or descriptive complements of the built environment
- Qualitative methods, especially observation or unstructured interviews, allow the researcher to develop an overall 'picture' of the investigation
- Built environment research involves affective characteristics as well as overall behavioural aspects
- Much built environment research is still largely exploratory. The use of qualitative methods allows for unexpected developments that may arise
- Quantitative analysis may complement the findings of qualitative methods by indicating their extent within aspects of the built environment
- Quantitative analysis may confirm or reject any apparently significant data and the relationships that may emerge from the research. Quantitative methods can be used to enable statistical testing of the strengths of such relationships
- If such relationships are determined, then quantitative methods are weaker in providing explanations. Qualitative methods may assist in understanding the underlying explanations of significance

5.2.4.2.5 Step five: case study validation

To assist in the validation of the case study results, each round of data was passed back to the construction companies for comment and criticism. The results were then discussed with the principle project supervisors to enhance feedback to validate the accuracy of the results; the comments were noted and these comments helped steer data collection before all of the results were triangulated. Once the propositions were understood, explanation building was applied to harmonise the results of each individual study (Eisenhardt, 1989).

5.2.4.2.5.1 Verification

Tying the emergent theory to existing literature enhances the internal validity and theoretical level of theory building from the case study research. After explanation building, the emergent theory is compared with the theoretical framework identified at the literature review phase. While linking the research to the literature is most important in research, it is particularly crucial in theory building research because the findings often rest on a very limited number of cases.

5.3 Conclusion

Chapter 1 introduced the area of investigation in this thesis. The research need was subsequently augmented in chapters 2 and 3; it was identified that construction reform, in lieu of process improvement and learning from manufacturing, was required for companies to remain competitive. Further, there was a lack of guidance in the measurement of the effectiveness of new design and construction project processes. The research need was also supported by the findings of a scoping survey questionnaire (chapter 4).

This chapter presented the research methodology used to undertake the research in this thesis. The research has been identified as taking the phenomenological approach due to the nature of the study and the real life context of the work. Various research strategies and purposes were discussed and the appropriate methodology was selected to best accommodate the constraints of the research and is exploratory in nature. The use of multiple research methods for data collection was used to triangulate the data in the case studies so that the bias, inherent in the case study strategy, could be significantly minimised. The Process Protocol will be used to test the PPE framework, due to the favourable adoption of the protocol by industry, the lack of available new project processes in the UK and the researcher's personal involvement in the research project. Castle Vale and Britannia Walk were identified as the most appropriate subjects; both adopted various aspects of the new project process. Thus, the multiple case study approach is used to examine the applicability of the PPE framework, and the single case study approach is used to test the effectiveness of the Process Protocol.

CHAPTER 6: THE PPE FRAMEWORK

6.1 Introduction

This chapter describes the development of the project process evaluation (PPE) framework, which aims to measure the effectiveness of implementing a new construction project process. It is based on the literature and empirical findings established thus far in this thesis. The literature review in chapter 2 highlighted the need for improvement in the construction industry and suggested that process modelling and learning from manufacturing (Latham, 1994; Egan, 1998). Chapter 3 reviewed the field of performance management and identified that there was sparse guidelines for the measurement of the delivery process. Chapter 4 supplemented these two reviews by means of a scoping survey questionnaire that assessed process, performance and IT related issues in both manufacturing and construction industries. The development of the PPE framework is described in this chapter; the justification for the steps and their content is made appropriate in the relevant section.

6.2 The need for the PPE framework

Today, companies across all sectors and industries develop new projects in a variety of ways ranging from chaotic to systematic, and the UK construction industry is no exception. The processes used are either tangible or intangible, functionally based or organisationally based (Nelson et al, 1999). Some companies, though perhaps mistakenly, believe and operate under the conviction that an idea or impetus will easily become a successful new product, and have been triumphant in doing so. While successful results are the obvious payoffs, many practitioners and academics alike advocate it is unwise to constantly rely on luck to salvage the success of the project. Unstructured development, a chaotic or random approach, usually leads to project failure (Cooper, 1994) whereby there is usually no formal structure in which to freeze and evaluate changes. This factor contributes towards the increasing number of organisations that are trying to develop and improve their processes in order to perform more effectively. Therefore, once the new project process has been selected, Hibberd and Djebarni (1991) suggest that comparisons should be made not just on the cost of the project, but also on how well the process achieves its proposed performance. Further, it is essential to justify the adoption of the new project process and/ or its need for change; changes may be small incremental adjustments to assist project team implementation or a complete overhaul of the new process, after all, project failure is not always a resultant of the process itself.

According to Cooper (1994), every firm needs a '…formal blueprint, roadmap, template or thought process for driving a new product from the idea stage to market launch and beyond.' In short, the process transforms the project brief, a precisely worded and carefully developed statement of the type of product the company wants and doesn't want, into a thinking and action framework to realise the idea into a product. The reasons offered by organisations for implementing a new project process are varied, but mainly the most effective driver for delivering a new management system have been performance improvement, an increase in bottom-line profit, effective risk management, assurance of product and/ or service quality to the customer and implementation for opportunity (Debenham, 2000).

In light of various government and institutional reports such as Latham (1994) and Egan (1998), there is currently a growing trend by UK construction companies to address the issues highlighted (including fragmentation, poor co-ordination and communication, informal and unstructured learning, lack of customer focus etc) and improve upon current practice through process improvement. This trend brought about the development of the Process Protocol, a common generic approach that spanned 'establish the need' through to the 'operation and maintenance' phase of the design and construction project process. The protocol was widely acclaimed through industrial interest and acceptance, and proved to be the impetus for a greater number of construction companies to re-engineer their design and construction project process; some companies adopted the protocol whilst others used it as a basis for developing their own process.[3] Therefore, the PPE framework is timely for the UK construction industry in its the quest for encroaching upon process improvement.

Project performance is not always directly attributable to process performance, and this is clearly evident in construction projects. There was reference earlier in this section of successful projects without the conviction of a fully planned process. A structured, clear and transparent process, all attributes of a successful process, may not lead always lead to a successful project. There are a whole host of internal and external factors to a project that can significantly hinder the enactment of the process. For example, the skills and capabilities of project team maybe outside the remits of conforming to the agreed steps of the process, or legislative laws and weather conditions that may prohibit the full implementation of the process. Ovenden (1994) supports this stance and asserts that human/ cultural factors must be considered when encompassing any change (such as a new project process; see section 2.3.3).

Therefore, it is unwise to assess the effectiveness of a new project process solely on the success of the implementation project. The PPE framework aims to develop a set of balanced metrics that will determine that the path of the project is attributable to the project process itself or to its implementation. This will assist in the decision making process of adopting the 'new' process on future projects, and in project steerage and direction. For example, explicit recognition of the stage a process has reached provides guidance for effective management; a particularly troublesome process can be modified if it manifests into a range of undesirable behaviour, particularly apparent for new project processes. Therefore, once a process has been selected, it is important to measure its delivery/ implementation in addition to its output since it is an integral part of the planning and control cycle of the project (Barnard, 1962).

[3] Examples of companies who have used the Process Protocol, either by adoption or inference, include: Taylor Woodrow, Property Techtonics, Alfred McAlpine, Marconi, Tilbury Douglas, BIW Technologies, British Nuclear Fuels Ltd (BNFL), British Telecom, Citex, Tarmac, CRISP, IAI, John Mowlem, Schal, P3 Knowledge Technology, CIRIA, Christiani & Nielsen, British Aerospace, Amec, WSP Group and Teamwork 2000.

Neely et al (2000) reports that the process of deciding which measures to adopt to measure the performance of the project process is valuable, not least because it forces management teams to be very explicit about their performance priorities and the relationships between these metrics, but also it provides the justification behind the adoption of a process or its need for change. Therefore, the PPE framework aims to address the lack of attention in the literature that has been paid to the design of metrics, as highlighted in chapter 3, and the profound lack of focus on process performance measurement in construction.

Performance measurement research in construction typically concentrates on project performance and has previously adopted a narrow focus, failing to respect the profoundly complex and interdependent nature of what is essentially a dynamic social system capable of infinite variation (Love & Skitmore, 1996; Nesan & Holt, 1999). According to Fowler (1990), high performance is best secured by analysing the work that needs to be done to achieve a predetermined result, and then by designing the most efficient sequence or method of work activities to suit. If a process dictates certain advantages, then assessments need to be made to evidence its value. Bond (1999) suggests that performance measures should be used in three identifiably distinct phases when governing processes: -

- Maintaining process status quo: to ensure a smooth flow of output according to the process/ schedule
- Process improvement: to continuously monitor and improve the process to produce the desired output
- Achieving process stability: less changes to the process enhances quality and productivity

The PPE framework aims to encompass the above factors. In summary, it aims to assess the effectiveness of implementing a new project process by considering the process itself and any implementation issues surmounting its execution on a project. After all, the success of construction projects largely hinge on the efficacy of the team enacting the work (Sidwell, 1990; see section 2.2.2 and 2.3.3). The PPE framework should be deployed once the new project process has been selected and as it is being continuously employed on the project.

6.3 The PPE framework steps

Each step of the PPE framework is presented here in a diagrammatic format, and is then preceded by the relevant supporting literature. The diagram follows the same lexicon underpinning the Process Protocol, whereby each process is broken down further and detailed in a second or third conjoining level, as illustrated in Figure 6.1. The lower level is composed of the sub processes of its related up-level process; the degree of level used follows that of the detail required describing the particular process (see Figure 2.3). Only the deliverables of the Level 1 process are displayed; and the arrows dictate a logical dependency between processes, those processes without arrows are subject to project specific customisation. This lexicon was selected due to the researcher's involvement in the Process Protocol; several medians of process representation was explored under the project and this was developed following lengthy consultation with practitioners and academics alike as a means that was easily understood and simple.

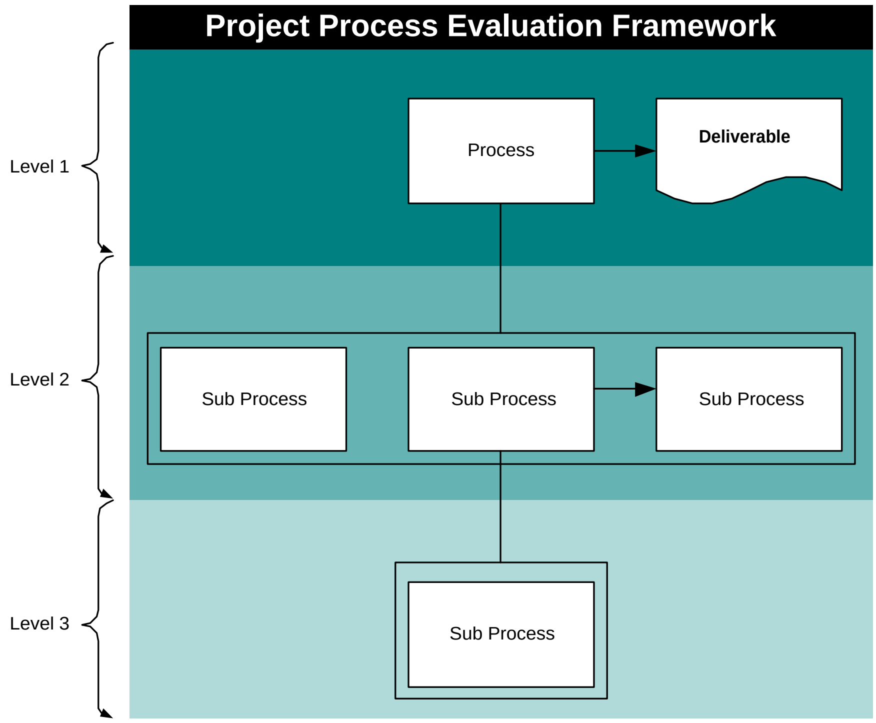


Figure 6.1: Lexicon of the PPE framework

6.3.1 Step 1: identify the need behind the selection of the new project process

The PPE framework should be enacted once a new project process has been selected and is being rolled out on the construction project. The first Step (Figure 6.2) involves identifying the reasons behind the selection criteria of the new project process, so that they can in turn be converted into process performance measures to provide the empirical evidence to substantiate its selection. For example, the Process Protocol strongly emphasises its six key principles of whole project view, progressive design fixity, a consistent process, stakeholder involvement/ teamwork, co-ordination and feedback. To the local government who has to build a new school, co-ordination is paramount whereas progressive design fixity may not be as there is a fixed budget and timescale for the project. Therefore, only the pre-contrived benefits of the process will form the process performance measures. The sub processes of this Step are as described below.

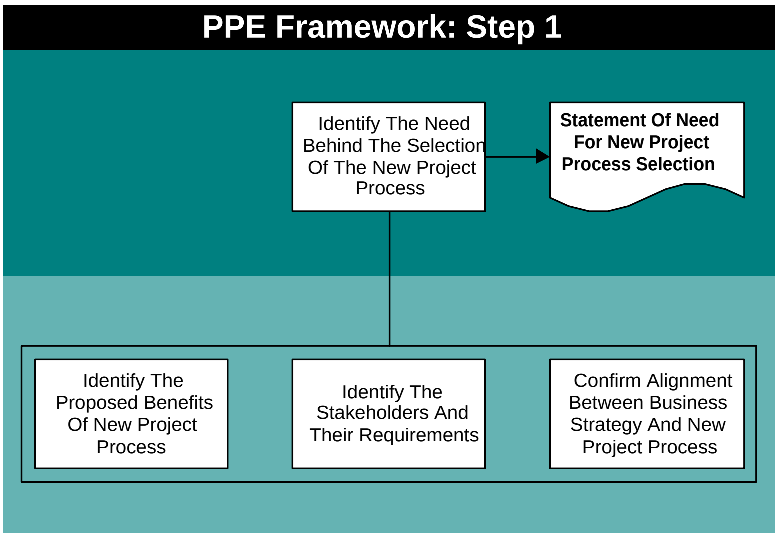


Figure 6.2: PPE framework, step 1

Identify the proposed benefits of the new project process:

According to Nelson et al (1999), there has recently been a whole host of new techniques and interventions introduced to the UK construction industry, each seemingly offering new benefits. For example, concurrent construction claims to reduce lead times, rework and cost amongst others (Coupland, 1992); whereas lean construction improves the process by reducing non-value adding activities (Koskela, 1992); and TQM enhances construction quality (Arditi & Gunaydin, 1998). Therefore, the proposed benefits of one process over another are paramount to the nature of its selection. It is these proclaimed benefits that will be used, in Step 2 of the PPE framework, to form critical factors for measuring the effectiveness of the new project process.

Identify the stakeholders and their requirements:

According to Kagioglou et al (1998), it is very important that the clients' needs, and equally the stakeholders' needs, of the project (and of the selected project process) are clearly identified and understood. The stakeholders to the project/ organisation are tenant to the process and to the strategy, and it is equally important to consider their needs when deciding upon the adoption of the new project process and consequently in developing the performance metrics. These needs not only expound upon the requirements of the building project so that they can be fully addressed, as suggested by Latham (1994) and Egan (1998), but also to understand the constraints of the project process itself. McNair (1991) supports this stance and identifies that it is important for organisations to monitor their own business processes so that any 'need,' from any of its stakeholders, can be identified in its early stages rather than its failure downturn. This 'need' maybe in the form of a capability issue, whereby the lack of capability of an assigned process to a group or an individual may in fact enthral the process. Therefore, it is important that the new project process caters for all of these issues so that it itself does not hinder the success of the project.

Hibberd and Djebarni (1996) support this stance and report that it is important to clearly identify the range and complexity of all the reasons behind the stakeholders' needs the interrelationships enlisted between them. More too, the demonstration of any deficiency should be communicated in a manner that is fully understood by all those that will be affected by the change, and in this way, the chances of getting process 'buy-in' and involvement are significantly increased by all the stakeholders to the project. Furthermore, this enables the ability to stand back from the 'need' and to view the situation from a holistic perspective was found to be important by many (Takeuchi & Quelch, 1983; Globerson, 1985; Dixon et al, 1990). This is fundamental when designing performance measures, and is similar in nature to that taken in change management initiatives, where the 'helicopter' view to a problem is used to reduce sub-optimisation (Clark, 1994).

Confirm alignment between business strategy and new project process:

If the world were stable there would be no need to change business operations. However, firms operate in dynamic environments and not stable ones, as both external competition and internal environments evolve over time (Hammer & Champy, 1995). Consequently, the firm's strategic objectives, by all accounts, have to change too. Therefore, in order for a firm to successfully compete against each other, relationships must exist between the firm's strategies and organisational actions/ project process (Dixon et al, 1990; Adam, 1992). This is particularly apparent if sustainable world-class performance is to be achieved (Adam, 1992). However, from the results of the scoping study in chapter 4, it is believed that this alignment in construction is not always present (see Figure 4.13).

6.3.2 Step 2: derive process performance measures for the project

Once the reasons behind the selection of the new project process have been determined, the project process performance measures are then derived. This is to be achieved by following a number of processes as illustrated in Figure 6.3. The processes in this Step should be enacted concurrently, the justification behind each process will be made apparent in the supporting literature.

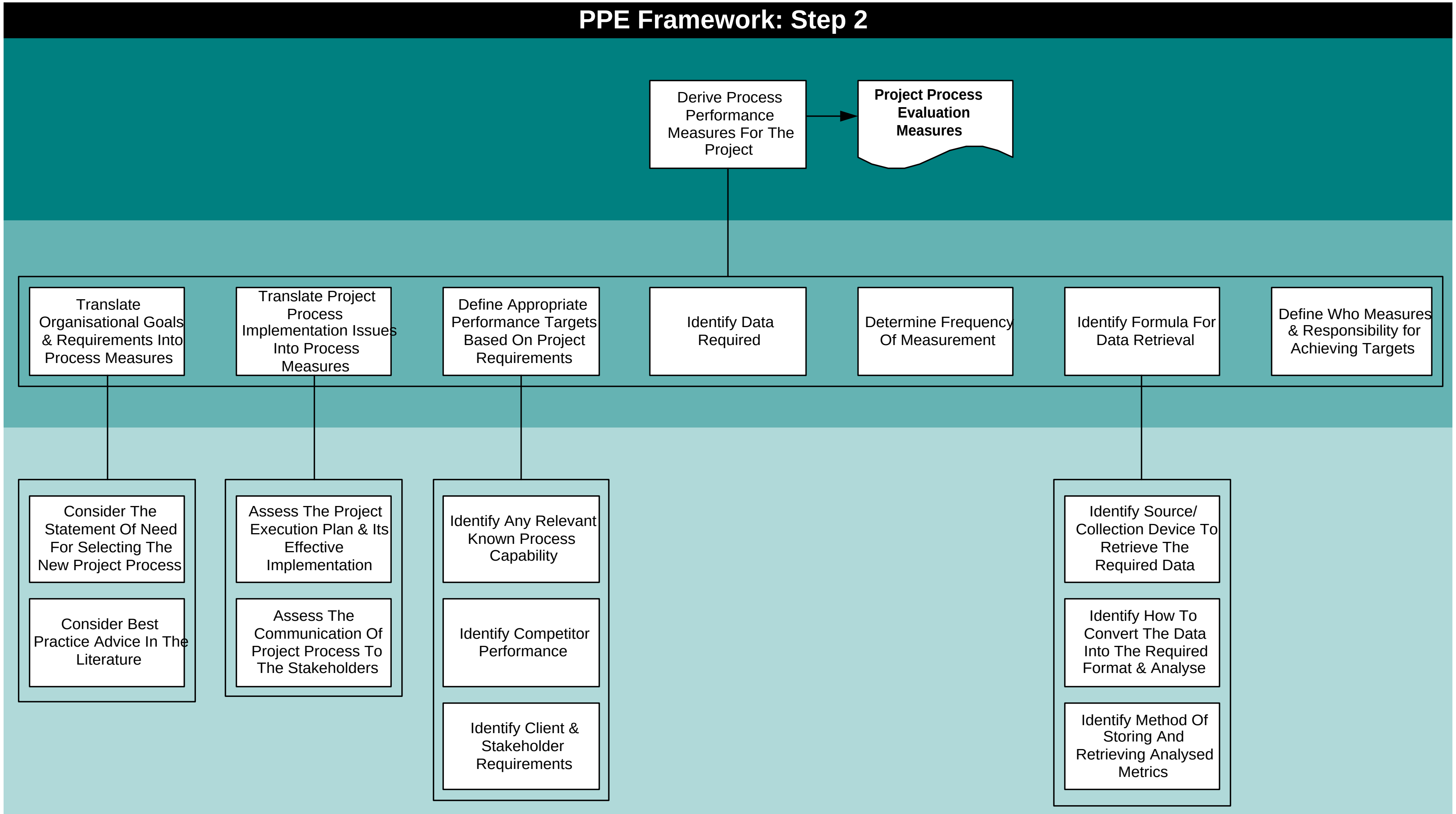

PPE Framework: Step 2
Derive Process Performance Measures For The Project
Project Process Evaluation Measures
Translate Organisational Goals & Requirements Into Process Measures
Translate Project Process Implementation Issues Into Process Measures
Define Appropriate Performance Targets Based On Project Requirements
Identify Data Required
Determine Frequency Of Measurement
Identify Formula For Data Retrieval
Define Who Measures & Responsibility for Achieving Targets
Consider The Statement Of Need For Selecting The New Project Process
Consider Best Practice Advice In The Literature
Assess The Project Execution Plan & Its Effective Implementation
Assess The Communication Of Project Process To The Stakeholders
Identify Any Relevant Known Process Capability
Identify Competitor Performance
Identify Client & Stakeholder Requirements
Identify Source/ Collection Device To Retrieve The Required Data
Identify How To Convert The Data Into The Required Format & Analyse
Identify Method Of Storing And Retrieving Analysed Metrics

Figure 6.3: PPE framework, step 2

This Step aims to address the lack of attention paid to the design of performance measures as highlighted in chapter 3. In doing so, it is important to reconcile measuring only the 'right' things as inappropriate measures are claimed not only to misrepresent, but also undermine efforts and resources (Green et al, 1991; Ghalayini & Noble, 1996; Upton, 1998). This is lucid when a large number of performance metrics is present in an organisation and everything is measured but little that matters (Letza, 1996). Brown (1994) who argues, '…measuring more things does not guarantee quality,' captures this stance.

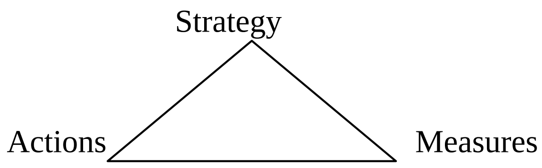
Translate organisational goals and requirements into process measures:

In order to derive appropriate performance measures to assess the effectiveness of a delivery process, a number of conjoining issues must be taken into consideration. Firstly, the selection criteria used to choose the new project process (that is aligned to the business strategy), and secondly, best practice issues need to be forethought before any metrics can be derived. The justification surmounting each of these procedures are explained briefly below.

The need for organisations to compete at world-class levels of performance has brought about the use of new product strategies, strategies that are of an increasingly wide variety (Johnson, 2001). Moreover, as strategy is the route a company takes to achieve its aims or vision, the daily actions of its processes and employees must line up with that strategy if it is to be effective, hence enforcing an integral link between the two. This was briefly addressed in Step 1 of the PPE framework. However, Dixon et al (1990), Maskell (1989) and Eccles (1991) recognised an additional third component in this equation. Strategy and action must be aligned to performance measurement and should not be considered in isolation (See Figure 6.4). Each component raises three fundamental questions facing any organisation: -

- What route are we taking to reach our destination? – strategy
- What do we do to get there? – actions or process

- What will guide us there? – measures



<u>Figure 6.4: The strategy, actions and measures connection (Dixon et al, 1990)</u>

Therefore, in considering these three questions, the organisational goals of the project can be used succinctly towards deriving process performance measures. The alignment of performance metrics with the business strategy has been well publicised in the literature (Globerson, 1985; Dixon et al, 1990; Kaplan & Norton, 1992), but Chapter 3 confirms it is still not commonplace; '…in many organisations …performance measures are rarely integrated with one another nor aligned to the business process' (Neely, 1999). Strategy in its wider context is a mixture of knowledge and assumptions about the organisation, its goals, objectives, action, milestones, budgets and plans (Kuwaiti & Kay, 2000), and strategic alignment is the extent to which performance measures are supporting or hindering aspects to the health of the organisation or project (Johnson, 2001). Performance measures need to be positioned in a strategic context, as they influence what people do (Lockamy & Cox, 1994). According to Peters and Waterman (1982), '…what gets measured gets done.' The pattern of decisions and action within an organisation defines the strategy in practice, and should not be considered purely as a means to provide information for management control and decision-making, but it can also serve as a powerful motivational tool (Tsang et al, 1999).

Furthermore, best practice advice should also be followed when translating the organisational goals and requirements of the project into process measures. Table 3.2 illustrates a whole host of key issues that cannot be ignored by the construction industry, for instance, measures should encourage behaviour, be continuously revised, demanding, flexible, clear and simple (Maskell, 1991; Lynch & Cross, 1991; Dixon et al, 1990; Turney & Anderson, 1989).

Translate project process implementation issues into process measures:

A structured, clear and transparent process may not always lead to a successful project. There are a whole host of internal and external factors to the project that can significantly hinder the enactment of the process. For example, the skills and capabilities of the project team maybe outside the remits of the agreed work activities, or legislative laws and weather conditions that may prohibit the full implementation of the process. Therefore, it is unwise to assess the effectiveness of a new project process without considering the degree and success of implementation of the project execution plan. Furthermore, the successful implementation of any process will also depend upon the acute awareness of the role and responsibility of each stakeholder to the project, thus iteratively affecting again the implementation of the project execution plan. The measures concerning the effective implementation of the project should also consider best practice advice, as detailed in the above paraphrase and in Table 3.2.

Define appropriate performance targets based on project requirements:

When devising project process performance measures, targets should also be identified (Compton, 1992; Hackman & Wageman, 1995). These targets, at first, may be vague in some instances when the project process is new, but Hackman and Wageman (1995) suggest that they should be based upon known process capability, competitor performance and client/ stakeholder requirements to determine a more appropriate goal. Further, it may be apparent to determine the trade-offs between these factors in order to derive the targets. The targets aim to confirm both that the process is performing and improving the nature of the business (Sink & Tuttle, 1989). According to Ghalayini and Noble (1996), these specific goals must also be set against a predetermined time horizon to enhance the proposition of success. In addition, they need to be carefully selected, if they are set too low the company will under achieve relative to its ability, and if they are too high the company will under perform relative to expectations leading to low morale in some instances.

Identify data required:

Identifying the data required should be enacted concurrently to defining the process performance metrics and their corresponding targets (Sink & Tuttle, 1989). This is because the data required for the proposed metric may not be an appropriate to the project (e.g. how many bricks are built per week when the project is of concrete construction). In addition, the availability and ease of data retrieval will also impact upon the frequency of collection (Johnson, 2001).

Determine frequency of measurement:

Johnson (2001) suggests that the frequency of measurement should be built into the measurement system at the onset. Further, it should be conducted concurrently to the design of the process performance metrics and particularly during the investigation of the availability of the data. The data required may fall only during certain times of the project (for example, the metric ‘planning application against time’ can only be measured during the enactment phases). Further, it is important consider that ‘…measuring more things does not guarantee quality’ and too much measurement can cause dysfunctional behaviour (Brown, 1994).

Identify formula for data retrieval:

Identifying the formula for data retrieval expounds after and during the identification of the data required, and may affect the identification of the project process measures. In Sink and Tuttle's (1989) book, 'Planning and Measurement in Your Organisation of the Future' that recollects the authors' extensive experience on designing performance measurement systems, it suggests that this activity also involves numerous issues, including: -

- Identifying the source/ collection device to retrieve the required data: this means locating where and how the data will be obtained; a tool can be used instead of manual counting for instance

- Identifying how to convert the data into the required format and analyse: by selecting the most appropriate method, technique and/ or tool for processing and analysing the measures at the onset will assist with evaluating the project process
- Identifying the method of storing and retrieving the analysed metrics: this will ensure that the results are easily available to the whole project team and can be used to inform future projects

Define who measures and who is responsible for achieving the targets:

All performance metrics, as with processes (activities and tasks), need to be assigned to particular members of the project team, encroaching ownership and adoption (McNair, 1991). The specific measuring roles must be laid out at the onset. The person who collects the data may not necessarily be the one who analyses it and works out how to improve upon the results; for example, the bricklayer (measurer) may report to the contractor his progress, and it will be the Construction Manager who analyses and develops a plan for improvement. However, that is not to say that it is always the one who conducts the work will collect the data, as there may be some bias towards the enactment of the task at hand. Therefore, the actors in the measuring process must be defined during the design of the measures. However, this again may hinder upon the frequency of measurement, due to the availability of the actor, and the understanding of the results, as the analyser may not understand all of the constraints of the metric.

6.3.3 Step 3: conduct project process measurement

Once the performance measures that evaluate the new project process have been confirmed they are then rolled-out onto the project (see Figure 6.5). According to Peppard and Rowland (1995), however successful the project has been to date, this is the stage that the project will transform. It is here where the empirical evidence to support the introduction of the new project process will either be substantiated or evoked, and where that the extent of resistance to the new process will be realised. This is an important factor when assessing the effectiveness of the delivery process (Peppard & Rowland, 1995). For example, the undertaking of a single construction project at the prototype stage will not ensure that regardless of the project participants, the process will have the same results; if different contractors and sub-contractors are employed the collaboration might be different and therefore it will present a clear illusion of the success or otherwise of the new process. If such problems arise, it is important that they are identified and resolved. The problems may necessitate a small incremental change or a significant overhaul of the process, thus supporting the need to assess process effectiveness and hence the need of this framework.

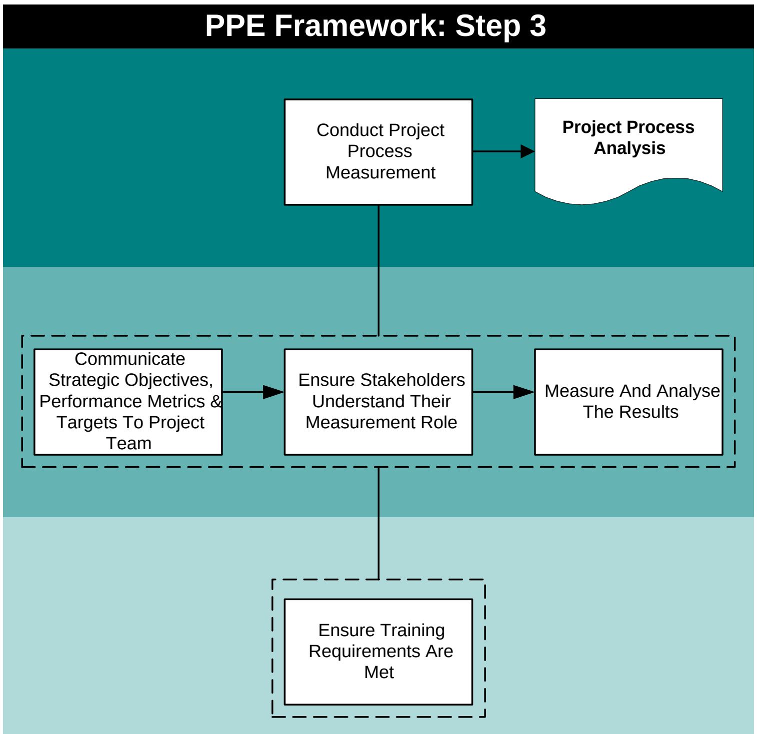


Figure 6.5: PPE framework, step 3

Communicate strategic objectives, performance metrics and targets to project team:

This process builds upon many of the issues raised in 'identify the stakeholders and their requirements' of Step 1 in this PPE framework, with which it was implied that it is important that that everyone involved in the project is aware of the project and performance requirements so that they can be achieved. In this way, the chances of getting ‘buy-in’ and participation from the whole project team are significantly increased, resulting in a more successful project (Ghalayini & Noble, 1996).

Ensure stakeholders understand their measurement role:

Following 'communicate strategic objectives, performance measures and targets to project team,' this process ensures that the actors involved in the measuring process understand their particular role, as previously defined in Step 2 of this framework. Furthermore, if required, the actors can be trained so that he or she can perform their duty to the best of their ability as to not heavily undermine effort and resources (Green et al, 1991; Ghalayini & Noble, 1996) by measuring the wrong things.

Measure and analyse the results:

Step 2 of the PPE framework also defined the formula for data retrieval, which amongst others, would have clearly laid out how to convert the data into the required format by selecting the most appropriate method, tool and technique for processing. Therefore, once the data has been collected it can be analysed. However, it is equally important at this stage to consider all of the constraints of the results so that a clearer evaluation can be reached. These constraints may be either be tangible, and this may possibly lead to the development of further metrics as part of the next Step of this framework, or intangible, whereby any limitations to the exercise may be worth alerting the reader to.

6.3.4 Step 4: continuously revise project process measures

The PPE framework should be entered into a continuous improvement programme to ensure that mechanisms are in place to make modifications to the process, as and when required (Oakland, 1995). Santos (1999) believes that this will assist the project team to monitor process and project improvement, and to assess the performance targets. This will help to indicate whether or not the project process is being enacted effectively, as process success is not directly related to project success, and to ensure that the process is improving the project as proposed. If measures are to evolve naturally, they may lead to diverge away from the strategy (Bourne et al, 2000). If strategy and measures are to remain in alignment, processes are required to regularly review the measures against the strategy. This thus relates to back to Dixon et al's strategy, actions and measures connection model (Dixon et al, 1990) in Figure 6.4.

Figure 6.6 illustrates the procedures to review the performance measures. This Step also mirrors much of the principles of the Plan-Do-Check-Act cycle (PDCA cycle; see Figure 6.7). Continuous improvement is a constant repeat of the PDCA cycle, or rather Step 4 of the PPE framework. This is whereby each phase of the cycle has an important role to sustain the ongoing improvement (Vonderembse & White, 1996): -

- Plan: identify problems or opportunities for improvement and develop a plan to make changes
- Do: implement the plan, documenting any changes made
- Check: analyse the revised processes to see if the goals have been achieved
- Act: standardise, document and divagate the results. In case of not achieving the goals, determine why not and proceed accordingly

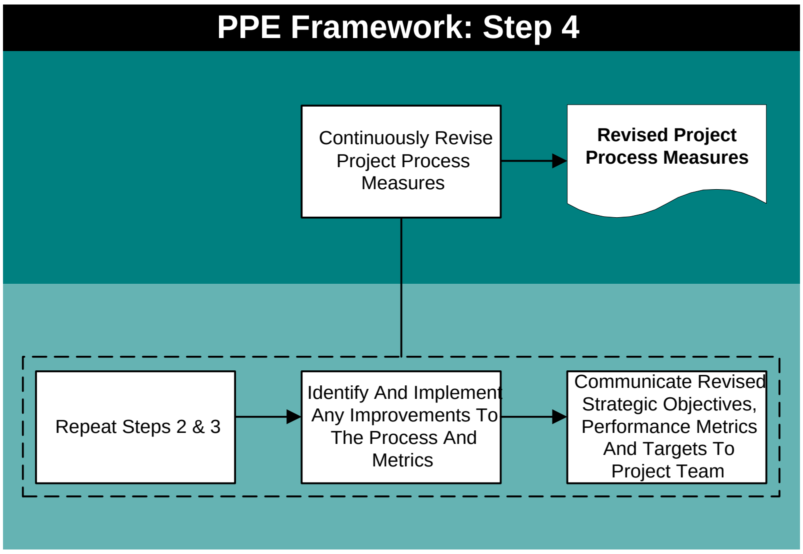


Figure 6.6: PPE framework, step 4

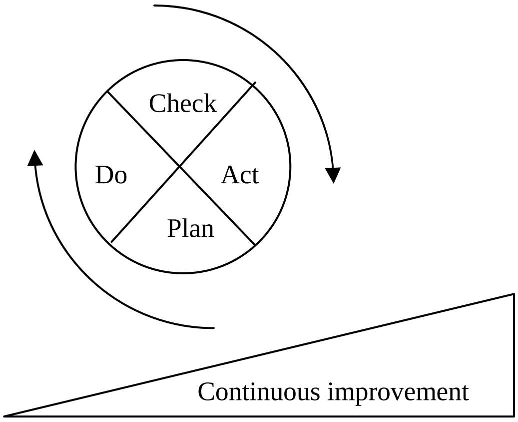


Figure 6.7: The PDCA cycle (Oakland, 1995)

Repeat Steps 2 & 3:

Steps 2 and 3 should be repeated periodically to endorse that a correct path of action is taken on the project (Neely et al, 1997). Performance measures are an integral part of the planning and control cycle of any organisation's core process (Barnard, 1962) and pursing advances in the wrong way can dissipate considerable resources (Schmenner & Vollmann, 1994). Therefore, repeating these Steps should facilitate the improvement of the project's performance, by reviewing and assessing the organisational goal measures, and the project process implementation metrics should help with project steerage (Neely et al, 1997). This is still not apparent in many industries let alone construction (Kaplan, 1984; Neely et al, 1995; Ashton, 1997). Performance measures should become tightly linked through the elimination of non-value adding activities so that timely and relevant feedback is achieved (Green et al, 1991). In addition, Cobb (1993) suggests that these regular feedback loops are short in order for organisations to be more responsive so that they can continuously improve, and Hackman and Wageman (1995) state that it is crucial at this stage to review the performance targets and to redevelop a plan towards achieving them. It may be apparent to either stretch or reduce them so that they are of relative to the ability of the project team, as described in Step 2.

Identify and implement any improvements to the process and metrics:

Once Steps 2 and 3 of this framework have been repeated, any problems surmounting should have surfaced. The problems may have hindered upon the enactment of the process, by means of internal (capabilities of the project team etc) or external factors (weather, legislative laws etc), or the performance metrics themselves may not have necessarily reflected the project goals. The problems should be rectified at this stage, and the improvements suggested should be subsequently introduced to the project. However, the construction process is complex with many dependant relationships (Compton, 1992) and so those metrics that have been rectified and changed may impact adversely elsewhere in the process, thus supporting a continuous revision of the project process measures.

Communicate revised strategic objective, performance metrics and targets to project team:

The revised measures should again be communicated to the project team so that everyone involved in the project is aware of the project and performance requirements so that they can be more easily achieved. This, it is anticipated, is to increase 'buy-in' and participation from the whole project team to forge project success.

6.3.5 Step 5: use findings to inform and improve future projects

The full benefits of undertaking any process improvement programme, as in Step 4 of the PPE framework, will not appear in a single instance of time. Only through time can project teams recognise how best to tailor a process to a project in order to substantiate all of its key benefits. Figure 6.8 displays a number of processes on how to achieve such.

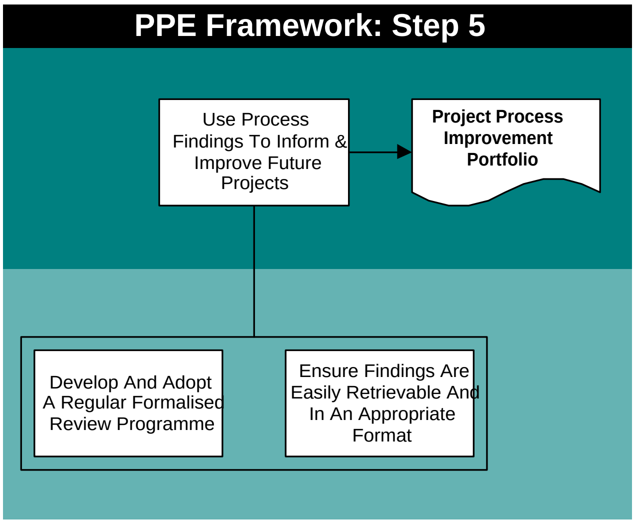


Figure 6.8: PPE framework, step 5

Develop and adopt a regular formalised review programme:

According to Bauly (1994), rarely are previous projects comparable to the present one, and so expert knowledge and lessons learned are not systematically incorporated back to improve the project process. Construction problem solving is largely reliant on experiential (empirical) knowledge, and that this knowledge is not codified in books and is weakly organised in memory (Li & Love, 1998). Furthermore, the 'problem solvers' perceive the problems from different perspectives and the body of experiential knowledge may appear to be diverse or even disparate. Therefore, the benefits from process improvement will emerge only if this wealth of construction knowledge can be effectively harnessed and used to inform in the planning and executing of future projects (Kartam, 1996; Kumaraswamy & Chan, 1998). Kartam (1996) suggests that construction companies must adopt some type of formalised lessons-leaned review in response to this problem, before the project team has dispersed.

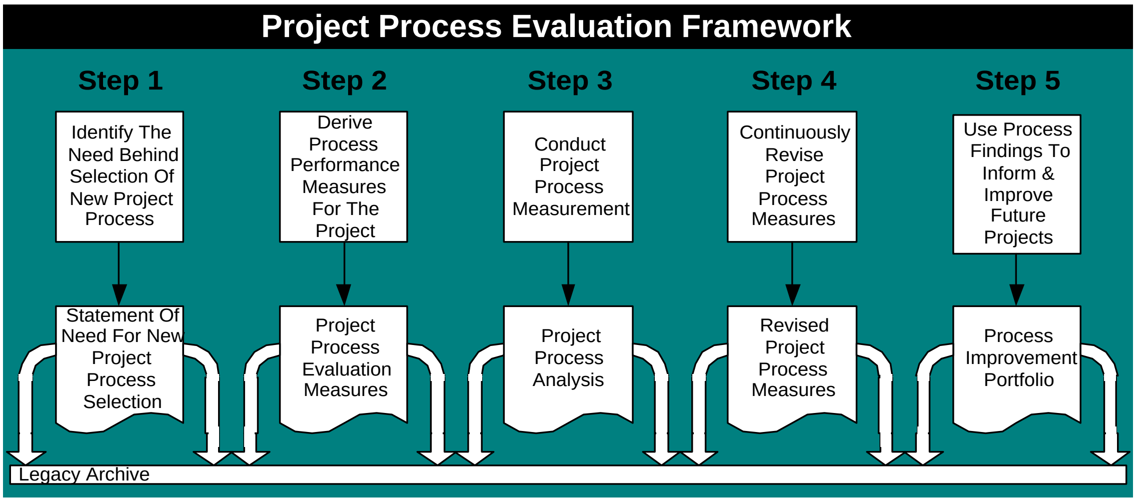
Ensure findings are easily retrievable and in an appropriate format:

The design and construction of a building is a complicated process (Howell, 1999), and the volume of project information is vast and growing (Rezgui & Cooper, 1998). The advent of information technology (IT) has provided construction organisations with low-cost tools that can optimise the work in hand, for example computer-aided-design (CAD) packages. Technology, however, is fast advancing and therefore it is important that the information is stored in a format that presides the difficulties of software and hardware upgrades so that the lessons learned can be easily used to inform future projects (Lee et al, 2001). The format may be in form of XML for instance, a standard IT language that outweighs the difficulties of compatibility. Consequently, competitive advantage for organisations will come from how the lessons learnt are acted upon (Hinks et al, 1997; Aouad et al, 1999).

For ease of retrieval of project documents, recent studies in the manufacturing industry show that firms that champion the use of IT such as electronic data interchange (EDI) and integrated databases reduce administrative costs, production time and improves profitability (Davidson, 1990; Bell, 1994; Baldwin et al, 1996). The UK construction industry is subsequently following suit with the introduction of information management systems that uses the Internet to give all members of the project team access to a common, centralised database of construction information (Lee et al, 2001). The attributes are as described in the legacy archive of the Process Protocol, a central repository or information spine (Hinks et al, 1997) and preside the format factors. Further, it is anticipated that the deliverables of the PPE framework would be fed into such a system, as described in section 6.4.

6.4 The PPE framework model

The PPE framework is illustrated in Figure 6.9, a scaled-down model of the Steps as previously discussed in section 6.3. Each process in the framework has various sub-processes and activities that cascade down into further detail, however these are not shown in the over arching model. Each level of activity supports the level above and ultimately the organisation’s goals, thus identifying the levels facilitates effective management of the overall process. Further, the level of detail each Step depicted helped to harness clarity, as some processes required added definition and so were modelled using three process levels. The researcher felt that this method of modelling the framework best suited the task in hand. Further, it added more detail and clarification of how to design process performance measures, addressing the lack of description in the literature as highlighted in



Chapter 3. Many of the frameworks, such as the balanced scorecard, provide an overview of what the measures should reflect, but they are still not explicit enough on the actual design of performance metrics (Neely et al, 2000).

Figure 6.9: The PPE framework

The PPE framework also consists of a legacy archive (similar to that of the Process Protocol), whereby the deliverables of each of the Steps are stored in a central repository and can be accessed by the project team at anytime. This, it is proposed, will enhance stakeholder involvement in the project, co-ordination, communication and feedback. Further, it is worth noting here that the Steps within this methodology do not include within it any specific time lines but will commence and end as the new project process is interplayed.

The framework should be implemented as soon as a new project process is deployed. It can be used by anyone in the project team, but is primarily targeted as a tool for the Process Manager. The Process Manager should be independent of the project (often called key master, process facilitator, gate meister or process keeper in manufacturing), whose role involves (adapted from Kagiouglou et al, 1996a): -

- Making sure that the project process works efficiently and effectively
- Facilitates every phase review meetings by ensuring the project team follow the process and its schedule (acting as a referee); his or her independent-to-the-project role ensures that no bias will prevail
- Updates the process for continuous process improvement: harnesses the lessons learned so that can be used to inform future projects

It is anticipated that the PPE framework will assist the Process Manager in these tasks. The PPE framework does not include any time lines, as the process of change is never-ending.

6.5 Conclusion

This thesis aims to evaluate the performance of new design and construction project processes (see chapter 1). Chapter 2 identified the growing need for improvement in the UK construction industry; Latham (1994) and Egan (1998) suggested that process modelling and learning from manufacturing could necessitate as the way forward. These suggestions brought about the emergence of new process initiatives, such as the BAA project process and the Process Protocol. Moreover, chapter 3 highlighted that there was little work in the area of measuring the effectiveness of new project processes. These factors were supported by the results of a scoping survey questionnaire (chapter 4). This chapter harmonised all the findings thus far in this thesis to develop a framework that assesses the effectiveness of a new construction delivery process. The framework methodology consists of 5 Steps, as outlined below: -

- Step 1: Identify the need behind the selection of new project process
    - Identify the proposed benefits of new project process
    - Identify the stakeholders and their requirements
    - Confirm alignment between business strategy and new project process

- Step 2: Derive process performance measures for the project
  - Translate organisational goals and requirements into process measures
    - Consider the statement of need for selecting the new project process
    - Consider best practice advice in the literature
  - Translate project process implementation issues into process measures
    - Assess the project execution plan and its effective implementation
    - Assess the communication of project process to the stakeholders
  - Define appropriate performance targets based on project requirements
    - Identify any relevant known process capability
    - Identify competitor performance
    - Identify client and stakeholder requirements
  - Identify data required
  - Determine frequency of measurement
    - Identify formula for data retrieval
    - Identify source/ collection device to retrieve the required data
    - Identify how to convert the data into the required format and analyse
    - Identify method of storing and retrieving analysed metrics
  - Define who measures and responsibility for achieving targets
- Step 3: Conduct project process measurement
  - Communicate strategic objectives, performance metrics and targets to project team
  - Ensure stakeholders understand their measurement role
    - Ensure training requirements are met
  - Measure and analyse the results
- Step 4: Continuously revise project process measures

- Repeat steps 2 & 3
- Identify and implement any improvements to the process and metrics
- Communicate revised strategic objectives, performance metrics and targets to project team

- Step 5: Use process findings to inform and improve future projects
  - Develop and adopt a regular formalised review programme
  - Ensure findings are easily retrievable and in an appropriate format

It was identified in section 5.2.5.1.1 that there is a lack of case study projects suitable for testing of the PPE framework; the project must have adopted a new project process and its timescale must fall within the timescale of this research investigation. The Process Protocol was finally selected for testing. Two case studies (chapter 7 Castle Vale & chapter 8 Britannia Walk) were identified, which each adopted differing aspects of the protocol.

CHAPTER 7: CASTLE VALE CASE STUDY

7.1 Introduction and research objectives

The literature reviews (chapter 2 & 3) and scoping survey questionnaire (chapter 4) substantiated the research need of this investigation; the lack of guidance of how to measure the performance of new construction project processes. Therefore, this thesis developed a PPE framework (chapter 6) using the findings in the literature reviews and scoping study. It is the aim of this chapter to test the PPE framework on the Castle Vale project, which implemented a new construction project communication process, the 'legacy archive' aspect of the Process Protocol. In doing so, the value of the Process Protocol can also be refuted or confirmed.

The construction project sought to construct a new Sainsburys supermarket (see Figure 7.1) and a petrol station, in addition to other apparent properties on the site in Birmingham. The new communications process, the Project Information Channel (PIC), is an Internet-based information management system developed by IT consultants Building Information Warehouse Technologies (BIW). The system mimics much of the legacy archive stream of the Process Protocol (BIW, 2001; see Figure 2.9), to which the BIW were partners in the research project.

Figure 7.1: Castle Vale project development

The validation of the PPE framework in this case study investigation centres on the results from various workshops and interviews with various key project team members, analysing the data generated by the PIC and administrating a survey questionnaire. In doing so, this study endeavoured: -

- To examine and map the process of design and construction on the project
- To identify how the PIC works operationally and to determine if it encompasses significant advantages over the traditional flow of design and construction information

7.2 Research methodology

The researcher was enlisted by the BIW and the client, Sainsburys, for assistance in measuring the performance of the PIC. Given the nature of the research being undertaken, as described in section 7.1, and the subsequent need for informality in this case study process, the Project and IT Managers of the project were subsequently employed to help determine the overall objectives of the case study and to gain tentative commitment from senior management. They were firstly briefed of the initial aims of the study, which were then discussed, to collectively agree on terms that were of benefit to both the researcher and to the project. This method of deployment evoked management 'buy-in' and enthusiasm, which led to much assistance when arranging appropriate workshops and meetings during the course of the enquiry. The research methodology of this case study followed the steps of the PPE framework, as illustrated in Figure 7.2 and described in the following section.

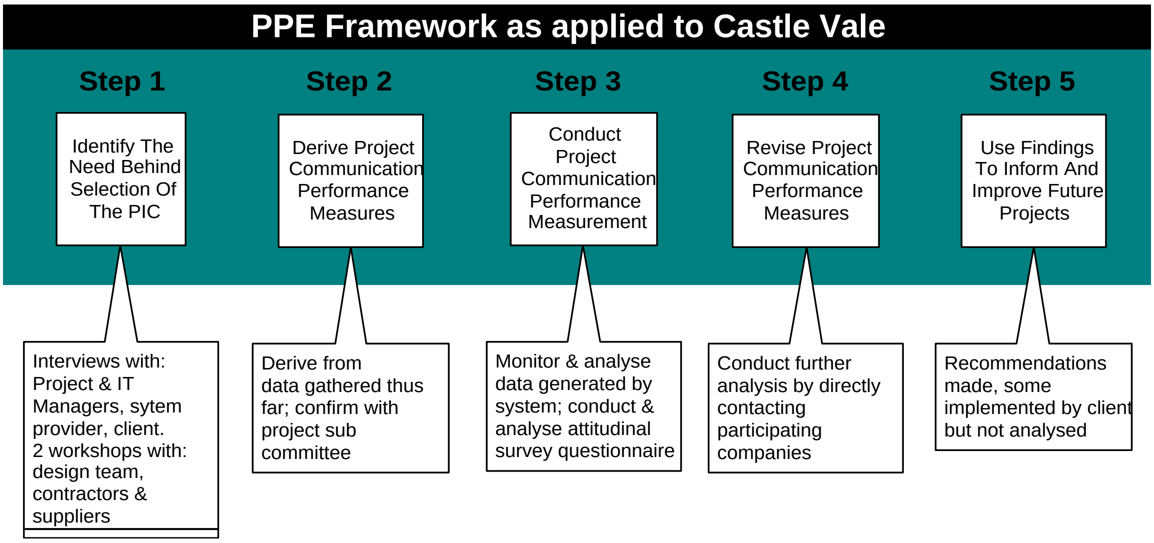


Figure 7.2: PPE framework as applied to Castle Vale

7.2.1 Step 1: Identify the need behind the selection of the PIC

The first step of the PPE framework proposes to identify the need behind the selection of the PIC. The PIC had already been introduced to the project at the time the researcher commenced investigation. Further, it became clear from the initial meeting with the Project and IT Managers that much consideration and examination had been placed over the selection of the PIC against other similar information management systems on the market. Therefore, the benefits claimed by the new communication process, and the benefits personified by the stakeholders of the project were identified, as suggested in the first step of the framework.

The benefits of the Process Protocol/ the PIC were apparent to the researcher due to her personal involvement in the research project, and numerous workshops and interviews were undertaken to identify the benefits from the stakeholders' perspective. These methods of data collection also assisted in modelling the design and construction project process. This was to assist in the understanding and placement of the new communication system in the overall project process.

The first workshop involved members of the design team, followed later with contractors and suppliers, to gain different perspectives on the project process and the selection of the PIC (see Table 7.1). The semi-structured workshops followed the following format as to determine the problems, benefits, visions and measures to the following criteria: -

- The participants of the workshop were asked to give a brief account of their role in the case study project
- An informal discussion with regards to the project process of design and construction from each participant's perspective followed
- The benefits, potential benefits and problems with the PIC were also discussed before potential measures were suggested

Workshop 1: design team	Workshop 2: contractors and suppliers
IT manager	IT manager
Landscape architect	Project manager
Principal architect	Main contractor
Client's internal fit-out designer	2 subcontractors
Client's internal architect	M&E engineer
Structural engineer	

Table 7.1: Workshop participant details

Each workshop lasted around two hours and was taped, with each of the participant's consent. This, in addition to the notes that were taken by the researcher during the interview, was used to map the project process and to determine the deliverables of Step 1 of the PPE framework. Informal interviews were then arranged with the BIW and later with the client, Sainsburys, in order to gain a clearer picture of the project. The primary purpose of the visit to the developers of the PIC was to receive a full demonstration of the system, as there were some discrepancies in its description from the workshop attendees; the intention behind the discussion with the client was to fully identify the reasons behind the selection of the new communication system. In both of these instances, the researcher took only notes during the study sessions and was later granted access rights to view the project document information on the PIC.

The design and construction project process model and the proposed benefits of the PIC that emerged from the workshops and interviews, were subsequently reviewed and agreed with the Project Manager, IT Manager, client and the BIW through a series of interviews. The four parties subsequently formed a subcommittee to assess the progress of the case study. The client, at this stage, also stated that the findings of this case study would be used to determine whether or not the PIC should be implemented on all future construction projects.

7.2.2 Step 2: Derive project communication performance measures

The project communication performance measures of the Castle Vale project were derived by the researcher from the information gathered at the workshops and interviews, by considering the following: -

- The need of the client and stakeholders for selecting the PIC/ the project's goals and requirements, as identified previously in Step 1
- Implementation issues of operating the PIC
- Best practice advice in the literature

In doing so, the researcher concurrently identified: -

- The data required for each measure
- The formula for data retrieval
- The source or collection device to retrieve the required data
- How to convert the data into the required format for analysing

A subcommittee formed following increased client interest. The committee comprised of the Project and IT Managers, the client and BIW, to continuously review the progress of the case study; at this stage, the proposed performance measures of the 'new' communication process. Amendments were made, which were again agreed by the committee before they were rolled out to the project.

7.2.3 Step 3: Conduct project communication performance measurement

Once the subcommittee agreed the project communication performance measures, the researcher conducted measurement of the PIC. Measurement was conducted towards the end of the construction project. Step 2 of the PPE framework identified the need to access of the data reports of the PIC system and to develop an attitudinal survey questionnaire, which was published on the project website. Figure 7.3 displays a screenshot of the on-line survey questionnaire. It was used to assess the soft issues surmounting the use of the PIC. The questions were derived by the researcher and agreed by the subcommittee. A full copy of the survey questions can be found in section B.1 of appendix B. In total, there were 71 (70.29%) responses out of the 101 project team members within the 38 project team companies.

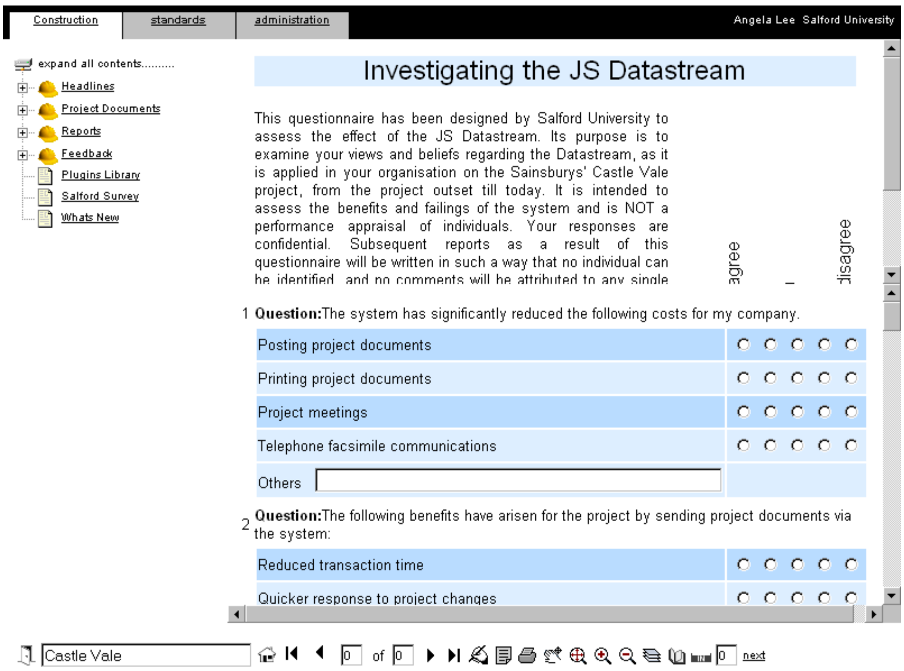


Figure 7.3: Screenshot of the on-line survey questionnaire

7.2.4 Step 4: Revise project communication performance measures

During the measurement stage, Step 3, it became apparent that additional costing information was required from each participating company. Through the results of the survey questionnaire and the workshops, it was expressed by several project team members that they felt that postage and printing costs had been shifted from the design team to the rest of the supply chain. Further data was required to either confirm or refute this claim. Therefore, a representative from each stakeholder company was contacted directly to obtain the relevant data. A copy of the letter can be found in section B.2 of appendix B.

7.2.5 Step 5: Use findings to inform and improve future projects

As stated in section 7.2.3, measurement was conducted at the end of the project and therefore the researcher could only identify improvements to the communication process, in anticipation that they would be used to inform future projects. However, as the client used the results of this study to determine whether or not they should introduce the PIC on all of their construction projects, they subsequently followed the recommendations of this study. Unfortunately, due to the time and cost constraints of the researcher, the effect of the recommendations could not be measured.

7.3 The project context

Sainsburys Developments commenced the £35 million regeneration scheme at Castle Vale, Birmingham, on-site on the 18th July 1999. The regeneration involved demolishing the existing Castle Vale shopping centre that was built in the 1960s and less than 30% occupied nineteen-storey block of flats. The scheme aimed to provide a 50,000 sq. ft. sales area for Sainsburys supermarket, and five retail units, totalling 85,000 sq. ft of retail space. This investigation concentrates only on the development of the £23 million supermarket and conjoining petrol station. It took 12 months on-site to complete (till the 5th July 2000) and an extra 3 and a half months for the fit-out of the supermarket. The PIC was rolled-out on the 1st August 1999 to which the researcher commenced investigation of the 8th October 1999. In actual fact, on-site work was completed earlier than scheduled and it was anticipated that this case study would help to determine if the new project communication system was a drivers behind the project's success.

7.3.1 The Project Process

The series of interviews and workshops conducted during Step 1 of the PPE framework provided the data for the researcher to map the project process. The process map provided a clearer insight into the design and construction process, as applied to the Castle Vale project, and to see where and to what extent the PIC was implemented (see Figure 7.4). The high-level design and construction process that was practised on the Castle Vale project is modelled using the framework of the Generic Design and Construction Process Protocol, with which the researcher was actively involved in. This method was felt to be most appropriate as both models follow the same outline structure. There were regular formalised reviews at Castle Vale, thus the stage-gates. Furthermore, the Process Protocol promotes the use of a legacy archive, namely the PIC on this project. It is clear from Figure 7.4 that the PIC was only introduced during Phase 6 of the project process, and it is still unclear at present, the extent the system will be used during Phase 9. The following section describes Phases 0-8 of the project process in greater detail, till the point where this case study research investigation ended.

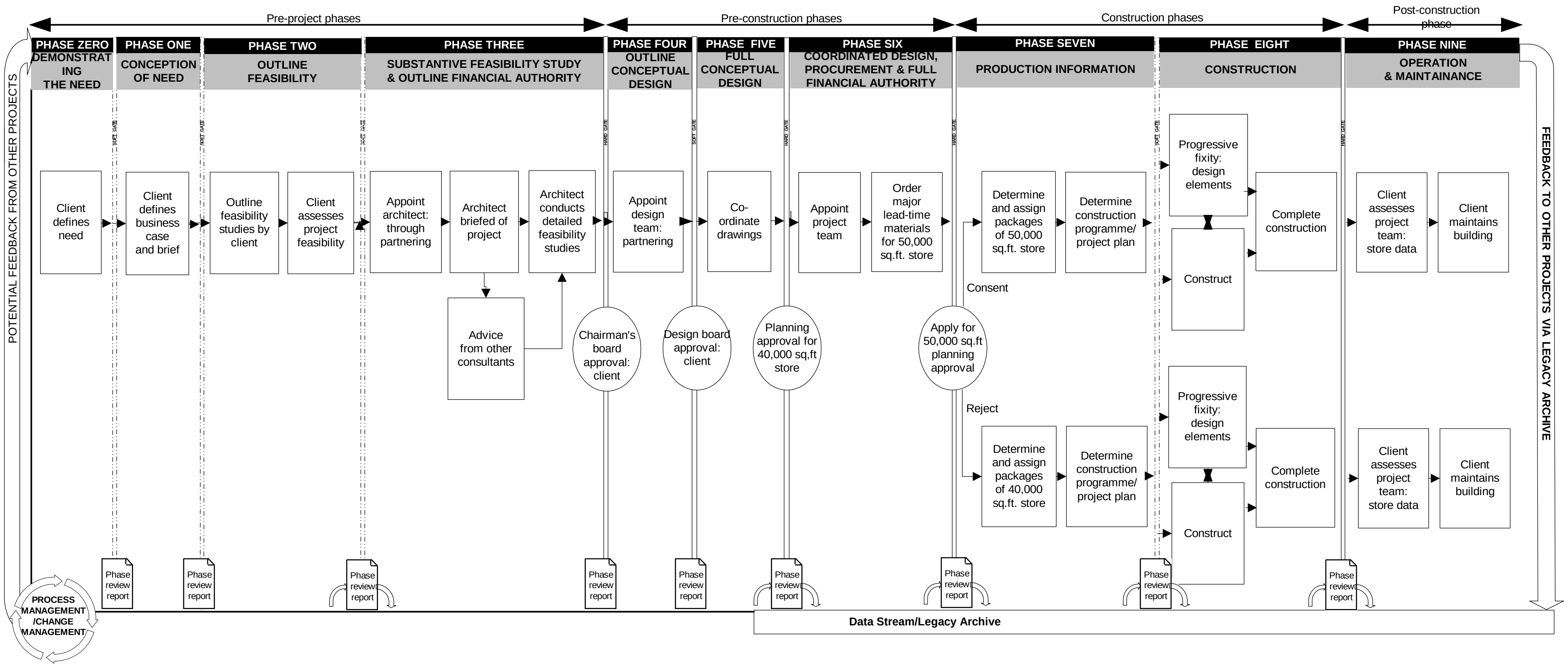


Figure 7.4: The Castle Vale project process model

7.3.1.1 Feasibility studies

The client selected the site of the project through in-house competitive analysis tests. The tests are part on an ongoing procedure for the company to determine new potential supermarket sightings. They include analyses of the business plan, catchment area, highways and infrastructure, competitors, etc, to select potential new stores. Sainsburys' Property and Estates Department manage the outline feasibility studies, however, another architectural company was employed to conduct the initial outline plans before the current architect, Chetwood Architects, was brought on board to further develop and test the site before applying for planning consent.

The needs of the client were principally determined through the results of the competitive analysis tests and to which Chetwood Architects was briefed of; the supermarket equated to approximately 40,000 square foot at this stage. Chetwood were appointed to firstly conduct feasibility studies, including a 'reasonably detailed' site plan outlining the basic floor plans, entrances, car park layout and proposed perspectives of the building. They were directly responsible for this process, though envisaged the help of other consultants as and when required, such as M&E (mechanical and electrical) consultants who advised on how the layout of the existing cable and water routes would affect the design. The results of the studies were then put forward to the client's board of directors, the Chairman's Board, in the form of a business case. The researcher was not granted access to this document.

7.3.1.2 Sainsburys' Chairman's Board approval

It is here, at the Chairman's Board, whereby the first crucial decision of the project was made. The board decided from the results of the feasibility studies if the project was viable or not. Four possible outcomes were considered; to develop the whole site, keeping the store and to lease the other properties; to build and to lease the whole site; to lay conditional requirements if the project was to proceed;

or to not build at all. The first option was finally decided upon from reviewing the business case. The architect conducted the feasibility studies on a no-fee basis, though the cost of which would have been recouped if the decision were to go ahead. This practice is common in the industry, particularly with partnered arrangements, which is apparent with Sainsburys and all of its consultants. The prospect of repeat work with the client adhered to be a major form of incentive for the (potentially unpaid) work. Sainsburys continuously assess the performance of their partnered companies.

7.3.1.3 Design team appointment

Once the decision to proceed with the project was reached at the Chairman's Board meeting, the design team was appointed to develop the plans and drawings towards full planning approval. The companies again were selected and appointed through Sainsburys partnered team arrangements. The design team consisted of eight key members, including an architect, a landscape architect, a structural engineer and an M&E engineer. Schal were also appointed at this stage as the Construction Manager for the project, effectively acting as the client on-site (Development/ Project Manager), controlling the quality, budget, programme etc having to directly report back to the client the project's progress on a regular basis. Sainsburys opted for a lump sum fee for Schal and this effectively enforced their position because they effectively would gain nothing by cutting corners and conversely, they would not benefit if the project were to be delayed.

7.3.1.4 Sainsburys' Design Board approval

The design team worked collaboratively together towards full planning approval whilst iteratively satisfying Sainsburys' internal Design Board. Planning was accepted for a 400,000 sq ft store. However, continued market analysis tests by Sainsburys resulted in the need for a 500,000 sq ft store. Furthermore, it was at this stage in which the client reduced its total construction budget across all of its projects. As a result, the design team re-looked to see how a reduction in cost in the design could be envisaged. Lower specification materials, such as the thickness of walls and standard components were opted for; the construction process that was beginning to form was re-examined; and the fit-out requirements were also relooked at. Moreover, consultation with the contractors and suppliers at this stage enabled buildability to be incorporated at the onset, much earlier than in the traditional design and construction process. The client's process of economising the design is called CRC (cost reduction changes) and is common practice for the design team on Sainsburys projects. The fit-out cost of the supermarket was reduced from £8.5 million to around £7.5 million, and it was at this stage that discussions with BIW commenced with the prospect of introducing the PIC to the project to further reduce costs. Several information management system providers were consulted; the proposed benefits of the PIC and its market leadership helped to secure its deployment.

7.3.1.5 Project team appointed

With approval from Sainsburys Design Board, the project team was selected, again through partnering arrangements. The team directly contracted with the client since there was no main contractor on board the project. The planning application for the 50,000 sq ft store was again granted and so the steel was ordered along with other elements with long lead-times, such as certain display cabinets, escalators and lifts.

7.3.1.6 Work packages

Schal, the Construction Manager for the project, assisted Sainsburys to divide the work at hand into individual construction work packages in terms of scope, time and cost. In this particular project, Sainsburys expressed a desire to only let a small number of packages; sub-packages were subsequently let in discretion of the original contract holder. Schal also produced the construction programme/ project plan at this stage that incorporated the details of the packages and formulated the path of the project information, in terms of what, when and to whom. The project team then collaboratively amended the plan to incorporate buildability, and each actor subsequently produced his or her own schedule in accordance to the overall programme.

7.3.1.7 Construction

Construction commenced on-site as early as possible. This was enabled by means of progressively fixing the design elements. Moreover, the participants of the workshops collectively agreed that was the only way to complete the work within the original construction time. Once the footprints of the buildings were determined (size, positioning etc) construction began on-site and the remaining elements were then designed sequentially based on the progressive design. This process is commonly used for commercial projects, such as Castle Vale, which have to respond to the changing market conditions. However, a freeze date has to be allocated for any additional design changes. This was set as twelve weeks before the building was due to be completed, any changes made after this date was perceived to be too costly and risky. Meanwhile, concurrently to the construction of the supermarket, Sainsburys' team of internal designers organised the fixtures and fittings of the store with respect to the latest market analysis tests, which were constantly reviewed and amended to cater for the changing market.

7.3.1.8 Reviews

There were formalised project reviews on the Castle Vale project. The design team met every two weeks, and the project team met every month with the client to report on the progress of the project. Further sub meetings were arranged as and when they were required.

The formalised reviews are represented as stage-gates on the project process model (see Figure 7.4). However, these do not follow the reviewing procedure as described in the Process Protocol, whereby the gates signify 'go,' 'no-go,' 'conditional go' or 'conditional no-go' of the project in accordance to the delivery of the phase deliverables, but they do signify the difference between the stopping or continuation of the project during the formalised reviews. The sub meetings are not displayed in Figure 7.4.

7.3.1.9 Assessment of project team

Sainsburys, at the end of the project, individually assessed the performance of the partnered project team. The findings would be used to govern team selection for future construction projects. They measured how well the companies performed in terms of time, cost, quality etc. using a scale of 1 to 10. This was an internal exercise and the results or criteria were not made available to the researcher.

7.4 Background to the PIC

The PIC is an advanced supply chain integration tool (BIW, 2001). The operation of the system will be described in the following section; its main features are: -

- Low implementation costs
- No specific hardware or software requirements - only a standard internet browser
- Secure, fast and complete access over standard telephone lines
- Constantly available, up-to-date, accurate information
- Create and share project information (including drawings, comments, queries, requests for information, procedures, minutes, team member details, variations, photographs, video and virtual reality renditions)
- View, zoom-in and comment on all drawings - even without a CAD system
- Full audit trail and a secure knowledge database for entire projects
- Each PIC system contains and provides to each user, all information and procedures relating to the client's design standards - team line-ups change constantly, so this allows every new participant to have immediate answers to any questions relating to the client's unique procedures e.g. what is the procedure for obtaining approval for a variation order?

- Reduces unnecessary network traffic so that team members are not swapped with irrelevant information or requests

7.4.1 PIC set-up/ accessibility

The principal aim of introducing the PIC to the Castle Vale project was to effectively improve communication by providing the infrastructure in which to handle project documentation, thus, to efficiently control project team co-ordination and communication. It was anticipated that the system would substantially reduce production cost and time, whilst increasing quality. The researcher perceived that this would only be achieved if every project team member co-operated in fully utilising the system. The system provides a unique project-specific website around a knowledge database, allowing all of a client's building project data to be made available to every project team member. The series of linked web pages distribute information to individual members of a project team, with each individual being allocated a password determining their level of interaction. The level of interaction was determined by the IT administrator for the project, Schal, at the outset and determined whether team members could download, upload or amend documents.

The practical set-up cost of the system varied depending upon how technologically advanced each participating company was. This ranged from purchasing PCs, modems and printers to connect to the Internet or simply nothing at all. However, the workshop participants who used the PIC perceived it as easy to set-up and to use. Sainsburys paid a lump sum fee and subsequently each member of the project team was permitted free access. Those companies who were not already connected to the Internet had to consider the cost of an ISP (Internet service provider). The Internet itself is an expense to run since the project team was required to constantly check the website for any project changes; the choice of a permanent, ISDN or a dial-up connection line would also affect the cost. However, these costs can be envisaged as beneficial and one-off since acquiring/ updating technology will only be apparent occasionally, and the same technology can be used for other projects. Moreover, the Internet can serve as another platform for recouping information such as emails, global literature on suppliers and components etc. Emails were originally routed to post boxes on the project and could only be accessed from certain machines; now they are stored on the Internet and can be read from any computer, inherently saving time. However, if there is a network failure the project information cannot be accessed, which is detrimental although the loss of data is minimal since it is backed-up everyday.

Up to now, the most common barrier to the electronic exchange of drawings has been the use of incompatible CAD systems. Although the PIC does not eliminate this problem, it does reduce its impact. As most project members only needed to comment on drawings rather than change them, they could do this by viewing the drawings over the Internet, thus the problem of software compatibility did not arise. The architects and designers published their drawings from their CAD systems onto the PIC as web-compatible DWF files, which other team members could then access with thanks to a free viewing tool called Whip.

Training for the use of the PIC was felt as inadequate by the project team, despite its self-explanatory image. All that was provided was a twenty-paged training manual, available to download off the website, and two demonstration sessions. Most notably, there were three different interfaces of the PIC that were introduced over the past few months and countless minor changes that the users were not notified of, for instance, the drawings had to be submitted in uppercase text. However, since the system is still being developed at the time of this investigation, this was merely a short-term hindrance.

7.4.2 Supply chain communication

The PIC is operated by firstly submitting the details of project drawings to the drawing register, this register acknowledges who is to complete to work, by when and whom it is going to be sent to in relation to the project programme/ plan of work. Consequently, as soon as a drawing is uploaded onto the system, all the relevant parties are notified via their headline/ front page of the website (see Figure 7.5). This page details the new information relevant to the user as soon as it is accessed by each individual's unique pass-code. The workshop participants favour this method of data retrieval over the typical email notification approach. It allows the participating project participants to 'pull' the information they require, rather than the industry standard of 'pushing' it out to everyone on a mailing list, regardless of how urgently it is needed, or even if it is required at all. Moreover, the system also notes when the document has been viewed, if at all, inevitably monitoring all data exchanges. This ensures the effective and transparent flow of information to the whole project team throughout the duration of the project. Furthermore, if a drawing is delayed in submission it is clearly apparent to the project team ensuring the effective and transparent flow of information. Comments can also be placed on each drawing (red-lining), enhancing communication and the plethora of knowledge of the project team.

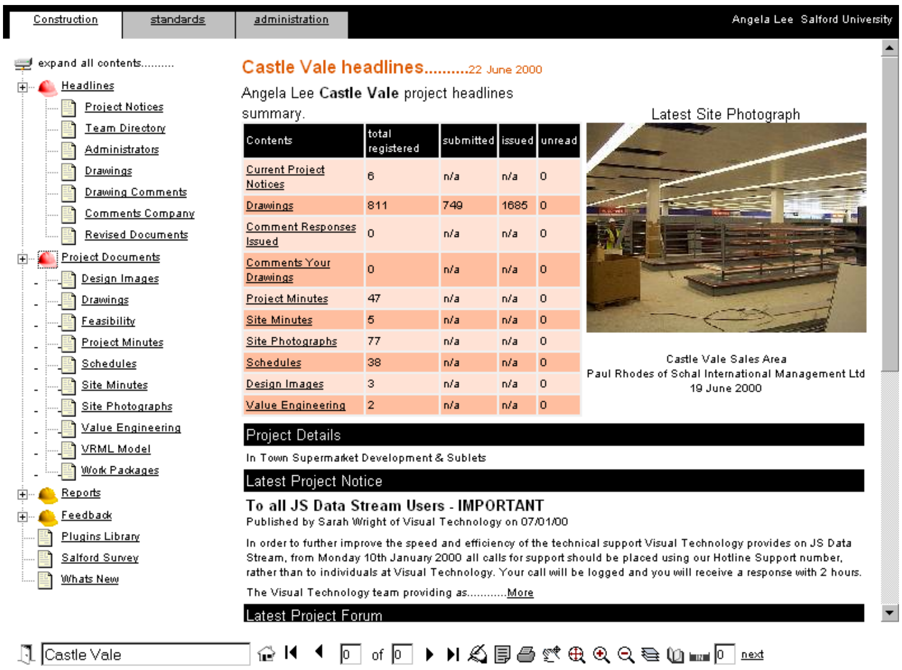


Figure 7.5: Screenshot of the headlines page of the PIC

In short, documents are no longer sent via post, thus outweighing all postage costs. However, the project team was still uncertain to the extent of the reduction in printing costs. The use of the PIC outweighs the design consultants' printing costs, the workshop participants felt that this had perhaps to a certain extent been redirected to the contractors and suppliers further down the supply chain.

Nevertheless, only the drawings that were specifically required, and not all of the revisions, had to be printed and possibly only particular sections; this, it is anticipated, would reduced the number of drawings that have to be printed. Also, due to the lack of on-site technical facilities, Schal had to print out drawings for the building team at Castle Vale, which became a costly procedure. This, it was envisaged, could be counteracted if there was a communal office for the site team and the printing costs proportioned to the amount used by each individual company. Perhaps also, if there was a shared projector room drawings could be viewed in A1 format and presides the need to print in some instances.

In addition to the drawings, the system hosts the project programme, whereby if changes to the course of work were paramount, the programme could be immediately updated and instantly viewed. Site photographs also permitted the progress of the project to be monitored without the cost of travel, the minutes of meetings etc are all also stored on the system and are available to download and print, if and when required, to save printing costs. All data was to be stored on the system even after the project was complete with the aim that the documents/ information could be modified and reused on other projects.

7.5 Project communication performance measures

The aim of this case study is to determine, by using the PPE framework, whether the PIC offers any significant advantages over the 'traditional' flow of design and construction information (in doing so, the Steps of the PPE framework are also validated). Steps 1 and 2 determined the project process communication measures of the Castle Vale project; step 1 identified the reasons behind the selection of the new process and step 2 converted these goals into metrics. The Process Protocol/ PIC suggested that implementation would provide the following six key principles. Empirical evidence is required to substantiate such, thus the aim of this investigation.

- A whole project view
- Progressive design fixity
- A consistent process

- Stakeholder involvement/ teamwork
- Co-ordination
- Feedback

These six key principles were expounded by the researcher and the project team during workshops to form the following sub benefits, to which the PIC would be tested against (see Table 7.2): -

Process Protocol/ PIC's 6 key principles	Performance benefits
A whole project view	Reduce communication costs Reduce paperwork costs Reduce storage requirements Reduce transaction times Reduce transaction costs Improve productivity Quicker access to appropriate data Strategic competitive advantage Improve quality of output
Progressive design fixity	NOT TESTED/ NOT APPLICABLE
A consistent process	NOT TESTED/ NOT APPLICABLE
Stakeholder involvement/ teamwork	Increase client involvement Easier links to project team members Improve focus on client's requirements Improve project team integration Encourages cross-functional project teams
Co-ordination	Improve delivery scheduling Increase information exchange Improve information version control More relevant and reliable data Improve filtering of information
Feedback	Quicker response on current project progress Quicker response to client enquires/ changes Reduce rework and waste Ease of referring back to data

Table 7.2: The proposed benefits of the PIC

The proposed benefits of the PIC and any implementation issues affecting the project team, as suggested by the PPE framework, were subsequently translated into five project communication performance measures. These metrics encompassed assessment of the proposed benefits. Further, for the purpose of this case study, the metrics were examined in terms of time, cost and quality, the three traditional measures of the construction industry. This best suited the client and the project team.

- A: To reduce the project's postal cost, this will be measured in terms of time and cost and quality
- B: To reduce the project's printing cost, this will be measured in terms of cost and quality
- C: To reduce the number of drawing revisions, as the PIC should encourage greater integration of the project team members, this will be measured in terms of quality
- D: The effects/ cost of using the PIC, this will be measured in terms of time, cost and quality
- E: The effective use of the PIC, this will be measured in terms of time and quality

7.6 Results

The results of the five metrics are detailed in the following section; each metric details the proposed measure, explicit benefits of the metric, the data collection method, the results, a list of the tangible and intangible factors that have to be considered when analysing the results, and the conclusion.

7.6.1 A1: to reduce the project's postal cost (*measures type:* time)

Measure: -

To measure the time saving incurred by 'posting' a project document via the PIC in comparison to the traditional method of posting (postal service).

Benefit tested: -

- To reduce transaction times

Method: -

To note the response time (via the data generated by the PIC) in which it took for the registered/ relevant project team members to view a randomly selected drawing (selected by the researcher and unknown to the project team members).

Results: -

The following table (Table 7.3) illustrates the time it took the seven registered recipients to view a randomly selected document: -

No. of access's	Time accessed	Time taken to access
1	21/03/00 14:11	20 days 2hrs 7min
1	01/03/00 11:05	1min
1	02/03/00 07:15	20hrs 11min
1	01/03/00 11:59	55min
1	01/03/00 11:06	2min
2*	01/03/00 16:52	5hrs 48 min
2*	02/03/00 08:39	21hrs 35min

* Response time invalid as the time shown denotes the last time the recipient accessed the drawing, and not the first time accessed.

Table 7.3: Table detailing the time it took the registered project participants to view a randomly selected document

Tangible/ intangible factors to consider: -

- The time available to the project team to view new drawings
- Internet connection problems and availability on the test day
- Relevance of drawing to registered recipients
- The importance/ priority of drawing to the registered recipients
- If the recipient was notified prior to the drawing actually being sent

- Personal matters that prohibit a project team member from viewing a drawing
- If the recipient was aware that someone else in the same organisation has already viewed the drawing, and felt that there was no further need to do so

Conclusion: -

The 'traditional' transaction time of posting a drawing via post is 1-2 days. The PIC has significantly reduced this transaction time, as the results in Table 7.3 clearly show. Therefore, the benefit tested, ‘reduce transaction times,’ is confirmed by this metric. Even if a courier had sent the drawing, the recipients still would not have received it in such a time, and the PIC is at a minute fraction of the cost of a courier. The recipient who took over 20 days to view the sample drawing indeed may not be significant result, as even if the drawing was sent traditionally by post there would be no guarantee that he/ she would immediately view the drawing, or if at all. Or perhaps that particular recipient was aware that someone else in his or her company had already viewed the drawing, and felt that they did not need to further look at it. By means of the PIC, it is clearly evident who has not viewed the drawing, or who has and at what time, and the results could potentially be used to define the subsequent impact to the project. However, the system needs to be able to measure the length of time the drawing was viewed rather than merely registering an opened but 'glanced' drawing. Moreover, drawings could also be lost-in-the-post, and therefore would significantly effect the transaction time.

7.6.2 A2: to reduce the project's postal cost (*measures type:* cost)

Measure: -

To estimate the total postage and packaging costs of sending all project documents via the post to the project team, and compare to that used by the system. It is proposed that that the PIC outweighs all postal costs.

Explicit benefits tested: -

- Reduce communication costs
- Reduce transaction costs

Method: -

Calculate the number of project documents sent via the PIC and multiply by an average postage and packaging cost, and an attitudinal survey questionnaire.

Results: -

The following table (Table 7.4) illustrates the total estimated cost of sending all project documents that have been sent since via the PIC: -

Total number of documents sent (a)	**Number of copies to be sent (b)**	**Cost factor (c)**	**Total cost (a x b x c)**
Drawings 1520 (715 drawings registered, 805 revisions)	38	£0.10	£5,776
Other (minutes and schedules) 37	38	£0.36	£506.16
Total			*£6,282.16*

b assumes that 1 copy of each document will be sent to each of the 38 companies, as not every company requires a drawing and some will require more than one.

c assumes that drawings are sent in sets, the sets being made up of varying number of drawings. The average cost of a drawing in a typical set is assumed to be £0.10. Other project documents are sent individually, priced at £0.26 for postage and £0.10 for packaging.
The results do not take into account extra copies that have been lost and have to be resent, or courier costs.

Table 7.4: Table illustrating the estimated costs of sending project documents

The following table (Table 7.5) details the results of the attitudinal survey questionnaire, followed by a respondent's general comments.

The PIC has significantly reduced the cost of posting project documents for my company		
Response	**Frequency**	**Percentage**
Strongly disagree	7	9.86
Disagree	10	14.08
Uncertain	13	18.31
Agree	22	30.99
Strongly agree	19	26.76
Total	*71*	*100*

Other comment: -

- The biggest problem we still have is sending paper copies to consultants/ contractors who are not up to speed with the use of the system

Table 7.5: Table illustrating attitudinal survey questionnaire results of the cost of posting project documents

Tangible/ intangible factors to consider: -

- Time and cost of folding/ preparing the document for postage
- Courier costs if the document is required urgently
- The impact of the PIC on the number of drawing revisions
- Cost of re-sending lost documents
- The size of the documents vary
- Not all drawings are sent to every company; more copies of some drawings are often needed in a company
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire
- The system does not incorporate the Construction Manager's Instruction (CMI), which still has to be sent
- Project documents that were lost in the post and need to be resent

Conclusion: -

The Castle Vale project has saved over £6,000 to date by using the PIC in postage and packaging costs alone. Therefore, the project's communication and transaction costs have been reduced. Indeed, the actual amount is more likely to be greater as it does not account at all for courier costs or packages lost in the post. Furthermore, this result has been reflected in the strong sense of agreement as highlighted by the attitudinal survey questionnaire. However, the postal costs of the project has not been completely outweighed as the CMI (Construction Manager's Instruction) still has to be sent due to legislative conditions, and as the additional comment highlights, drawings currently still have to be sent to some parties who are not using the system. Therefore, the benefits cannot be fully reaped unless everyone adopts the PIC, and if it can incorporate factors such as the CMI (thus being an important industry and cultural consideration for reaping the benefits of modern technology).

7.6.3 A3: to reduce the project's postal cost (*measures type:* quality)

Measure: -

To measure the impact of receiving the project documents on time/ as soon as they are completed.

Explicit benefits tested: -

- Improved delivery scheduling
- Quicker response on current project progress
- Quicker response to client enquiries/ changes
- Improve productivity
- Quicker access to appropriate data

Method: -

Attitudinal survey questionnaire

Results: -

The following table (Table 7.6) details the results of the attitudinal survey questionnaire, followed by the respondents’ general comments.

The following benefits have occurred by sending project documents via the system		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
Reduced transaction time	Freq.	2	8	8	34	19
	%	2.82	11.27	11.27	47.89	26.76
Quicker response to project changes	Freq.	1	9	17	33	11
	%	1.41	12.68	23.94	46.48	15.49
Reduced rework and waste	Freq.	3	17	33	12	6
	%	4.23	23.94	46.48	16.90	8.45
Reduced risk	Freq.	4	17	33	15	2
	%	5.63	23.94	46.48	21.13	2.82
Improved delivery scheduling	Freq.	2	12	27	25	5
	%	2.82	16.90	38.03	35.21	7.04

Other comments: -

- The system would work better if people used it correctly
- The system does not necessarily improve the performance of its users
- It is obviously quicker to send/ receive individual drawings by the system than by post. However, when there are large numbers of drawings, the time spent uploading and downloading can be quite considerable. For documents such as letters it is probably as quick by facsimile, probably quicker, but faxes are still used

Table 7.6: Table illustrating attitudinal survey questionnaire results of posting project documents

Tangible/ intangible factors to consider: -

- Attitudes and perceptions will vary
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

For all of the benefits queried, there was a general consensus in agreement that the PIC had improved the transaction time and the response to project changes. However, in the cases of reduction in rework, waste and risk benefits, and improved delivery scheduling, the uncertain category rated the greatest. This maybe because the respondents were simply uncertain of those particular benefits or, as captured by the additional comments, the system is still not being utilised effectively.

7.6.5: B1: to reduce the project's printing cost (*measures type:* cost)

Measure: -

To determine the total cost of printing all project documents, including drawings and minutes, and to see if the cost has been transferred from the consultants to the other members of the project team.

Explicit benefit tested: -

- To reduce paperwork costs

Method: -

Calculate the number of documents sent on the PIC and multiply by an average printing cost of paper and ink cartridges to determine project's printing cost in that of the 'traditional' method. To contact each company to see if the cost of printing project documents has significantly been redistributed from the consultants to the contractors, against that of a similar project using the 'traditional' method, and an attitudinal survey questionnaire.

Results: -

The following table (Table 7.7) illustrates the estimated printing cost of sending all project documents via the 'traditional' postal system.

Total number of documents sent (a)	**Number of copies to be sent (b)**	**Cost factor (c)**	**Total cost (a x b x c)**
Drawings 1520 (715 drawings, 805 revisions)	38	£0.70	£40,432
Other (minutes and schedules) 37	38	£0.10	£140.60
Total cost of printing project documents			*£40,572.60*

b assumes that each company prints out 1 sets of drawings, as some companies may not require the particular set and some may require more.

c assumes that it costs 70p for the paper and ink used to print out one drawing, and retrospectively 10p for other project documents.

Table 7.7: Table illustrating total cost of printing project documents

The following table (Table 7.8) illustrates the responses from each company, detailing the cost of printing out project documents compared to that of a similar project using the 'traditional' method of operation. Out of the 52 companies contacted, only 2 client/ consultants and 14 contractors/ suppliers replied, therefore, the results cannot be conclusive.

Company	Cost of printing, the 'traditional' method (a)	Cost of printing, using the JS Data Stream (b)	Cost saving or detriment (a-b)
Client/ Consultant			
1	£1,300	- £370	- £ 370
2	£12,500	- £5,000	- £5,000
Contractor/ Supplier			
1	Uncertain	Uncertain	Uncertain
2	£29	£45	+ £16
3	Not evaluated	£30	Uncertain
4	Uncertain	Uncertain	Uncertain
5	Uncertain	Uncertain	Uncertain
6	£50	£250	+ £200
7	£238	£352	+ £114
8	£0	£80	+ £80
9	£0	£100	+ £100
10	£0	Uncertain	Uncertain
11	£0	£100	+ £100
12	£0	£50	+ £50
13	'Many thousands'	£0	Uncertain
14	Uncertain	Uncertain	Uncertain
On average, it has saved each client/consultant			*£2,685 .00*
On average, it has cost each contractors/suppliers an extra			*£94.29*

Table 7.8: Table illustrating the cost of printing project documents to the project team

The following table (Table 7.9) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

The JS Data Stream has significantly reduced the cost of printing out project document for my company		
Response	**Frequency**	**Percentage**
Strongly disagree	20	28.17
Disagree	14	19.72
Uncertain	11	15.49
Agree	17	23.94
Strongly agree	9	12.68
Total	*71*	*100*

Other comments: -

- Our company's designers still require hard copies of drawings that we now have to print out ourselves, therefore costing us time and resources
- The cost of printing has been passed down from the consultants
- We still have to print out the drawings for our work, so instead of receiving a pack of drawings, someone in our company has to spend time downloading then printing them
- The printing costs were previously held with the consultants but now seem to be distributed throughout the whole project team
- We still have to print out the drawings for storage, as electronic copies are not legally binding
- It is difficult to view drawings on a standard 17" monitor, which is why we have to still print

Table 7.9: Table illustrating attitudinal survey questionnaire results of the cost of printing project documents

Tangible/ intangible factors to consider: -

- Drawings that have been lost and need to be reprinted
- The size of the document
- The appropriateness of the size of drawing relative to the printing paper
- Printing wrong drawings or wrong sections of drawings

- If the cost of printing has significantly been redirected to other project team members
- The impact of the PIC on the number of drawing revisions
- The cost of storing hard copy documents
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire
- The contractors/ suppliers still need to work off the drawings, and so they still have to be printed

Conclusion: -

If the 'traditional' method of posting and printing documents were enacted on this project (in that each company was granted only 1 copy of each revision), it would have cost approximately £41,000 on printing costs alone. However, the project team still need to work off the drawings and so they still have to be printed. This metric sought to seek if there had been a reduction in printing costs.

The method of determining the actual printing cost of the project remained to be somewhat subjective, as it is directly related to who printed it (in-house or commercially; obviously commercially is more expensive), the use of which printer/ plotter, the relevant size of the printed drawing etc. With the introduction of the PIC, it was perceived that not as many copies had to be printed as they could be all viewed onscreen, however as evidenced by the comments of the attitudinal survey questionnaire, this is still not effective. Further, all revisions do not necessarily have to be printed with the use of the PIC, as project team members only have to print documents that are necessary and only the latest revision. It does seem however, that the printing costs have been redistributed from the client/ consultants to the rest of the supply chain, as the results of individual company responses and the attitudinal survey questionnaire clearly show. There seem to be mixed feelings as to whether printing costs were reduced since it is only natural to consider your own circumstance, and not that of the client/ project's. However, if it indeed it actually costed each contractor/ supplier an extra £94 and each client/ consultant saved around £2,600, by logic the project would have saved a significant sum by means of the system. Unfortunately, the results were not conclusive to fully support this.

The use of the PIC also ensures that the project information can be stored in a retrievable format for the future, presiding storage costs, and the advances and subsequent problems of electronic software and hardware upgrade. Typically, to combat this problem, clients have had to commission consultants to either survey or to redraw the hardcopy plans of the property again. Now, all the project information is stored in databases, and so can be retrieved and manipulated easily for all future use, which again reduces storage costs of the data. However, this benefit has still not been reaped as consultants on the project today still print and store documents for around 15 years after the project has been completed, as an extra 'comfort' for all pending eventualities. Although the system appears to address compatibility problems, only through time will these extra costs be outweighed through change in the industry’s culture.

7.6.6 B2: to reduce the project's printing cost (*measures type:* quality)

Measure: -

To measure the impact of printing a project document as and when it is required.

Explicit benefits tested: -

- Quicker access to the appropriate data
- Reduce storage requirements
- Reduce rework and waste

Method: -

Attitudinal survey questionnaire

Results: -

The following table (Table 7.10) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

The following benefits have occurred for my company by printing our own project documents		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
Reduced storage requirements	Freq.	9	15	9	29	9
	%	12.68	21.13	12.68	40.85	12.68
Quicker access to the appropriate data	Freq.	5	2	5	43	16
	%	7.04	2.82	7.04	60.56	22.54
Reduced rework and waste	Freq.	6	14	29	18	4
	%	8.45	19.72	40.85	25.35	5.63
Reduced transaction times	Freq.	5	8	11	39	8
	%	7.04	11.27	15.49	54.93	11.27

Other comments: -

- The system is quicker but generally does not reduce waste
- We still use the same quantity of paper, although the quality of documents is reliant on the person printing the document rather than how the actual sender wanted the document to appear

Table 7.10: Table illustrating attitudinal survey questionnaire results of printing project documents

Tangible/ intangible factors to consider: -

- Attitudes and perceptions will vary
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

The respondents of the survey questionnaire all generally agreed that by printing their own project requirements via the PIC, reduces the storage requirements, enables quicker access to the appropriate data and reduces the transaction times. However, there still appears to be some degree of uncertainty with this prospect leading to reduced rework and waste. The system will not reduce rework and waste if it had not been fully implemented at the outset, which it hadn't. If advances in communication, as with the PIC, had been fully incorporated at the start of the project, then perhaps the consultants would have worked together more effectively and brought forthright buildability into the design.

7.6.7 C1: to reduce the number of drawing revisions (*measures type:* quality)

Measure: -

To calculate the number of drawing revisions to determine whether they are a detriment or a bonus to the project.

Explicit benefit tested: -

- Reduce paperwork costs

Method: -

Calculate the number of drawing revisions via the PIC and conduct an attitudinal survey questionnaire.

Results: -

The following table (Table 7.11) illustrates the number of drawing revisions/ versions of the project.

Number of drawing versions	Number of drawings
1	612
2	340
3	362
4	77
5	38
6	28
7	20
8	12

9	9
10	6
11	4
12	3
13	3
14	3
15	2
16	1
Total number of drawings	*1520 (715 drawings, 805 revisions)*

Table 7.11: Table illustrating total number of drawing revisions

The following table (Table 7.12) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

The PIC has significantly reduced the number of drawing revisions for the project		
Response	**Frequency**	**Percentage**
Strongly disagree	13	18.31
Disagree	28	39.44
Uncertain	20	28.17
Agree	6	8.45
Strongly agree	2	2.82
Total	*69*	*97.19*

Other comments: -

- It is easier to revise a drawing now so there are more revisions
- The number of revisions is probably unaffected by the PIC's environment

Table 7:12: Table illustrating attitudinal survey questionnaire results of the number of drawing revisions

Tangible/ intangible factors to consider: -

- Attitudes and perceptions will vary
- Cost and time implications of consultants to meet together to work on a drawing
- Number of revisions will be dependent on the drawing type

- Number of revisions will be dependent on the client
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

It appears from the attitudinal survey questionnaire that the number of drawing revisions of the project has not been noticeably reduced, though this figure could have remained typically the same or increased; further analysis is required. It was envisaged, however, that the figure should have been reduced, as the project team members were all expected to view and comment on the relevant drawings so that a revision (if necessary) will encompass a whole host of comments from the various disciplines in the project team. This would, hopefully, improve the final product by means of buildability – the involvement of the whole project team on the design of the supermarket. However, the number of drawing revisions could be interpreted as, as suggested by a survey questionnaire respondent, that 'it is easier to revise drawings so there are now more revisions.' Clearly, the challenge here remains to find if revisions are a good thing; they may cost more, but the finished product should surely be an improvement. It must also be reiterated that the number of drawings is not as important, but rather the timing of the revision - the later the revision, the more detriment to the project. Again, further analysis in this area is required and perhaps this factor should be incorporated into the PIC. Moreover, a important factor that must not be overlooked when interpreting the number of revisions is the client's changing business need, as in this case study, will also have a major impact on the number of drawings in the project and so in this sense the results cannot be conclusive.

7.6.8 C2: to reduce the number of drawing revisions (*measures type:* quality)

Measure: -

To calculate the number of drawing comments posted on the PIC to determine whether they are a detriment or a bonus to the project.

Explicit benefits tested: -

- Improve quality of output
- Reduce rework and waste

Method: -

Calculate the number of drawing comments and an attitudinal survey questionnaire.

Results: -

The following table (Table 7.13) illustrates the number of comments as per the 1520 drawings (715 drawings and 805 revisions) that have been produced since the launch of the PIC and the test day.

Number of comments (a)	**Number of drawings (b)**	**Total number of comments as per drawing (a x b)**
1	39	39
2	15	30
3	3	9
4	5	20
5	3	15
Total number of comments		*113*

Table 7.13: Table illustrating total number of comments as per drawing

The following table (Table 7.14) details the results of the attitudinal survey questionnaire, followed by the respondent's general comments.

The ability to be able to comment on drawings has incurred the following benefits		**Strongly disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly agree**
Reduced rework and waste	Freq.	3	13	32	18	5
	%	4.23	18.31	45.07	25.35	7.04

Improved quality of output	Freq.	2	12	29	24	4
	%	2.82	16.90	40.85	33.80	5.63

Other comment: -

- The simplicity of the system encourages more people to comment, and this is only a good thing

Table 7.14: Table illustrating attitudinal survey questionnaire results of drawing comments

Tangible/ intangible factors to consider: -

- Attitudes and perceptions will vary
- The confidence of a project member to publicly comment on a drawing
- The designer's negative feeling towards the public display of comments
- If the comment is appropriate
- The extent in which a drawing was reviewed and if it was reviewed at all
- The impact of viewing a drawing too late
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

The total number of comments placed on the 1520 drawings (715 drawings and 805 revisions) via the PIC was 113. Even though the number of comments is relatively small in relation to the number of drawings, it appears that the ability to be able to comment has reduced somewhat rework and waste, and improved the quality of output (through the results of the attitudinal survey questionnaire). Perhaps the perceived benefits would significantly increase once the ability to comment on the PIC is used more proactively. Moreover, it will be interesting to define which drawings have the most comments and to be able to comment on other project documents, such as minutes, as they still have to be printed out, written on and then passed back to the author.

7.6.9 D1: the effects/ cost of using the PIC (*measures type:* time and quality)

Measure: -

The user friendliness of the system

Explicit benefits tested: -

None; the PPE framework suggested measuring the implementation of the new project communication process

Method: -

Calculate the number of technical feedback queries on the system and an attitudinal survey questionnaire.

Results: -

The total number of technical feedback comments of the PIC was 56. The following table (Table 7.15) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
I had prior experience of computers before the project	Freq.	1	3	1	26	40
	%	1.41	4.23	1.41	36.62	56.34
The system is easy to use/ self-explanatory	Freq.	5	8	16	36	6
	%	7.04	11.27	22.54	50.70	8.45
I often ask my company nominated IT manager for help to use the system	Freq.	8	28	9	21	5
	%	11.27	39.44	12.68	29.58	7.04
I often ask the	Freq.	8	32	13	14	4

project nominated IT manager for help to use the system	%	11.27	45.07	18.31	19.72	5.63
I often ask a colleague for help to use the system	Freq.	10	24	9	22	6
	%	14.08	33.80	12.68	30.99	8.45

Other comments: -

- The general layout of the system is fairly straightforward and easy to use
- I do not usually require help to use the system, but sometimes require advice when interrogating AutoCAD drawings
- The system would be utilised better if we received better training
- A user group would assist in resolving common problems

Table 7.15: Table illustrating attitudinal survey questionnaire results of the effects of using the PIC

Tangible/ intangible factors to consider: -

- Attitudes and perceptions will vary
- Number of technical queries that have been solved by others and are not noted on the system
- Computer literacy of the project team members before the PIC
- Appropriateness of feedback query
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

The number of technical feedback queries of 56 is relatively minor in relation to the 101 project team members from 38 companies, denoting that the PIC is user friendly. This is reiterated in the results of the attitudinal survey questionnaire. The majority of the respondents had prior experience of computers before the project; yet felt that the PIC was easy to use/ self-explanatory. Moreover, as the team members received no or little training, the effective operation of the system must be credited to its simplicity. Therefore, in implementing the system there had been no considerable downside effects.

Perhaps the benefits of the system could be more readily reaped if there was more training or an implementation user-group. The researcher felt strongly throughout this case study that the users did not envisage the full potential project benefits of the PIC, and perhaps by disseminating the benefits (of this study) they would more proactively use the system.

7.6.10 D2: the effects/ cost of using the PIC (*measures type:* cost)

Measure: -

The Internet connection costs of using the system.

Explicit benefits tested: -

None. The PPE framework suggested measuring the implementation of the new project communication process.

Method: -

To calculate the duration in which each project team member has accessed the system and multiply by an average Internet connection cost, and an attitudinal survey questionnaire.

Results: -

The following table (Table 7.16) details the cost and number of times the PIC was accessed by 196 people, of which 101 of them were team members from 38 companies.

Number of access's (a)	Number of times accessed (b)	Average length of time of accessed (c)	Average cost of access (d)	Total cost of access (a x b x c x d)
1	18	10	£0.03	£5.4
2	20	10	£0.03	£12.00
3	11	10	£0.03	£9.90
4	14	10	£0.03	£16.80
5	5	10	£0.03	£7.50

6	8	10	£0.03	£14.40
7	4	10	£0.03	£8.40
8	3	10	£0.03	£7.20
9	5	10	£0.03	£13.50
10	2	10	£0.03	£6.00
11	5	10	£0.03	£16.5
12	1	10	£0.03	£3.60
13	1	10	£0.03	£3.90
14	2	10	£0.03	£8.40
15	3	10	£0.03	£13.50
16	2	10	£0.03	£9.60
17	1	10	£0.03	£5.10
18	1	10	£0.03	£5.40
19	3	10	£0.03	£17.10
20	4	10	£0.03	£24.00
22	4	10	£0.03	£26.40
23	2	10	£0.03	£13.80
24	2	10	£0.03	£14.40
25	1	10	£0.03	£7.50
26	3	10	£0.03	£23.40
27	1	10	£0.03	£8.10
28	2	10	£0.03	£16.80
30	1	10	£0.03	£9.00
31	1	10	£0.03	£9.30
32	2	10	£0.03	£19.20
34	2	10	£0.03	£20.40
35	1	10	£0.03	£10.50
36	3	10	£0.03	£32.40
39	2	10	£0.03	£23.40
40	1	10	£0.03	£12.00
44	1	10	£0.03	£13.20
45	1	10	£0.03	£13.50
49	1	10	£0.03	£14.70
52	1	10	£0.03	£15.60
54	1	10	£0.03	£16.20
56	2	10	£0.03	£33.60
61	1	10	£0.03	£18.30
62	1	10	£0.03	£18.60

63	1	10	£0.03	£18.90
65	2	10	£0.03	£39.00
68	1	10	£0.03	£20.40
69	2	10	£0.03	£41.40
73	1	10	£0.03	£21.90
78	1	10	£0.03	£23.40
80	1	10	£0.03	£24.00
86	1	10	£0.03	£25.80
89	1	10	£0.03	£26.70
90	1	10	£0.03	£27.00
92	2	10	£0.03	£55.20
97	1	10	£0.03	£29.10
100	1	10	£0.03	£30.00
111	1	10	£0.03	£33.30
112	1	10	£0.03	£33.60
115	2	10	£0.03	£69.00
116	1	10	£0.03	£34.80
135	2	10	£0.03	£81.00
139	1	10	£0.03	£41.70
164	1	10	£0.03	£49.20
179	1	10	£0.03	£53.70
183	1	10	£0.03	£54.90
187	1	10	£0.03	£56.10
208	1	10	£0.03	£62.40
212	1	10	£0.03	£63.60
213	1	10	£0.03	£63.90
215	1	10	£0.03	£64.50
229	1	10	£0.03	£68.70
250	1	10	£0.03	£75.00
281	1	10	£0.03	£84.30
342	1	10	£0.03	£102.60
350	2	10	£0.03	£210.00
357	1	10	£0.03	£107.10
374	1	10	£0.03	£112.20
402	1	10	£0.03	£120.60
458	1	10	£0.03	£137.40
465	1	10	£0.03	£139.50
527	1	10	£0.03	£158.10

725	1	10	£0.03	£217.50
1212	1	10	£0.03	£363.60
Total cost of accessing the JS Data Stream				£3,639.60

c assumes that the project team only access the system for 10 minutes.

d assumes that the cost to access the system is only 3p, though this Table varies in accordance to what dial-up connection each company has.

Table 7.16: Table illustrating the cost of accessing the PIC

The following table (Table 7.17) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
I have regular and easy access to a computer	Freq.	2	3	0	21	45
	%	2.82	4.23	0	29.58	63.38
I have a company computer allocated specifically to me	Freq.	3	4	0	18	46
	%	4.23	5.63	0	25.35	64.79
The company computer was supplied to me prior to the project	Freq.	5	6	3	14	43
	%	7.04	8.45	4.23	19.72	60.56
The set-up costs of the system was significant for my company	Freq.	6	12	16	19	18
	%	8.45	16.90	22.54	26.76	25.35
I access the system regularly every day	Freq.	4	21	3	28	15
	%	5.63	29.58	4.23	39.44	21.13
A lot of time is wasted in accessing the system regularly	Freq.	3	19	17	24	8
	%	4.23	26.76	23.94	33.80	11.27
The cost of accessing the system is significant for my company	Freq.	3	16	28	17	7
	%	4.23	22.54	39.44	23.94	9.86
The system has	Freq.	5	22	30	10	4

significantly reduced the cost of project meetings	%	7.04	30.99	42.25	14.08	5.63
The system has significantly reduced the cost of telephone/ facsimile communications	Freq.	8	21	17	21	4
	%	11.27	29.58	23.94	29.58	5.63

Other comments: -

- The cost of accessing the system is dependent on the speed of the PC and the time of the day
- Relatively the same time would be wasted in looking at the documents that were sent through the post
- A lot of time is wasted through downloading, saving and printing drawings, whereas with hard copies they would just be copied if required
- The main problem is that an extra role is created for someone to check and download the relevant project documents
- Our phone charges have increased due to the system
- Project meetings are still necessary so that the team can meet on a regular basis, the cost here is the wasted hours and cost of travelling, and only video conferencing will reduce this
- The set-up cost for my company was significant
- It is a full time job for somebody to constantly check for updated information
- The system has incurred no additional costs for my company, with the exception of on-line time
- No cost whatsoever
- There was an additional Construction Manager's resource required
- Nominated colleagues in our office access and disseminate the information
- Looking through the post, if not more, would waste the same time
- Sometimes it takes too long to access the system, especially after 11am
- Publishing drawings can take up a lot of time
- We loose a lot of time downloading, saving and printing drawings, whereas with hard copies we would just copy them if required
- The telephone charges are quite high
- The main problem is that an extra role is created for someone to check for and download documents
- We spend at least 2 hours a day checking for documents on 14 projects
- The system is of benefit but highlights that a dedicated person at each company is needed to access and print off all project documents

Table 7.17: Table illustrating attitudinal survey questionnaire results of the cost of using the PIC

Tangible/ intangible factors to consider: -

- The different dial-up links that are used give differing connection costs
- If the system was being fully utilised whilst connected to the PIC
- The effect of the automatic log-out time when the system is not being utilised on the actual number of accesses
- Availability of Internet connection to access the system
- The differing length of access time
- The use of log-off when the system is not in use
- The differing costs of accessing the system at different times of the day
- If the company already had computers prior to the project
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire
- If the company already had Internet connection prior to the project

Conclusion: -

The cost of accessing the PIC (Internet charges) to date is around £3,600 and is minimal in relation to the total cost saved in postage, printing, packaging project documents, and considering that there are 101 users from 38 companies. However, this figure does not take into account the various costs of the dial-up link. However, it appears through the attitudinal survey questionnaire that most of the companies further down the supply chain (i.e. contractors, subcontractors and suppliers) have envisaged 'significant' costs of accessing the system, but in reflection of the whole project, the costs are negligible. This may be because they did not originally have Internet capabilities.

The set-up costs to be able to access the system seem to be significant through the results of the survey questionnaire, however, this seems to be somewhat questionable in that the majority of respondents already had a computer prior to the project, and their company allocated a computer specifically to them. Perhaps the 'set-up' costs reflect the plotter/ printer cost or the connection to the Internet, as the respondents were disillusioned to as the accessing costs and appeared to have been confused with this and that of the telephone and facsimile costs. Moreover, as they all have easy access to a computer everyday, the majority did access the system regularly though were uncertain as to whether this wasted valuable time; this may be related to the fact that inappropriate documents were sent to them. Furthermore, as more and more projects are advancing towards Internet technology, their costs (through connection lines) will lower, and the Internet itself could be used for several projects. The system does not seem to have brought down the cost of project meetings, and therefore, new technologies have to be reviewed.

The most prominent factor identified by the comments, was the time it took to download documents, particularly when there were several such items, which also supported the need for a document controller. Although typically there is a document controller, their role now is indeed greater and possibly one may be required per company. However, this need must be viewed against other cost, time and quality benefits provided by the system.

7.6.11 D3: the effects/ cost of using the PIC (*measures type:* quality)

Measure: -

The quality of access to all project information as and when required

Explicit benefits tested: -

- Quicker response to client enquiries/ changes
- Increased client involvement
- Improve focus on client's requirements
- Strategic competitive advantage
- Improve project team integration
- Encourages cross-functional project teams
- Improve productivity

- Ease of referring back to data

Method: -

Attitudinal survey questionnaire

Results: -

The following table (Table 7.18) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
The system enables a quicker response to client changes	Freq.	3	13	21	27	7
	%	4.23	18.31	29.58	38.03	9.86
The system enables a greater focus on client's requirements	Freq.	3	12	32	18	6
	%	4.23	16.90	45.07	25.35	8.45
The system provides strategic competitive advantage	Freq.	3	7	28	26	7
	%	4.23	9.86	39.44	36.62	9.86
The system provides easier communication links to the project team	Freq.	2	2	10	41	16
	%	2.82	2.82	14.08	57.75	22.54
The system provides greater project team integration	Freq.	1	5	22	35	8
	%	1.41	7.04	30.99	49.30	11.27
The system enables a cross-functional project team	Freq.	1	5	26	31	8
	%	1.41	7.04	36.62	43.66	11.27
The transparency of project information has significantly improved product productivity	Freq.	0	8	32	26	5
	%	0	11.27	45.07	36.62	7.04
The system enables easy access to the latest project documents	Freq.	2	6	3	36	24
	%	2.82	8.45	4.23	50.70	33.80
The system enables easy access to old project documents	Freq.	4	5	16	30	16
	%	5.63	7.04	22.54	42.25	22.54

Other comments: -

- The productivity of the project has been unchanged by the system
- The system is a step in the right direction, but needs to be user-friendlier
- Old project documents cannot be accessed at the moment, as there are none!
- The PIC has caused a loss of personal involvement and communication
- It would be good to see client feedback on the system, as we are uncertain to their perception
- Users have become more isolated, for example, there are less telephone communications between members of the project team
- We are unaware of how to access old project documents
- Archived/ old drawings are much easier to retrieve using the PIC

Table 7.18: Table illustrating attitudinal survey questionnaire results of the cost/ effects of using the PIC

Tangible/ intangible factors to consider: -

- Attitudes and perceptions will vary
- Time it takes to access the information if it was paper stored
- Project transparency advantages
- Impact of ease of access to regular site photographs
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

From the results of the attitudinal survey questionnaire, it appears that the system enabled a quicker response to client changes and to focus more on their requirements, though perhaps the system did not help them to be fully involved in the process. This particular question has perhaps been misinterpreted; as the client had access to the system and could check the course of the project at their leisure, far encroaching their involvement than 'traditionally.' Further, the researcher believes that this may be due to, as stated earlier, to the natural instinct of the respondents assessing their own circumstance, and not the benefits ascertained by the project as a whole. Therefore, user-groups or the dissemination of the PIC's success (possibly through the results of this investigation) will perhaps encourage proactive use of the system.

The system also provides strategic competitive advantage, easier communication links, greater team integration, a cross-functional team and easy access to new and old project documents. However, the attitudinal survey questionnaire respondents were still unsure as to the project's productivity, this may be attributed to the fact that the system was not introduced at the outset. In particular, it was noted in the comments that some participants felt that the system reduced the amount of personal interaction, and this may affect the success of the project. However, this must be viewed against the savings in telephone and meetings costs, and the time wasted in social performa. This factor requires further assessment.

7.6.12 E1: the effective use of the PIC (*measures type:* time and quality)

Measure: -

If the drawings have been sent to the appropriate project team members.

Explicit benefits tested: -

- Improved information exchange
- Improve filtering of information
- Improve delivery scheduling
- Strategic competitive advantage
- More relevant and reliable data

Method: -

Analysis of the PIC and an attitudinal survey questionnaire

Results: -

The total number of times the drawings had been viewed by its registered recipients is 11,618. Therefore, with 1520 drawings (715 drawings, 805 revisions), each drawing was viewed on average by 7.6 people.

The total number of drawing notifications that had been automatically sent out to those registered recipients who had not viewed a particular delegated drawing is 17,014. Therefore, with 1520 drawings (715 drawings, 805 revisions), on average 11.2 people had not viewed a delegated drawing.

The following table (Table 7.19) details the results of the attitudinal survey questionnaire, followed by the respondents' general comments.

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
The appropriate project information is always sent to me	Freq.	9	20	11	28	3
	%	12.68	28.17	15.49	39.44	4.23
A lot of time is wasted in having to view the allocated project documents	Freq.	2	14	10	29	16
	%	2.82	19.72	14.08	40.85	22.54
Do you agree that the PIC provides a significant benefit over the traditional method?*	Freq.	N/A	8	N/A	51	N/A
	%		13.56		86.44	

* Due to administration problems, only 59 people responded to this question and the percentages reflect as such.

Other comments: -

- It is important that the allocation of drawings is right from the beginning
- A lot of information is not relevant to me
- Unless the right people are on the distribution lists, information can be impossible to access
- It is an unfortunate fact of life that document management systems are still in their infancy and that people are struggling to keep up. It does take rather a long time to access large documents and drawings. There is also a slight problem in that we are notified of all documents issued on the system, be them relevant to our trade package or not, but we still have to view them to remove them from the list of pending documents
- Once again, unless distribution list management is carried out, irrelevant documents can be received
- The organisation (by project) of the system is relevant to my company; we have a small amount of information from a large number of projects

- There is a requirement to access specific package information/ drawings. The system does not allow for this at present
- It is essential to get projects on the system at the earliest possible stage; it is particularly useful for consultants at the planning stage where there is a vast amount of data exchange
- I believe the system provides great benefits to all involved. But it will require an on going investment and development to introduce the Construction Management method of CMIs and costing information, for instance
- Too soon to tell
- The benefit is only marginal
- I think that document management systems are definitely the way forward, but this is not to say that we should utilise technology for technology sake. Some processes are obviously faster and easier using the PIC, whereas others are not. I think along with reviewing the benefits and pitfalls of the system itself, we as an industry should also review what we need the system for. There are some tasks that will not be quicker until technology becomes quicker
- The biggest problem is that there is no way of knowing that there are new documents to be viewed without looking, email notification would help
- Once the culture is established, then this is a very good tool for any team
- I am still uncertain as to whether the system is a benefit to our company, however, with more use and collaboration between trades we would no doubt find it advantageous

Table 7.19: Table illustrating attitudinal survey questionnaire results of the effective use of the PIC

Tangible/ intangible factors to consider: -

- People have different perceptions of whether a drawing is specifically relevant to them
- Time wasted in viewing an inappropriate drawing
- The effect in which a person has not received an appropriate drawing
- If people have used the drawing register effectively
- The length of time of spent viewing the viewed drawing, or if the document was simply opened and then closed
- If the drawing has been viewed by someone else in the same organisation
- The familiarity of the PIC respondents who conducted the attitudinal survey questionnaire

Conclusion: -

As the PIC places no time restrictions in order to view a nominated drawing, the results clearly show that the majority of the drawing recipients do not view the drawings they have been issued. This clearly places a question over the effective use of the drawing register, if the drawings were sent to the appropriate parties in the first instance, or whether the recipients of the drawing would have even viewed the drawing if it were sent via the 'traditional' postal system. This result is reflected in the results of the attitudinal survey questionnaire, as the respondents were somewhat dismayed to as whether the appropriate drawings were sent to them, and generally felt that a lot of time was wasted in having the view the allocated documents. Perhaps the way to address this question is to make effective use of the register and to place a time limit on flagging a drawing 'viewed.' However, the possibility of someone else from the same company could have viewed a particular drawing and subsequently, the registered recipient felt that it was not necessary to view it again, has also have to be considered. Framed in these terms, the above results could be very misleading.

Moreover, if inappropriate drawings can be sent to someone, then conversely, a drawing might not have been sent to the appropriate person. Therefore, the system needs to incorporate a check mechanism so that there is a two-way system. Also, it may be interesting and of benefit to the project team, if the system detailed all new drawings, so that they could easily view the progress of the project elsewhere. Therefore, the extent of the system improving the filtering of information and delivery scheduling is questioned, whereas the benefit of increased information exchange is substantiated.

In addition, some respondents also expressed that they would prefer to be notified by email of any new documents. However, this suggestion seems to contradict the original idea of a headlines page that outweighed all the countless emails that would be otherwise generated. Moreover, if a respondent was working on numerous projects, they may possibly not fully concentrate on the one project at hand. Therefore, maybe the use of SMS (simple messaging service) from mobiles might be the answer as they are quick and short, and you simply cannot ignore them! Further, this would be particularly beneficial if this and the system could incorporate other features, such as notifying the relevant parties when materials have arrived, for instance. The future development of the PIC is endless.

Finally, 86.44% of respondents believed that the PIC offers significant benefits over the 'traditional' flow of design and construction information. The results speak for themselves. Further, the 13.56% of respondents who disagreed, it would be interesting to find out exactly why and more importantly, if they were regular or merely casual users of the system. This confirms that competitive strategic advantage was gained by implementing the PIC.

7.7 Summary of results

The process of design and construction was mapped and the PPE framework was used to assess the benefits of adopting the PIC on the Castle Vale project during the investigation. The system was measured in terms of time, cost and quality, the 'traditional' method of operation. Table 7.20 summarises the results of the testing of the project communication performance benefits of the PIC as it was applied on the Castle Vale project. It is clear that the majority of benefits tested were substantiated, thus, the four Process Protocol/ PIC’s key benefits were also substantiated. Those benefits that were either subjectively confirmed or uncertain, will require further analysis since the metrics that were tested did not fully evoke their application. However, the benefits have been somewhat restricted, as the PIC had only been in operation for 8 months and was not introduced at the project's outset. Infact, it was introduced during Phase 7 of the design and construction process (see Figure 7.4).

Process Protocol/ PIC’s 6 key principles	Performance benefits	Tested in which metric	Result
A whole project view	Reduce communication costs	A2	Confirmed
	Reduce paperwork costs	B1, C1	Uncertain
	Reduce storage requirements	B2	Confirmed

	Reduce transaction times	A1	Confirmed
	Reduce transaction costs	A2	Confirmed
	Improve productivity	A3, D3	Confirmed
	Quicker access to appropriate data	A3, B2, C2	Confirmed
	Strategic competitive advantage	D3, E1	Confirmed
	Improve quality of output	C2	Uncertain
Progressive design fixity	NOT TESTED	N/A	N/A
A consistent process	NOT TESTED	N/A	N/A
Stakeholder involvement/ teamwork	Increase client involvement	D3	Uncertain
	Easier links to project team members	D3	Subjectively confirmed
	Improve focus on client's requirements	D3	Subjectively confirmed
	Improve project team integration	D3	Confirmed
	Encourages cross-functional project teams	D3	Subjectively confirmed
Co-ordination	Improve delivery scheduling	A3, E1	Uncertain
	Increase information exchange	E1	Confirmed
	Improve information version control	E1	Confirmed
	More relevant and reliable data	E1	Confirmed
	Improve filtering of information	E1	Uncertain
Feedback	Quicker response on current project progress	A3	Confirmed
	Quicker response to client enquires/ changes	A3, D3	Subjectively confirmed
	Reduce rework and waste	B2, C2	Uncertain
	Ease of referring back to data	D3	Confirmed

Table 7.20: Summary of the benefits tested on the Castle Vale project

7.8 Recommendations for future improvement

Step 5 of the PPE framework suggested to 'use findings to inform and improve future projects.' However, due to the cost and time restraints of the researcher, this Step could not be fully enacted in this case study investigation. Moreover, the client would use the results to help evaluate the effectiveness of the PIC for implementation across all of their construction projects. Subsequently, the client did apply many of the recommendations made, but the extent of such was not measured.

This case study investigation concluded that IT was also new to many of the downstream subcontractors and suppliers and so they were subsequently less familiar with the potential of the system. Furthermore, as they were only engaged in a small part of the design and construction process, they did not fully entail the full benefits to the whole project. The whole project team were not as immediately flexible in their business processes to respond to the introduction of the system, since some were still operating in the 'traditional' way, for instance, they still printed out all drawings rather than the latest revision when it was required. Further, the PIC outlined in this paper is a tool to help the construction industry improve its transfer of information, however, the researcher believes that it is crucial that the culture of the industry changes in order to implement fully the opportunities presented. This stance is supported by the Building (2000) magazine, who agree that by sharing information will free up professionals to do more skilled work, and will give employers better value for money '…there 's no doubt that e-commerce will provide lower costs and better project turnaround. It's a realigning of the process …its not about doing what we do on paper faster - that is the tip of the iceberg - the real value is to redefine the process in a more effective way.' Therefore, in order to obtain the maximum benefits of the PIC, the following have to be ascertained: -

- Maintain a partnering and preferred suppliers relationship system
- Align each company's business process to the system
- More training to fully use the system and of its benefits

7.9 Conclusion

The emerging need for generic guidelines for the UK construction industry in the assessment of new design and construction project processes was made clear in chapters 1 through to chapter 4 of this thesis. The summation of 'best practice' in the literature reviews (chapters 2 & 3) contributed to the development of a PPE framework to assess the benefits of implementing a new project process (chapter 6). This chapter presented and discussed the implementation of the framework as it was applied on the Castle Vale project, to assess the benefits of a new project communication process, namely the PIC. The PIC, is in essence, the legacy archive of the Process Protocol and aims to outweigh the 'traditional' flow of design and construction information. This case study tested the validity of the framework and in addition, substantiated many of the perceived benefits of the Process Protocol through empirical evidence, such as a whole project view and co-ordination.

The need for such guidelines were amplified by the approach of the Castle Vale project team to the researcher for assistance in the performance measurement of their new project communication process. In this case study investigation, many of the Steps of the PPE framework were implemented, although the application of Steps 4 and 5 were restricted somewhat due to the nature of the construction project and time constraints; the researcher only commenced investigation towards the end of the project. By means of the framework, the immediate benefits of adopting the system were identified and measured against project team implementation barriers in order to ascertain a balanced performance perspective. The metrics were measured in terms of time, cost and quality (the three traditional indicators of construction performance): -

- A: To reduce the project's postal cost, this will be measured in terms of time and cost and quality
- B: To reduce the project's printing cost, this will be measured in terms of cost and quality
- C: To reduce the number of drawing revisions, as the PIC should encourage greater integration of the project team members, this will be measured in terms of quality
- D: The effects/ cost of using the PIC, this will be measured in terms of time, cost and quality
- E: The effective use of the PIC, this will be measured in terms of time and quality

The findings demonstrated that by using the PIC, significant tangible and intangible savings were reaped; over £6000 alone on stamp and envelope costs was saved on postal omissions of all project documentation, and this figure did not include the labour intensity costs of the procedure. Moreover, nearly all of the survey questionnaire respondents believed that the PIC had assisted the project in terms of co-ordination and communication channels. In addition, many of Process Protocol's key principles were confirmed in varying degrees.

Following the completion of this case study, through the invaluable benefit of the PPE framework, the PIC has since been implemented company-wide across the client's construction projects. This enforces the benefits of the PIC and further amplifies the validity of the PPE framework. It must also be noted that the method used to model the PPE framework was particularly helpful since the steps were self-explanatory and like the Process Protocol model, allowed project customisation.

CHAPTER 8: BRITANNIA WALK CASE STUDY

8.1 Introduction and research objectives

This case study investigates the Britannia Walk project, London, which aimed to develop social and key worker housing, speculative offices, a pharmaceutical manufacturing unit (PMU) and car parking facilities. The project was a collaboration effort between Alfred McAlpine Special Projects (AMSP), the University of Salford and the Department of Environment, Trade and Regions (DETR) to implement and evaluate the principals of the Process Protocol. The PPE framework, developed in Chapter 6, was used to assess the success of this 'new' design and construction process. In doing so, the value of the Process Protocol was also assessed. The need for such a framework was described in chapters 1 through to 4.

This chapter describes the research methodology undertaken to test and validate the PPE framework and provides a discussion of the issues arising (many of which reflect the unpredictable nature of the industry) that have prohibited the full implementation of the protocol. The investigation is based upon workshops, interviews and a survey questionnaire.

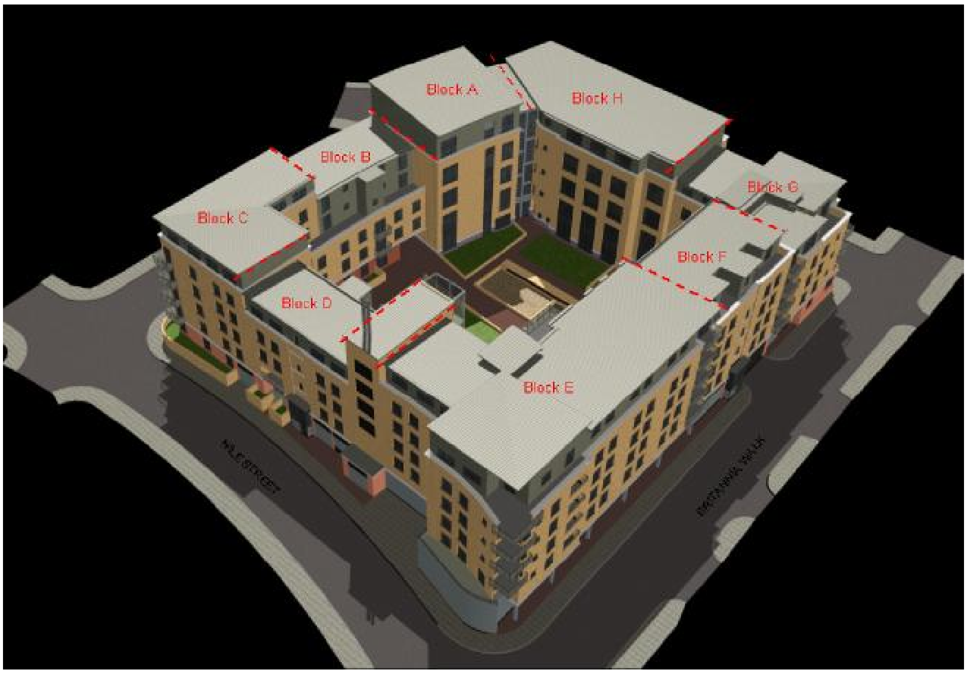
8.2 The project context

The Britannia Walk project was selected in June 1999 (although Hackney Borough Council was first approached in 1996 to develop the site, which was at the time an NCP car park), as part of the DETR's Partners in Innovation (PII) research programme to test the effectiveness of the Process Protocol. Britannia Walk was considered to be worthy of studying due to its unusual project organisation and development characteristics (see Table 8.1 and Figure 8.1); it is a project of various developments with several clients and stakeholders. The principal clients were Islington and Shoreditch Housing Association (ISHA) and

Moorfields Eye Hospital NHS Trust, who each employed separate project management consultants; ISHA is represented by Bailey Garner, and Moorfields by Hunter and Partners. The complexion of the project was amplified since some of the project team members had a financial stake in certain aspects of the development. For example, AMSP funded the development of Block H, and was also the main contractor and Project Manager on the project; JCMT who are the main project architects would take possession of Block A on completion and also contributed private finance to the scheme (to which Propylion Ltd was subsequently founded). In addition, during the construction stage ISHA had sold the key worker development to Kennington Housing Trust (KHT), which particularly impacted the project. KHT had their own specific requirements that needed to be incorporated into the design, subsequently causing additional delays to the project programme. Implementation of the protocol commenced in October 1999 during the construction stage of the development.

Accommodation	Details	Funding
General Needs	27 1-bed/ 2-person flats 16 2-bed/ 4-person flats 3 4-bed/ 7-person maisonettes	Corporation of London Social Housing Grant & Private Finance (ISHA and KHT)
Key worker housing	2 1-bed flats 5 2-bed flats 23 3-bed flats 4 4-bed flats	Private Finance (ISHA and KHT)
Pharmaceutical manufacturing unit	Includes plant areas and ancillary offices	English Partnership and Private Finance (Moorfields Eye hospital)
Speculative offices - Block A	Ground & first floor: 1 office unit of 311m^2 useable space Second, third and fourth floors: each with 2 work units of between 71 and 11 m^{2}per unit	Private Finance (Propylion and AMSP)
Workforce offices - Block H	Five storey office block totalling 1450 m^2 with 15 underground car park spaces	English Partnership

Table 8.1: Description and funding arrangements



<u>Figure 8.1: The Britannia Walk development</u>

Figure 8.1 illustrates an outline design proposal of the Britannia Walk development; it is split into eight separate blocks and wrapped around a central courtyard, with the pharmaceutical manufacturing unit and car parking facilities being housed in the basement. Although a considerable amount of design work had already been undertaken once it was decided to adopt the Process Protocol, the final contracts between the stakeholders were not in place. Figure 8.2 illustrates the project organogram as it stood when the Process Protocol was first applied to the development.

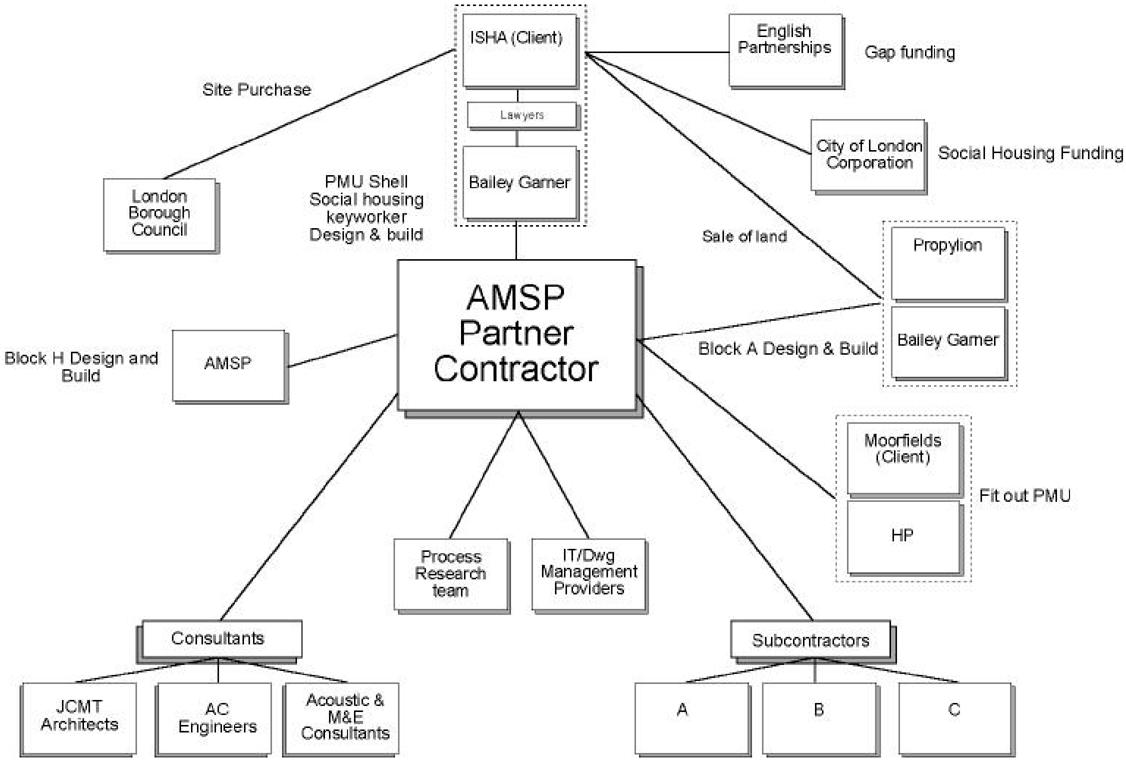


Figure 8.2: Project organogram, November 1999

8.3 Research methodology

The DETR and AMSP led the development of the multiuse project, and with assistance from a small consultancy company (P3KT, who acted as the Process Manager for the project), implemented the 'new' design and construction project process, namely the Process Protocol. However, by the time implementation began, the project was already in Phase 5. Therefore, it was decided to only apply certain elements of the model as and when required as not to disrupt the development. The project team and the Process Manager used the Process Protocol guide and final report (Kagioglou et al, 1996a; Kagioglou et al, 1996b) to implement the deliverables of the research project, somewhat independent from the developers (the University of Salford) to reduce any inherent bias. The University of Salford, hence the researcher, was deployed during the construction stage (Phase 8) to evaluate the effectiveness of the Process Protocol as it was implemented on the Britannia Walk project, to which the PPE framework was agreed and adopted. The research methodology of this case study followed the steps of the PPE framework as illustrated in Figure 8.3 and is described below in the following section.

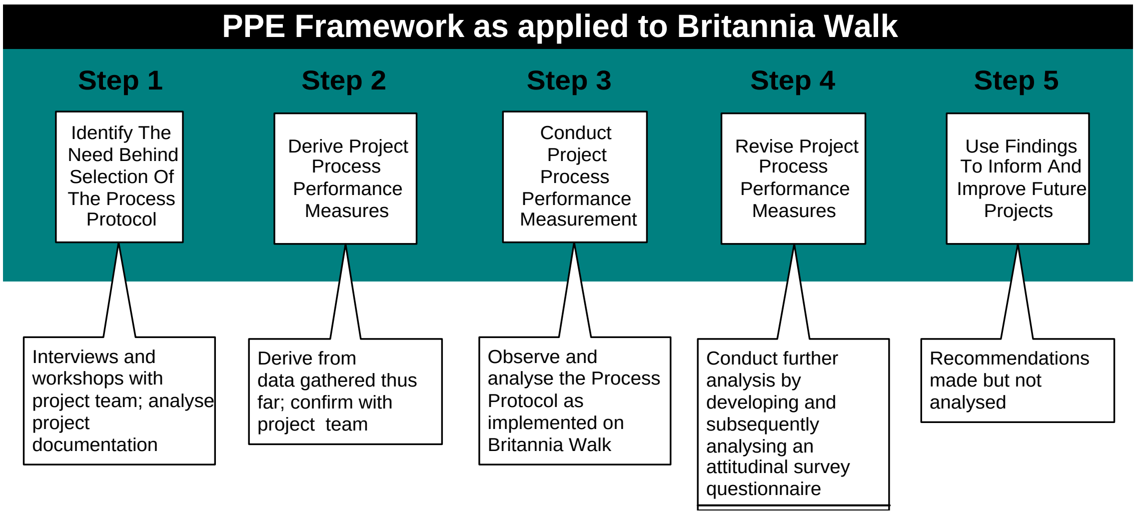


Figure 8.3: PPE framework as applied to Britannia Walk

8.3.1 Step 1: identify the need behind the selection of the new project process

The initial stage of project tracking and analysis was to identify the reason behind the selection of the Process Protocol, as made by the DETR and AMSP. This was achieved by regular visits to the site and by attending project meetings to gain a clear insight into the project. The observant role of the researcher was felt to be best suited as to not influence or hinder the project team's implementation of the Process Protocol. Access was also granted to view all project documentation, and since the role of the researcher was management driven, there was much co-operation from the project team. A series of interviews with the Project and Process Managers was conducted to ascertain the areas of the project where the Process Protocol was applied.

8.3.2 Step 2: derive process performance measures for the project

The project communication performance measures of the Britannia Walk project were derived from the information gathered from the project documentation and interviews with the Project and Process managers. The metrics considered the following issues: -

- The need behind the selection of the Process Protocol over other such processes by the DETR and AMSP, as previously identified in Step 1 of the PPE framework
- The implementation issues of the Process Protocol to the project team; how and to what extent it was operationalised
- Best practice advice in the literature

In doing so, the researcher concurrently identified: -

- The data required for each measure
- The formula for data retrieval
- The source or collection device to retrieve the required data
- How to convert the data into the required format for analysing

Once the project process performance metrics was derived, they were subject to review by the DETR, the Project and Process Managers. Amendments were made, which were also subsequently agreed in order to gain acceptance, commitment and co-operation before they were rolled out to the project.

8.3.3 Step 3: conduct project process measurement

Once the project process performance measures were agreed, the researcher conducted measurement. This was achieved by primarily observing the progression of the project, by noting the impact of the implementation of the Process Protocol, attending project meetings and reviewing the relevant project documentation. Two workshops were also arranged, with both the design and the construction team, as to gain different perspectives of the implementation of the model. The Project and Process Managers were present during both workshops, which were analysed to form the founding for this report.

8.3.4 Step 4: continuously revise project process measures

During the measurement stage, Step 3, it became apparent that additional intangible issues would benefit the evaluation of the ‘new’ project process. Therefore, an attitudinal survey questionnaire was developed. Again, the DETR, the Project and Process Managers agreed the contents of the survey before it was distributed to the project team members; the amendments suggested were reviewed and subsequently incorporated. A full copy of the questions can be found in Appendix C.

The attitudinal survey questionnaire was distributed by the Process Manager to the main project participants, which was later followed-up by numerous telephone calls by the researcher due to a lack of response. In total, there were only 6 responses. This may be due to the fact that at the time of deployment, late during the construction stage, many of the original team members who were involved in the implementation had left the team. The researcher, Process and Project Managers felt that newer members of the project team would inevitably skew the results, as they did not fully understand the original objectives of the implementation project. The results were analysed in terms of percentages, which ideally suited the project team. Some of the respondents were later contacted by phone, to further amplify upon their responses.

8.3.5 Step 5: use findings to inform and improve future projects

As measurement was conducted during the construction stage of the project, the researcher could only identify improvements to the project process; the timescale of the project did not allow them to be implemented and condescendingly assessed. Many of the improvements were suggested by the project team through a workshop that relayed the findings of the analysis of the protocol, with both the design and construction professionals of the project team.

8.4 Implementation of the protocol

The PII funding to implement the Process Protocol on the Britannia Walk project was not granted until Phase 5 of the development. At this late stage of the construction project, the Project and Process Managers considered it to be inherently difficult to fully implement the model. Therefore, the areas of concern of the project that required improvement were identified, to which the principles and key deliverables of the Process Protocol was applied.

8.5 Project process performance measures

The aim of the Britannia Walk case study is to provide the empirical evidence, by using the PPE framework, to substantiate certain Process Protocol (new project process) implementation features. The protocol boasts six key principles of project improvement. Certain aspects of the process, as detailed in Table 8.2, were executed on the project to corroborate such, and which in turn will be used to assess improvement. The success of these metrics will be assessed in comparison with tracking the implementation of the protocol.

Key principles	Method
A whole project view	Process execution plan – project process map
A consistent process	Project execution plan – information-requirement schedule/ production process map, procurement plan
Co-ordination	
Stakeholder involvement/ teamwork	Stakeholder list Communication strategy
Progressive design fixity	Grouping design elements/ fixity
Feedback	Through a workshop; not measured

Table 8.2: Performance metrics of the Britannia Walk project

8.5.1 Process execution plan

Although the ‘process’ information of the project on Britannia Walk was sparsely documented in various reports, the Process Manager developed a process map as part of the process execution plan of the Process Protocol. There were no process maps in play at the commencement of the implementation project during Phase 5, and its introduction became the project’s first key deliverable. The map aims to set out the work to be done on the project in a coherent and comprehensive manner, becoming a ‘complete’ tool to illustrate the high-level/ key deliverables and project activities that need to be undertaken during the course of the project.

8.5.1.1 Project process map

One of the key principles of implementing the Process Protocol was to communicate the process strategy to the project team; mapping the intended project process and identifying the responsibilities for the delivery of the required information achieved this. The map aimed to communicate this information in a simple, transparent and co-ordinated manner, in order to provide a common focus or frame-of-reference for the project by allowing the whole team to see what they should be doing, what is being done and what has to be done during specific project phases.

The project had often fallen behind schedule before the Process Protocol was implemented. The workshop participants and project documents revealed that this was mainly due to: -

- Poor communication between main clients and their respective design teams
- Delay by the clients in responding to proposals from the project team
- Unknown start on-site date leading to reduced sense of urgency and reduced priority
- Lack of formal contract between employers and certain consultants, leading to increased risk and greater frustration

After discussions with the Project Manager, the client and their representatives, it was agreed that it would be useful to produce a process map that identified the key design information required to counterbalance this slippage. The Process Manager led this development. The key project elements were placed on the process map, a timeline was also included on the request of the management team and the appropriate stage gates were identified.

Four project process maps were produced in total as part of the implementation project, in an attempt to address the slippage in the delivery of required project information. Four versions were developed because the map itself was static, being paper-based, and required constant updating as the project progressed. Figure 8.4 illustrates the fourth and final project process map; it provides an initial description of the project process. It is clear from Figure 8.4 that the phases on the Britannia Walk project were not modelled on the ten phases of the Process Protocol, but rather on the three main phases (pre-construction, construction substructure and construction superstructure). This was due to fact that implementation of the Process Protocol began during the outline-feasibility stage, and there was little project documentation relating to the earlier phases. The stage gates signified the suitable times for the project meetings, which were positioned on the map at points when a number of packages of information were required and consequently needed a major review. The intention of the stage gates as identified on the maps was to operate them as formal stage reviews according to the protocol. This would require involvement of the clients (both principal clients) and the project team. However, because of the complexity of the project, coupled with the fact that the majority of the information required was fundamentally dealing with design information, it was decided to operate these formal review meeting as design meetings, which unfortunately involved the client representatives and not the clients themselves. Further, the protocol was considered to be too generic to be of use at an operational level, therefore, mini stage gates/ meetings were subsequently introduced.

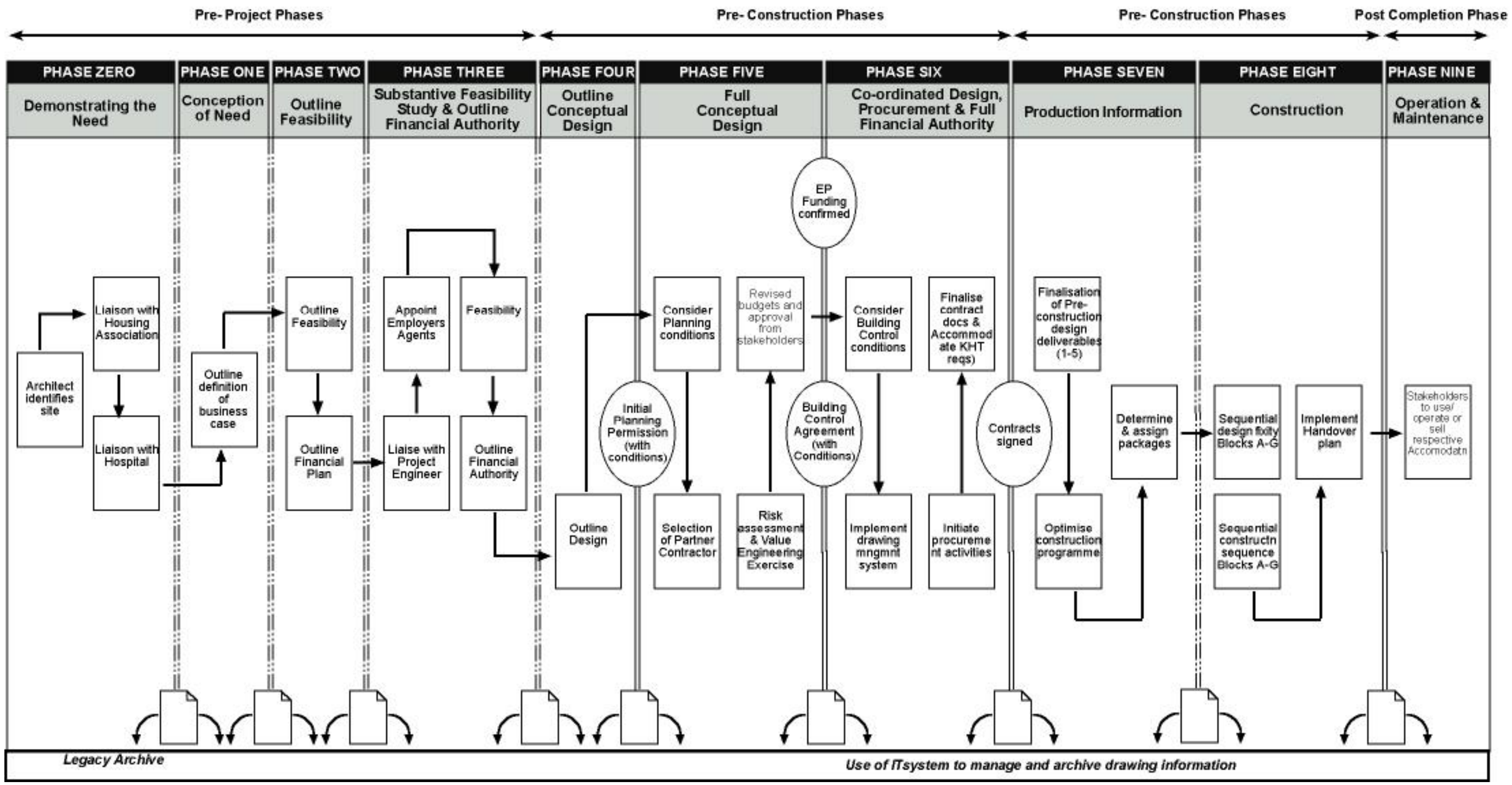


Figure 8.4: Britannia Walk project process map

The project process map received positive feedback during the analysis workshops, particularly since it was simple to understand. However, it's usefulness was somewhat limited as it only remained relevant for as long as the information or dates were accurate, and unfortunately, it was not constantly updated during the course of the project due to time and cost constraints. A live project process map would have been more appropriate, which could easily be accessible over the Internet, to aid project navigation and to enable the 'drilling down' to the operational processes. The map did, however, enable the project team to collectively discuss the co-ordination/ priority of the project deliverables in time for the stage gate/ phase review, thus improving project monitoring. This connotation of role and responsibility, to satisfy the requirements of the phase review as opposed to traditionally completing the work item in isolation, seemed to have improved the working relationship of the team. Further, this activity also inspired the project engineers to refine the project deliverables in greater detail in accordance with the phase reviews. The participants of the workshop felt that the introduction of the stage gates and deliverables at the outset would have increased the hit-rate of the project deliverables, through greater project visibility and co-ordination.

8.5.2 Project execution plan

The complexity and size of the project made it difficult for the Project Manager to control and monitor the project's progress. The project process map, as part of the process execution plan, did aid co-ordination but it was felt by the project team that a more detailed document was required for the complex construction stage. Further, due to the early involvement of the contractor on the project, there was a strong emphasis on ensuring that the relevant information was produced to enable production activities to be undertaken as early and as efficiently as possible. Therefore, a project execution plan was devised as part of the implementation of the Process Protocol, to structure the work at hand. The project execution plan comprised of an information-requirement schedule and a production process map.

8.5.2.1 Information-requirement schedule and production process map

In order to monitor the significant work items during the construction stage, an information-requirement schedule and production process map was developed as part of the Process Protocol to aid the execution of the project, in particular: -

- The information had to be available to ensure that the contractors could obtain realistic quotations from the subcontractors and suppliers regarding the specific work packages
- The information had to be provided to ensure that the package could be efficiently fabricated/ built on-site with the minimal amount of delay and/ or revision

It is clear that in both instances, the quality of information is crucial, but the same information is not necessarily required for both. Further, it was the differentiation between the information required for procuring the work items and the information required to actually construct the different aspects of the building, which became problematic to control as the project progressed due to its inherent complexity. Therefore, in order for these two aspects to be effectively satisfied, an information-requirement schedule was developed and implemented by the Process Manger (see Table 8.3). This schedule replaced the usual clarification of the required information at the design team meetings.

	Deliverables	Dates agreed	Action	Current Status
1.0	Pre-construction phase			
1.1	Employers requirements documents			
1.2	Contractors proposals			
1.3	Final basement dimensions			
1.4	Superstructure dimensioned architectural layout			
1.5	PMU dimensioned architectural layout			
1.6	PMU: Plant locations and service requirements			
1.7	Overall outline specification and materials			
1.8	Tower crane layouts and loadings			

1.9	Outline structural design, column, pile locations and loadings
1.10	Piling design and layout
1.11	Statutory authorities: services, water storage
1.12	Setting out details and datum’s
1.13	Co-ordinated below-ground drainage with sub structure
1.14	Prepare construction health and safety plan
1.15	Initial submission for building regulations approval
1.16	Start on-site
2.0	Construction phase - substructure
2.1	Final details for all foundations, pile caps and beams
2.2	Final details for below ground drainage and services
2.3	PMU: Final details of builders works requirements
2.4	Confirm lift details
2.5	Final details for PMU basement structure
2.6	Final details for car park basement structure
3.0	Construction phase - superstructure
3.1	Final structural details & bending schedules
3.2	Final details for top floor steel framing and roof construction
3.3	Final architectural details for elevations, detail sections, masonry & window details & cladding
3.4	Final M&E layouts
3.5	Final architectural details for finishes, floors, walls, ceilings, fixtures and fittings
4.0	Pharmacy manufacturing unit
	Final details of services and fit out requirements
	Final details of service shaft structure
5.0	External works
5.1	Finalise details for hard and soft landscaping

Table 8.3: Section of the information-requirement schedule

The design deliverables of the information requirement schedule were decided upon after close examination of the construction programme. These were sequenced depending on when the information was required for construction of the sub structure, PMU and the superstructure, for each individual building block and also after deciding on appropriate lead times. The deliverables decided upon were as follows: -

- Structural design drawings
- Piling design
- Piling works for construction
- Foundation works for construction
- PMU steel work, including the service shaft
- PMU substructure
- Superstructure - block A
- Superstructure - construction block E
- Superstructure - construction block H
- Superstructure - construction blocks B, C and D
- Superstructure - construction blocks F and G

For each of the above deliverables, a drawing identification number allocated by the schedule composed the specific design information that was required to complete each illustration. After consultation and discussion with the design team, the deliverables and their owners required for completing each constituent drawing was agreed by all parties involved before the project process map was fully implemented. The schedule had a positive impact on the project. At the first design team meeting to which the schedule was presented, the team members immediately started to discuss the provision of information from other disciplines. It seemed that they were now focusing more on hitting the deliverable as opposed to the information solely relevant to them. It was interesting for the researcher to observe the change of behaviour of the participants and the immediate success of the Process Protocol. The members of the meeting openly asked others when they would provide them with the specific information they required to complete their part of the deliverable. Immediately they were prioritising the work that needed to be done earliest in order to meet the requirements of the stage gate on time. Therefore, the schedule provided the project team with assistance in the phasing of the different developments on-site, in particular, it provided a clear outline of what and when information was required, and the key delivery dates from suppliers.

Significantly also, the engineers adopted the same approach when providing their design programmes to the rest of the team. The information requirement schedule illustrated when the stage gates were due, and identified the drawings the engineers were responsible and when they had to be provided by.

The schedule was updated on a regular basis, both by the Process and Project Managers, making it easier for the Project Manager to monitor project progress. However, the information that was required was forever changing making changes to the schedule somewhat cumbersome. Firstly, the design team would focus on finishing a certain aspect of work only to be told by the contractor that another specific piece of information was required more urgently. Secondly, the information being derived fed into many different aspects of work and at times it became difficult to clearly see the chain of project activities and deliverables. Thirdly, the role of the Project Manager was changed three times during the course of the implementation project, each of which had a set of specific requirements that only supplemented to the complexity of the project. Last, but by no means least, client changes and the poor communication channel between the client (e.g. Moorfields) and their representatives supported this need. The clients and their respective project teams seemed to view their individual developments almost separate to the rest of the development project. Therefore, a more strategic way to represent the information was developed, through a production process map that would incorporate the following in addition to the information requirement schedule: -

- The project procurement programme: defined the production packages and identified the key dates for when design information was required, when enquiries had to be submitted to the suppliers/ sub contractors, and when enquiries had to be returned
- Design review meetings: ensured that the design was right (in terms of cost and buildability) by obtaining feedback from the specialist suppliers and contractors. A meeting schedule needed to be produced, outlining

when meetings would take place, whom should attend and what they would address regarding the specific procurement packages

The production process map consists of 'information strands' that describes the design and procurement process of each specific construction package in the procurement schedule (see Figure 8.5). These strands link with the key activities in the production stage, providing the Project Manger with a holistic view of the design and production process for the given period for ease of project tracking. The map also incorporates a time line in the same way as the design process maps had done.

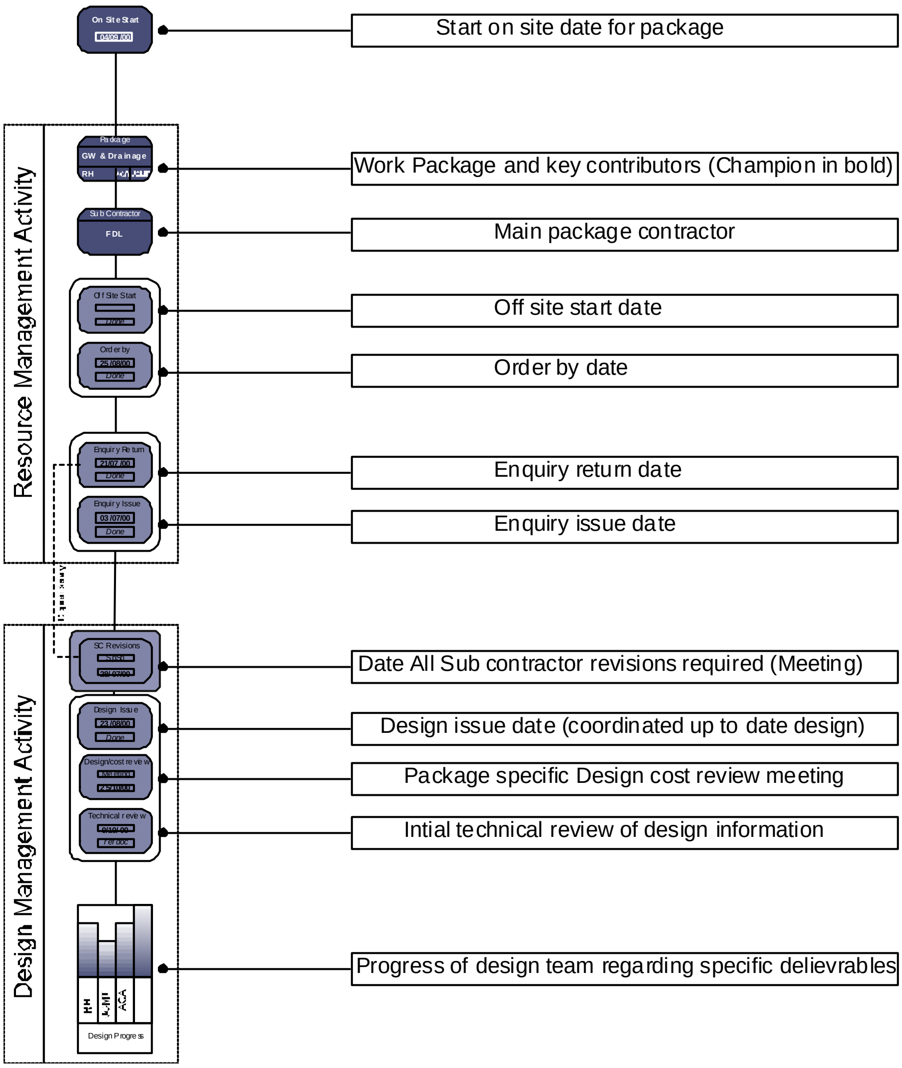


Figure 8.5: Information strand of the production process map

The Process Manager compiled each information strand of the production process map by identifying the specific design information that needed to go into each work package deliverable. The design team was asked to provide an estimate of the progress of the work at each of the design meetings, stating how much of their contribution had been completed and how long it would take to complete the remaining work. This provided an overview of the progress of the project. Once the information had been collated, a meeting was held to undertake a technical review and to obtain a group assessment of the design package to ensure effective co-ordination of design elements. A design cost review meeting then followed with the presence of the quantity surveyor to clarify the expected cost of the package prior to the design issue date. The two meetings were then scheduled to allow enough time for any modifications or changes to be dealt worth prior to the design issue date. This could range from between one and two weeks depending on the package and its design complexity. The design issue date was viewed as being cast-in-stone in order to try and achieve design fixity at the scheduled dates, and so as to not have a knock on effect with the procurement programme.

Once each package price had been estimated and the team had agreed the respective drawings, it was then issued as a formal enquiry to the respective suppliers and subcontractors. Two weeks was given for a response from the enquiry to return. Once this was received a date was set by which time any subcontractor revisions would be required to be completed. After any modifications or value engineering had been undertaken on the package and the sub contractor revisions stage was completed, an order was placed with the relevant suppliers at the correct time to allow them to successfully order/ fabricate the required package elements. This off-site start date was scheduled after consultation with the package contractors to enable sufficient time for preparatory work prior to the final on site start date. The main work packages that were identified on the original project procurement plan consisted of the following work package deliverables: -

- Groundwater and drainage
- Piling
- BWIC and incoming services

- Structural steelwork (substructure and shaft)
- Concrete frame and floors
- Screeding and waterproofing
- M&E mains installation
- Brickwork and blockwork
- Scaffolding
- Lightweight steel frame
- Roof coverings & rainwater installations
- Windows external doors and screens
- Metal work including balconies
- Wall cladding
- M&E installations

Each of the information strands were then combined and mapped into the production process map according to their on-site start date along the map timeline. The key construction packages, as described by the construction programme, were also included in the map so the project team could quickly identify when the work package deliverable was due to start on-site and what other activities would be in progress at the same time. The analysis workshops concluded that both the information requirement schedule and the production process map benefited the project. In particular, the map operationalised the schedule and provided a greater co-ordination of the design, procurement and production information, through increased transparency and visibility of the production process. The Project Manager utilised the production process map to help structure and visualise the critical information and to help to track and monitor progress by ensuring meetings were scheduled at the correct times and that information was submitted in accordance with the design, procurement and production programmes.

However, the benefit of the map was limited in that any slippage in the delivery of the design information and any resultant change to meeting dates had to be rescheduled manually, as the map was static/ paper-based. Although this was not an insurmountable problem, the efficiency of the tool could obviously be enhanced considerably by automating the map so that it can be dynamically updated. Of greater significance however, the workshop participants believed that the success of the use of the map and constituent information strands was hindered due to the familiar situation of the contractor asking the design team to redesign packages so that they could meet the required budget. The design team was not always sure what was the target budget and the subsequent rework was a cause of continual frustration. With a more open-book approach to these packages a large amount of rework could have been avoided, as the design team would be more informed of the budget to which they were designing.

8.5.3 Stakeholder list

An initial prioritised list of stakeholders of the project was produced in August 1998 as part of the original planning submission. However, only internal stakeholders, those with development interests in the project, were identified and their requirements captured. No omissions were made of external stakeholders, as suggested by the Process Protocol.

Problems arose, particularly on-site when construction work began. Residents in the vicinity often complained of the noise during certain times of the day, and the issue was only resolved once a formal meeting was arranged and the problem discussed. The identification, requirements and prioritisation of all stakeholders is a key deliverable of the Process Protocol; it aims to address any potential hindrances to the project at the onset. The workshop participants collectively agreed that the stipulation of all stakeholder interests is apparent, and should be defined and possibly addressed in the project brief. Moreover, the full benefits of this process were not substantiated since it was felt too late to introduce such a measure.

8.5.4 Communication strategy

Prior to the implementation of the Process Protocol, the exchange of information on the project was felt by the workshop participants to be inadequate due to the complexity and size of the scheme, in particular, with the distribution of drawings to the nominated recipients. The actual mechanics of how the information should be communicated and exchanged was not effectively defined at the outset, posing a key problem area for the project. It was agreed that all documents should be sent to the Project Manager for verification, but this was bypassed on several key occasions. The obvious repercussions to the project of this missed procedure became duly obvious when the work was delayed when there was no immediate consent from the Project Manager. Moreover, it was not only the Project Manager who did not receive the relevant project documents. There were frequent disagreements between the team members regarding if and when certain documents should have been received. Further, drawing revisions and versions added to this confusion.

The workshop participants felt that the exclusion of various parties from the drawing circulation was primarily due to the close working relationship between the architects and the engineers, who would attempt to resolve design issues between themselves. Problems would arise at design meetings when documents would be discussed to which the neither contractor or Project Manager had received. The contractor would then become concerned that they were not being kept informed and that their early involvement on the project was not exploited effectively. Also the different architects catering for different client requirements' added to the complexity, particularly since the various organisations were rarely all round the same table at the same time.

To combat these problems, a drawing distribution matrix was developed as part of the Process Protocol communications improvement strategy. The matrix clearly indicated who should receive and comment upon specific types of information. However, as the project progressed, it became cumbersome to constantly update the matrix since it was paper-based/ static. Therefore, it was decided to introduce an IT drawing control system to the project, not only to ensure quick responses and decision-making but to encompass effective auditing as well. This notion in part follows the legacy archive of the Process Protocol.

Although there were initial discussions regarding the utilisation of a structured e-mail system by the client representatives to combat the problems of information exchange prior to the implementation project, no formal solutions were introduced. Many of the project participants did not have a personal e-mail account. This meant that although messages could be received, the potential for an EDI (Electronic Data Interchange) system would be particularly problematic at such a late stage in the project as a significant upgrading of existing IT systems would be required. Further, the incompatibility of software systems caused significant problems. There was no attempt at the beginning of the project to co-ordinate the different systems so that they could be utilised harmoniously throughout the whole project team.

A more effective communication strategy was adopted during Phase 6 of the project with the employment of the RSUK Quality Management system (RSUK is merely a drawing distribution system that enables team members to view, and comment on drawings from other design disciplines, it does not fully represent the implications of Process Protocol’s legacy archive). The system was selected by key project team members and managed by the Project Manager throughout the duration of the project. The system was seen to be of benefit to the workshop participants principally in terms of receiving/ monitoring drawing exchanges as there was less confusion regarding revision and version numbers. They also felt that they received documents much earlier due to the electronic exchange of information instead of paper mail, but was considered inferior to the actual exchanging of CAD files by either disk or via e-mail. The system did not however dramatically reduce the slippage in the delivery of packages of design information and the problems in attaining design fixity, which was largely due to continual changes to the brief.

8.5.5 Grouping design elements/ fixity

After the implementation of the information requirement schedule and the subsequent project process maps as part of the Process Protocol, it became apparent that slippage in the delivery of the pre-identified information somewhat persisted. Although project slippage was reviewed at each design team meeting, 68% of design information was provided later than the initially agreed date (this figure was calculated using the actions and task-completions of the meetings). This was due in part to the persistently changing client requirements, particularly with the emergence of a new client, KHT, and their aspirations during the construction stage. However, it was also evident that the team was not communicating the project information seamlessly and at times, incorrect drawings were passed around. This, coupled with simple delays, such as not sending the information on time (which occurred frequently from one of the client representatives who seemed to have to suffer long delays in obtaining agreement on decisions from their client), resulted in the cycle of information flow being slowed considerably.

In order to address this problem, the design information was grouped into deliverables, the content of which were made up of specific drawings. Instead of asking for the provision of separate drawings, the Project Manager asked for the provision of completed deliverables, which required the input of various design organisations. The pre-construction phase of the project was then broken down into mini phases to effectively manage the project, thus consisting of the following: -

- All layouts confirmed
- Piling pile caps and ground beams
- Steel work to PMU
- PMU substructure
- Superstructure: structural concrete details

This fixing of design elements improved the slippage of the project, and allowed for the changing requirements of the clients. The workshop participants strongly felt that without this provision in place, the project would have fallen well behind the proposed targets.

8.6 Attitudinal survey questionnaire

Step 4 of the PPE framework stipulated examining and revising the project process measures of the Britannia Walk project. Therefore, it was decided to further examine the views and beliefs of the process strategy as implemented on the project through an attitudinal survey questionnaire. A full copy of the questions can be found in C.1 of appendix C. Telephone interviews with the respondents followed the analysis of the results as to ascertain a clearer understanding of their responses. The results are detailed in the following section.

Only 14 questionnaires were issued and subsequently returned. This low sample was accredited to the fact that the project team at the time of survey (late construction stage) were new to the project and were not fully aware of the Process Protocol implementation project. The results may have been skewed if the questionnaire was sent to the whole project team.

8.6.1 Results

The first section of the survey questionnaire relates to the use of processes in each of the respondent's own companies. This was to gain a clear insight to the respondent's familiarity with 'process management.' It is clear from Figure 8.6 that the all of the survey questionnaire respondents were familiar in using process to manage construction projects in their own individual companies. Further, this result was substantiated with the strong correlation of using a consistent project process; this result follows the same trend as illustrated in Figure 4.5 of the diagnostic survey questionnaire. Therefore, the notion of working to a set of processes and procedures was not new to any of the team members, more rather, any discrepancies to the implementation the Process Protocol could be directly attributed to the introduction of the 'new' project process rather than the 'process' method of working.

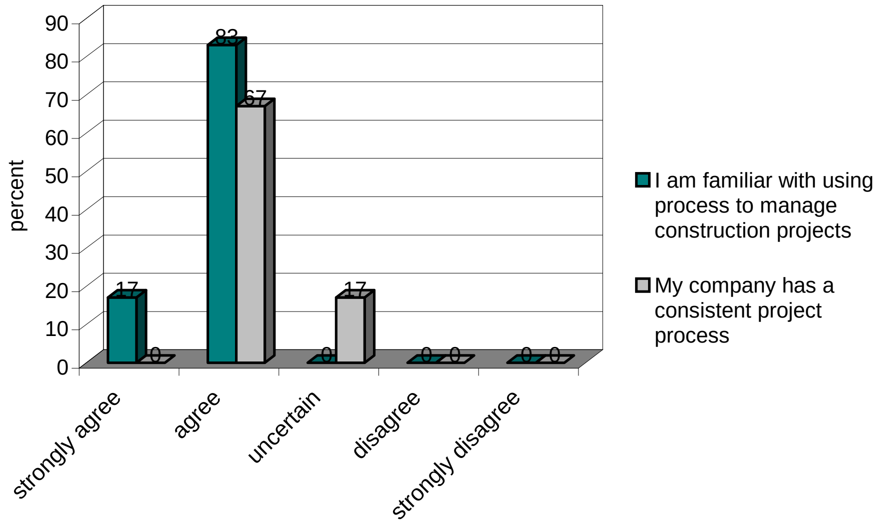


Figure 8.6: Survey questionnaire results to the use of processes

The project processes of the survey questionnaire respondent's companies, more often than not, were changed and adapted to each individual project, as illustrated in Figure 8.7. However, the results of the change/ adaptation of project processes are fairly varied across the agree, uncertain and disagree criteria, and hence there seems to be a lack of consistency in the response. This result indicates that the project team is somewhat familiar to new working practices and should readily adopt the Process Protocol. Moreover, all of the results were similar to that of the diagnostic survey questionnaire (see Figure 4.6 and 4.7).

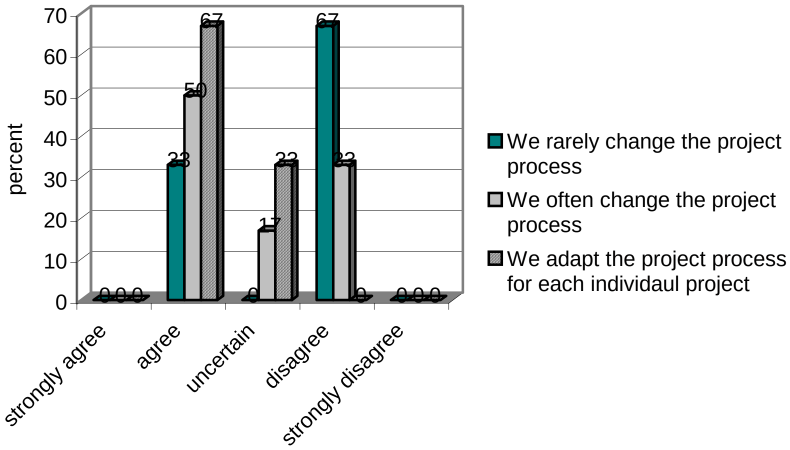


Figure 8.7: Survey questionnaire results to the adaptation of processes to a project

The survey questionnaire responses to 'the project process is always defined at the beginning of the project process' and 'we never omit steps from the predetermined project process' is somewhat varied. In both instances, the response across the selection criteria is uniform in each of the respondent's companies. Although 50% of the respondents agreed or strongly agreed to the predefined project process, there was also a significant amount of uncertainty and disagreement. Likewise, 50% of the respondents disagreed to the omitting of steps in the process, and the rest were uncertain or agreed. Moreover, the results in Figure 8.8 mimic that of Figures 4.8 and 4.9 of the diagnostic survey questionnaire; thus reaffirming the trend of construction practitioners in the UK.

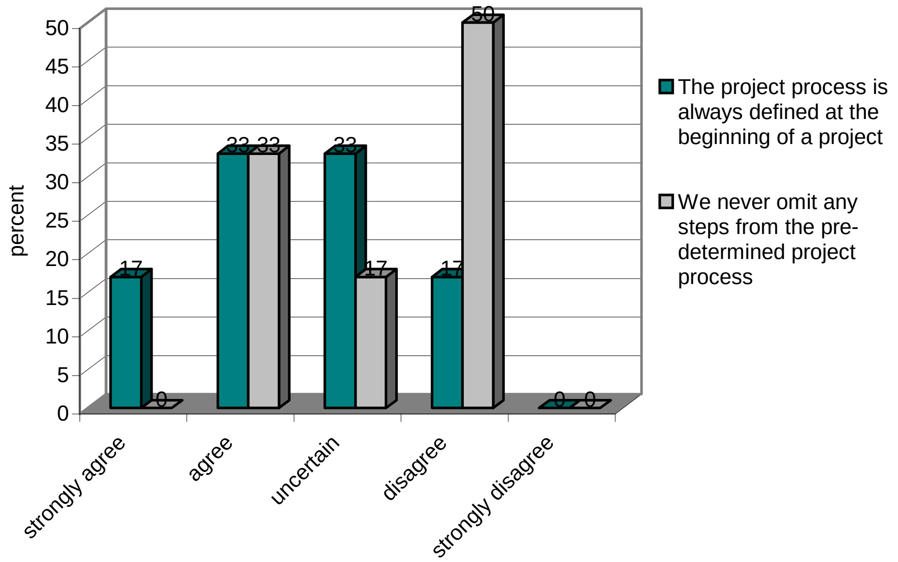


Figure 8.8: Survey questionnaire results to the definition and operation of project processes

The majority of the questionnaire respondents believed that it was not clear at the front end in their own individual companies how the project process will be managed (see Figure 8.9), in a similar fashion to the result of the diagnostic survey questionnaire (see Figure 4.10). However, regular project reviews were always conducted throughout the project. This suggests that although at the start of the project it was not always apparent who was leading the project, it was always instinctive that reviews will be conducted. The two responses are somewhat contradictory to each other, in that if there was no clear project leader then how were reviews and project decisions to be made.

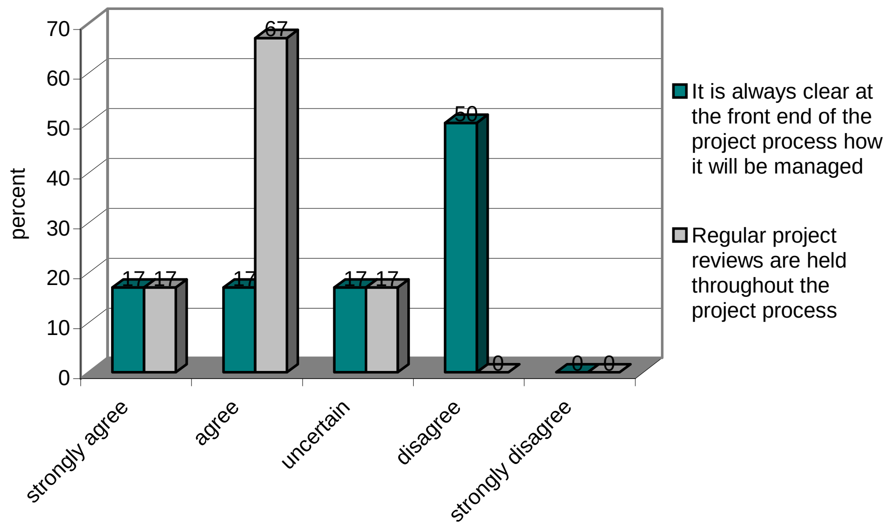


Figure 8.9: Survey questionnaire response to the management and reviews of the project process

Figure 8.10 illustrates that 20 – 40% of projects in the respondent's companies, go through a consistent process. This result is supported by Figure 8.7, in that the project process is changed and adapted to suit each individual project, and likewise by Figure 8.8, whereby the project process was not always defined at the outset. Clearly, a degree of notoriety in a consistent project process may help improve project success (Latham, 1994). Moreover, this result somewhat mirrors that of the diagnostic survey questionnaire in that 67% of the respondents agreed that 60-100% of their projects went through a consistent project process (see Figure 4.1).

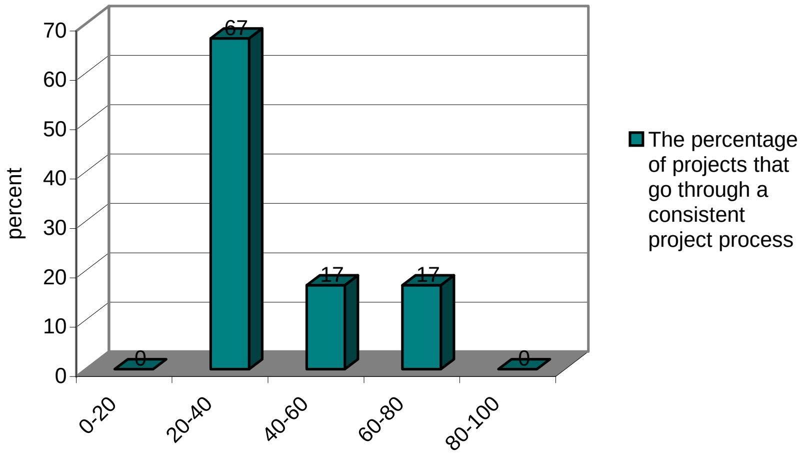


Figure 8.10: Survey questionnaire response to the use of consistent project processes

The subsequent questions of the survey questionnaire relate to the execution of the Process Protocol as applied to the Britannia Walk project. It appears from the survey questionnaire that the 'new' project process was not clearly defined on the outset of the implementation project (see Figure 8.11), although the roles in its operation were clear. These responses are somewhat contradictory, and thus there may be an anomaly in the results. If the project process was not clearly defined at the outset, then how can the project participants understand their roles?

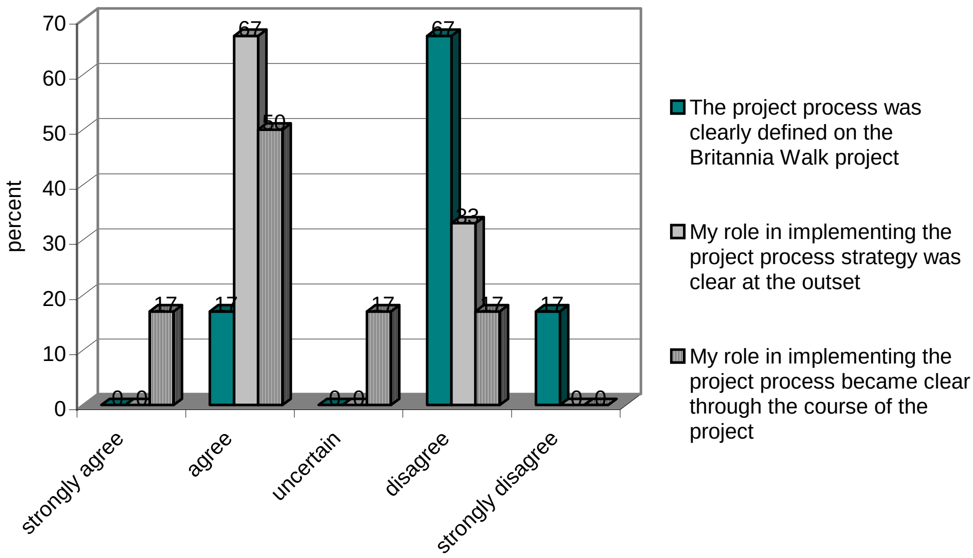


Figure 8.11: Survey questionnaire results to the implementation of the project process to Britannia Walk

Figure 8.12 details that it was the Project Manager/ Contractor who drove the implementation of the Process Protocol on the Britannia Walk project. Further, it is clear that the client's representative and the architect were not involved in this process. The client's role in the implementation project was somewhat illusioned; the majority of the questionnaire respondents were uncertain if the Process Protocol was client led. This may be attribute in part to the strong support of the 'new' project process; it is typical that any innovation is either driven or heavily supported by the client on construction projects. However, in the case of Britannia Walk, there was more than one client and a new client emerged during the construction stage of the project, who obviously were not involved with the Process Protocol on the outset, and so therefore not all the clients drove the implementation project.

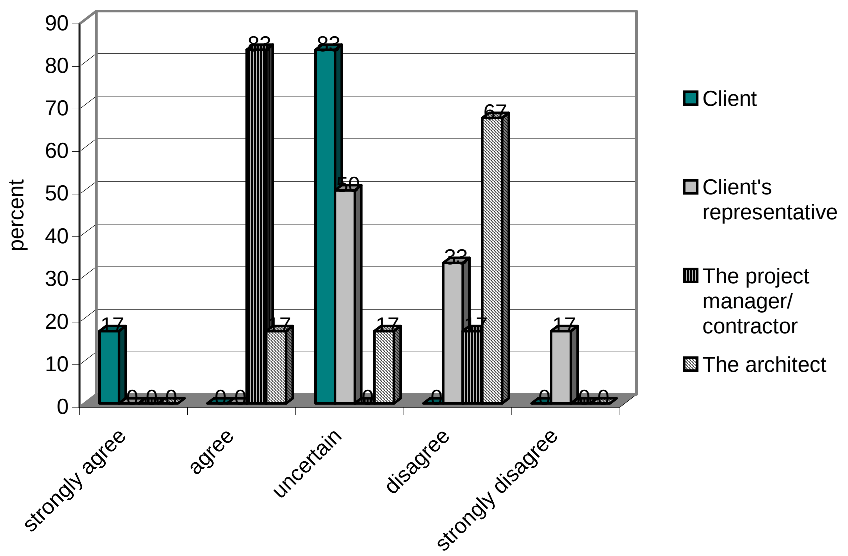


Figure 8.12: Survey questionnaire results to the drivers of the Process Protocol on Britannia Walk

It appears from Figure 8.13 that the project processes was, more often than not, changed on the Britannia Walk project throughout the course of the work, although the response to 'we rarely changed the defined project process' and 'we often changed the defined project process' was fairly uniform across the selection criteria (see Figure 8.13). This indicates that the survey questionnaire respondents were possibly unsure to the definition of the project process, nor were familiar with the process maps. However, any changes to the project process were quick and easy to implement.

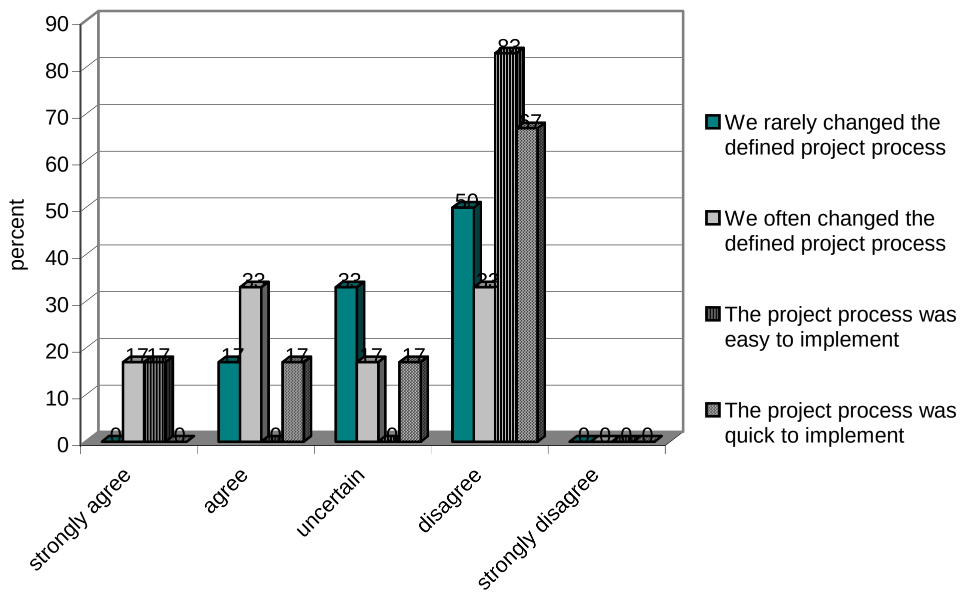


Figure 8.13: Survey questionnaire results to the implementation of the Process Protocol on Britannia Walk

Figure 8.14 suggests that none of the survey respondents had prior experience of the Process Protocol prior to the implementation project. However, the principles of the model were not sufficiently explained to the project team, as indicated by uniform response across the selection criteria. Further, this stance is supported by the response to the statement ‘the Process Protocol is easy to understand;’ the results typically mimic that of each other. Moreover, all of the respondents did accept the principles of the model. Thus ascertaining that the protocol was never appropriately explained at the outset; if the project team agreed with the principles of the Process Protocol then they would have readily adopted it.

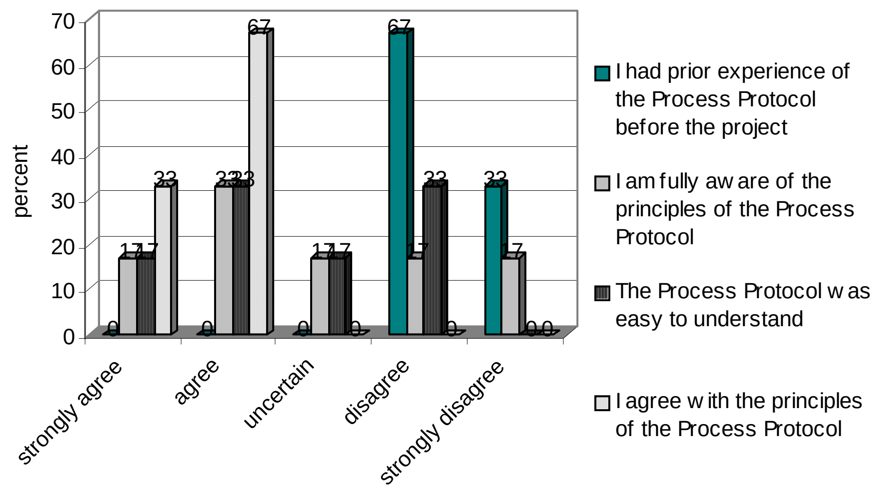


Figure 8.14: Survey questionnaire results to the understanding of the Process Protocol

The majority of the questionnaire respondents either agreed or strongly agreed that by implementing certain aspects of the Process Protocol on the Britannia Walk project, (see Figure 8.15) a whole project view, team communication and co-ordination improved the success of the project. There was, however, a certain degree of uncertainty in these categories due to the static nature of the tools developed (i.e. paper based process maps and schedules). The project team conceded that the use of progressive design fixity and an increased delivery exchange did no doubt benefit the project, through the use of grouping the project deliverables and introducing RSUK as part of the legacy archive system.

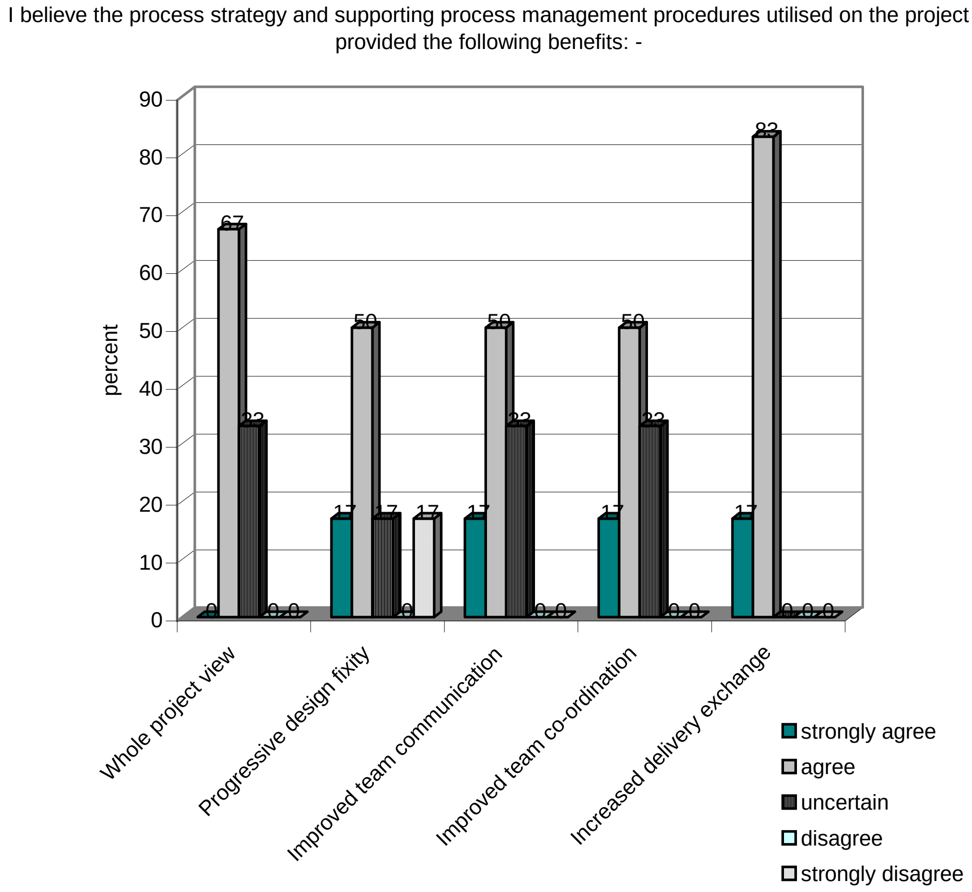


Figure 8.15: Survey questionnaire results to the utilisation of the Process Protocol (part 1)

Figure 8.16 illustrates that 67% of the questionnaire respondents believed that the Process Protocol improved stakeholder involvement, productivity and encouraged the use of cross-functional teams. However, there was also a strong degree of uncertainty or disagreement (33%) in the case of cross-functional team and improved productivity. This was due to fact that only discrete deliverables of the Process Protocol were implemented, and their benefit did not seem to affect the rest of the project; as explained from the subsequent telephone interviews with the respondents. This explanation was also given to support the result of ‘reduced lead times,’ in which there was equal consensus over the agree and uncertain selection criteria. The project team was also uniform in their response in that the model helped to focus on the client’s requirements over the strongly agree, agree and disagree selection criteria. The telephone interviews confirmed that the deliverables of the Process Protocol did aid in the structuring of the project, but as many of the models were static/ paper-based, it did not whole-heartedly cater for the ever-changing needs of the clients.

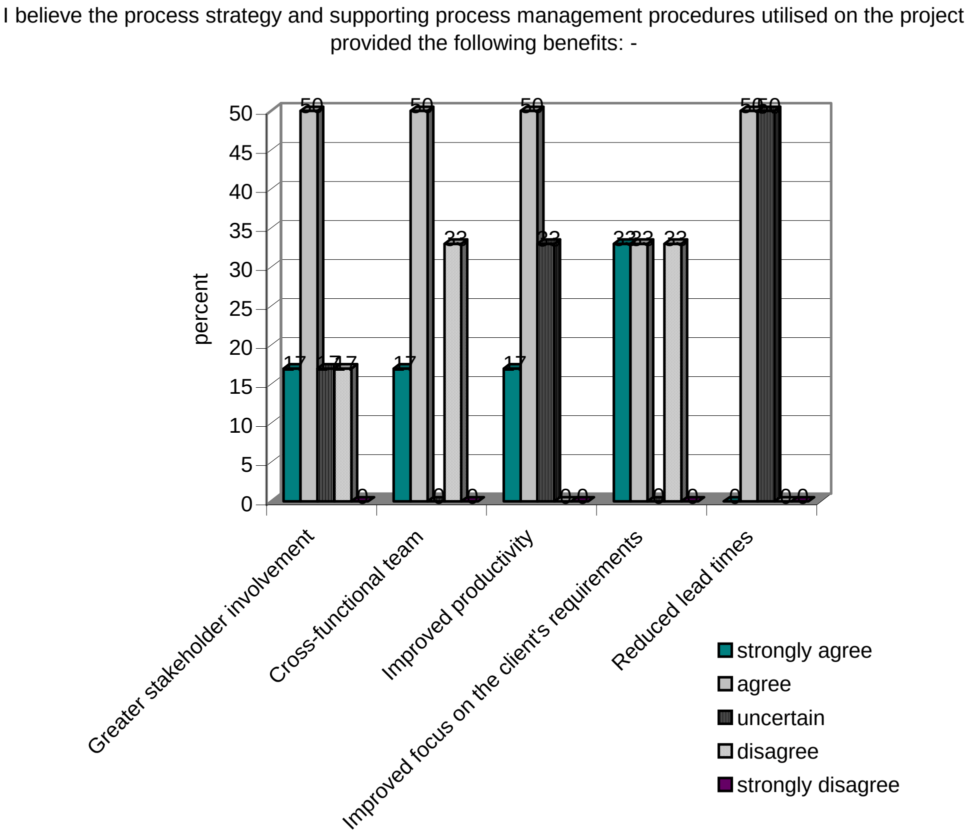


Figure 8.16: Survey questionnaire results to the utilisation of the Process Protocol (part 2)

The questionnaire survey respondents all agreed that the deliverables of the Process Protocol improved the delivery exchange of information, reduced risk, provided a quicker response to client enquiries/ changes and increased client involvement (see Figure 8.17). However, there was a significant degree of revetment to the latter three criteria. The subsequent telephone interviews with the respondents revealed that although the deliverables of the Process Protocol provided a greater detail of clarity and understanding of the risk involved in the project, this did not significantly reduce the risk. In addition, the deliverables outlayed the changes made by the client in a more coherent manner, but they did not provide the mechanism for a more noteworthy improvement to occur. The notion that the Process Protocol reduced rework and waste was not conclusive, 50% strongly agreed or agreed and 50% were uncertain or strongly disagreed to the statement. On reflection with the respondents, the structuring and prioritisation of the project information helped to reduce drawing revisions, but this could have been improved if the team was more integrated.

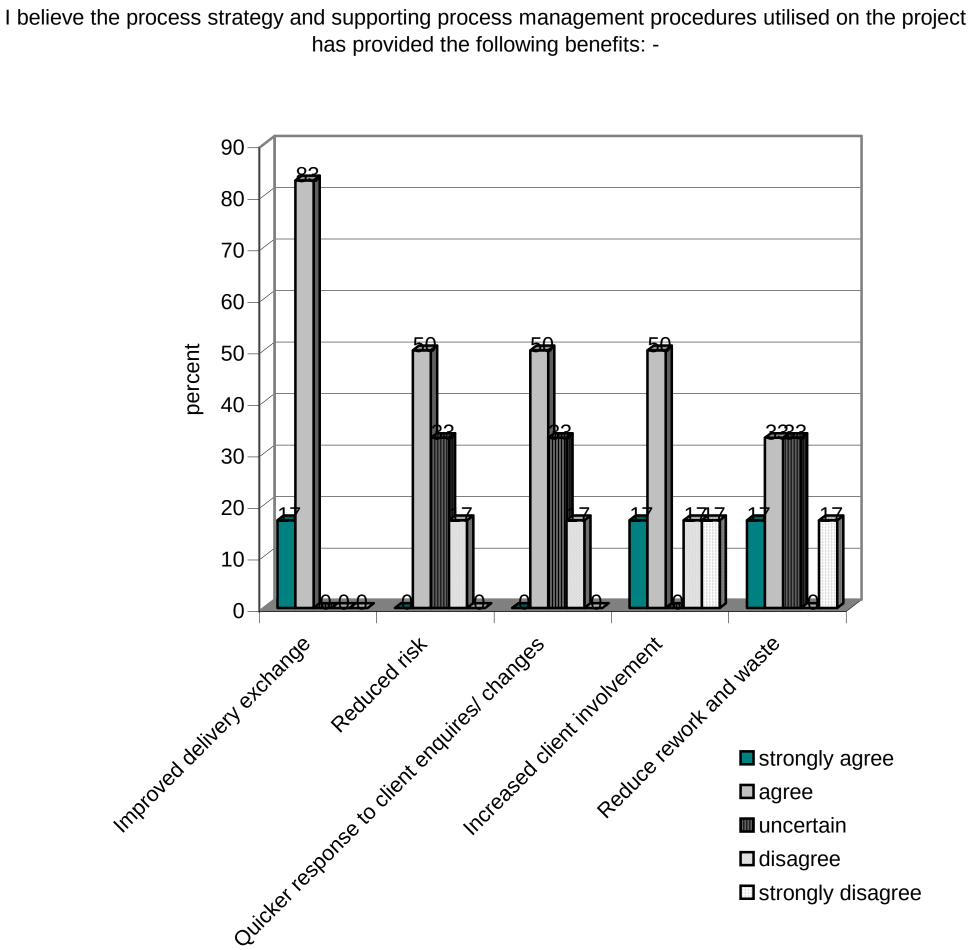


Figure 8.17: Survey questionnaire results to the utilisation of the Process Protocol (part 3)

Figure 8.18 indicates that 88% of the questionnaire respondents believed that if the Process Protocol were fully implemented (all aspects and at the onset of the construction project), it would benefit most construction projects. Perhaps the results of this case study could have showed more positive results if the protocol was fully adopted.

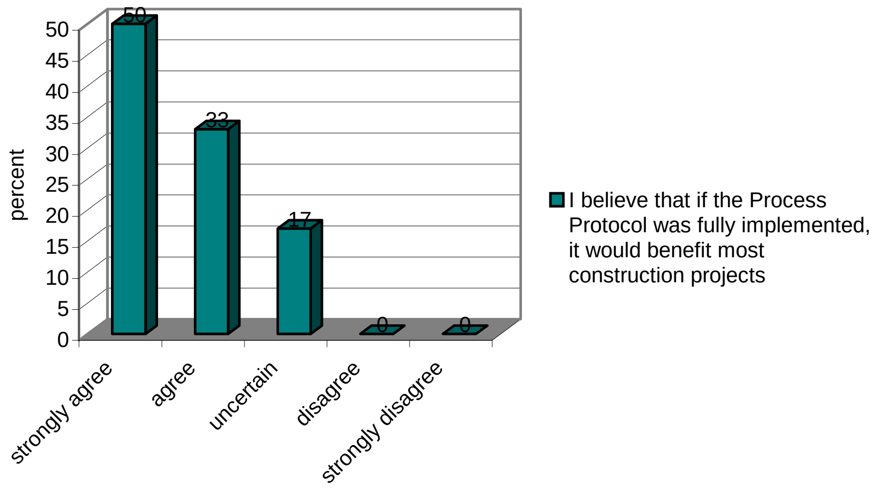


Figure 8.18: Survey questionnaire result of the perceived benefit of the Process Protocol

8.7 Summary of results

The PPE framework was used to test the key principles of the Process Protocol as they were applied on the Britannia Walk project. Table 8.4 illustrates the founding results, and confirms many of its perceived benefits. However, the full extent of the benefits are somewhat limited due to the fact that the model was not implemented until Phase 5 of the project, and more importantly, only certain deliverables were implemented. Further, the workshop participants all agreed that the inherent complexity of the project, with its many clients and stakeholders who performed different roles, significantly affected the effectiveness of the model.

Process Protocol's 6 key principles	Tested from observation, interviews and workshops	Tested within survey questionnaire	Results
A whole project view	Process execution plan – project process map	'The project process was clearly defined on the Britannia Walk project' (Figure 8.11)	Confirmed; maps need to be 'live,' introduced
A consistent process	Project execution plan – information-requirement		

Co-ordination	schedule/ production process map, procurement plan	Provided a '…whole project view, improved team communication and improved team co-ordination' (Figure 8.15)	at the onset, partnering principles need to be fully utilised
Stakeholder involvement/ teamwork	Stakeholder list Communication strategy	Provided '…increased delivery exchange, greater stakeholder involvement, cross-functional teams and improved delivery exchange' (Figure 8.15 – 8.16)	Confirmed; other aspects of the legacy archive needs to be introduced
Progressive design fixity	Grouping design elements/ fixity	Provided '…progressive design fixity' (Figure 8.15)	Confirmed
Feedback	(See section 8.7)	Not measured	Not measured

Table 8.4: Summary of the benefits tested on the Britannia Walk project

8.8 Recommendations for future improvement

Step 5 of the PPE framework stipulated the gathering of lessons learnt to inform future projects. The workshop participants all agreed that the 'delay' in the implementation of the Process Protocol on the project and its inherent complexity, limited the effectiveness of the model. The complexity of the relationships between the key project contributors and the existence of several clients made it difficult to identify one clear management authority that had executive control and influence over the whole development. This became the root of many of the problems encountered on the project and restricted the establishment of a cohesive and well-integrated project team. In particular, the three key client organisations rarely met at the same time and other team members seemed to attend the project meetings as representatives of their clients and not as core project team members. Therefore, it was difficult to identify the organisation that was responsible for ensuring a cohesive team and for undertaking an overall co-ordination role.

Although this is in part understandable due to the numerous clients and variety of roles involved, a formal workshop should have resolved this issue by identifying incentives, objectives and champions at an early stage. Moreover, the workshop participants also believed that considerable improvement could have been reaped if all aspects of the protocol were adopted, and if it was introduced earlier in the project and if the following steps were taken. These steps were derived from the outcome of a post-analysis workshop following the dissemination of the results of this study: -

- Early planning and agreement of a process implementation strategy: crucial for any process to be effective. The strategy would impose a clear direction for the project, in terms of roles and responsibilities, before any contracts are set. This would particularly aid inexperienced clients who have little knowledge of construction projects, such as with ISHA
- Understanding of the terminology and principles: to ensure a common understanding and agreement of the process objectives. This would bypass much of the confusion experienced by the team members of Britannia Walk
- Buy-in from the whole project team: even with a well-structured process strategy, a project will only be effectively implemented if the team support it and adhere to it. The team must be involved in the planning of the project to ensure a sense of ownership and subsequently buy-in
- Communication: the objectives of the project need to be communicated to the whole team to avoid marginalizing disciplines, as in the case of Britannia Walk. A project communication strategy is vital for project success, and needs to be defined and implemented at the outset. Moreover, mapping the project process is an ideal method to communicate the objectives to team, but it should be constantly updated
- Standard deliverable sets: the structuring of project information into clearly defined deliverables will assist in delivery, particularly if participation is required from numerous team members. In addition, it is important to have a standard method of representing the information so that it can be reviewed easily

- Project workshop/ induction: the Process Protocol was alien to the project participants; it is important for the team to understand the approach for buy-in. A workshop/ induction would have contributed to understanding and acceptance. Further, it would have provided an opportunity for participants to provide their comments on the Process Protocol, enabling them to contribute to strategy development
- Top management commitment: commitment and drive from all senior managers will enable buy-in of the new project process

Unfortunately, the above steps were only suggested and were by no means implemented on the project. Therefore, their effectiveness was never measured.

8.9 Conclusion

This research investigation aims to develop a PPE framework (chapter 6) to assess the effectiveness of implementing a new design and construction project process. The drive for the tool was highlighted in chapter 1 through to chapter 4; process modelling and learning from manufacturing was suggested as methods for improving the performance of the construction industry. The literature reviews and scoping study highlighted that the introduction of a new project process should be accompanied by a mechanism to assess its impact, as there is currently no specific device/ guidelines in the management arena to support this feat. The research methodology in chapter 5 stipulated the need to test and validate the framework in order to verify its applicability. The Process Protocol was used as the founding project process to test the model; the Castle Vale project (chapter 7) implemented the legacy archive, and in this chapter, the Britannia Walk project is used to validate the framework and to substantiate the benefits of the process.

Aspects of the Process Protocol, as applied on the Britannia Walk development, are detailed in this chapter. The tracking of the implementation project and its performance analysis, using the PPE framework, provided a valuable insight into how, and the many factors that hinder, the operationalisation of the ‘new’ process model. These factors include the terminology, commitment, and understanding by all project stakeholders. Nonetheless, it is clear from the case study that the aspects of the Process Protocol that were adopted did benefit the performance of the construction project, particularly by means of process mapping. Process visibility of the work structure was immediately created, and thus improved project communication and co-ordination. However, the advantages of process maps would have been significantly improved and more apparent if they were not static/ paper-based, but rather, could easily be updated and viewed henceforth by the whole team (as described in the Process Protocol guidelines).

In summary, despite some implementation issues, this case study presents empirical evidence to substantiate the benefits of adopting the Process Protocol, although all the workshop participants felt that the project would have been enhanced if the whole model were introduced in its entirety at the outset of the project. However, the results of the survey questionnaire may not fully represent the views of the whole project team, as only 14 members were available to complete the study. Framed in these terms, the results can be considered inconclusive.

CHAPTER 9: DISCUSSION AND ANALYSIS

9.1 Introduction

The aim of this thesis was to develop a framework that could be used to evaluate the effectiveness of implementing a new design and construction project process. This was achieved by investigating the literature in the areas of project processes (chapter 2) and performance management (chapter 3) in both manufacturing and construction industries, with the aim of identifying best practice and transferring them to construction. A scoping study was undertaken with companies within both industries (chapter 4) to inform and support the direction of the research. The literature reviews and scoping survey questionnaire was then used to develop, as described in the research methodology (chapter 5), the project process evaluation (PPE) framework (chapter 6). The PPE framework was subsequently tested on two case studies that adopted various aspects of a new design and construction process (chapters 7 and 8).

In both case study projects, it was the project team who were eager for assistance from the researcher to measure the success of the Process Protocol, thus confirming the timely and novel need of the PPE framework. Therefore, the aim of this chapter is to critically review the validity of the PPE framework as it was applied on the two case study projects. In doing so, the benefits/ key principles of implementing a new project process (in this instance, the Process Protocol) will be evaluated.

9.2 Cross case study analysis: the Steps of the PPE framework

The following section aims to examine the validity of the PPE framework as it was applied on the two case study projects, namely Castle Vale and Britannia Walk. As discussed in section 5.2.5.1.1, gaining access to construction case studies alone is intrinsically difficult for a researcher, as projects usually outlast the duration of the research investigation. Added to this problem was the research requirement to investigate case studies that adopted a new project process. The two case study projects selected each implemented differing aspects of the Process Protocol. The researcher played the role as 'observer as participant,' described in section 5.2.5.2.3, in order to avoid direct impact on the course of the construction project. It is anticipated that the analysis of the case studies will either refute or confirm the Steps and the subsequent validity of the framework.

9.2.1 Step 1 analysis

Table 9.1 illustrates the application of Step 1 of the PPE framework, namely the identification of the need behind the selection of the new project process, on both the Castle Vale and Britannia Walk case study projects. The selection and implementation of the Process Protocol had already taken place at the time the researcher commenced investigation in both instances. Moreover, as the researcher's role in each study was management driven, there was much commitment and co-operation from the whole project team. This management support made it easier to implement the PPE framework.

Identify the need behind the selection of the new project process	Implementation at Castle Vale	Implementation at Britannia Walk
Identify the proposed benefits of the new project process	• The Process Protocol had already been introduced to the project at the time of investigation • Data collection methods included interviews with Project and IT managers, attending project team meetings and reviewing project documentation	• The Process Protocol had already been introduced to the project at the time of investigation • Data collection methods included interviews with Project and Process managers, attending project team meetings and reviewing project

	• Interview with the system developer for a full demonstration of the operation and benefits • Interview with the client	documentation • Reviewed original project proposal
Identify the stakeholders and their requirements	• The interview with the Project and IT managers identified the stakeholders to the project • The managers subsequently organised two workshops with the stakeholders (design team and the contractors) to gain their perspective of the system • Interview with the client to ascertain client's requirements	• The interview with the Project and Process managers identified the key stakeholders to the project • Subsequently attended a series of project meetings to gain perspectives of the project process • Reviewed original research proposal to ascertain client's requirements
Confirm alignment between business strategy and new project process	• Researcher was informed that there was alignment through the interviews with the client and the Project and IT managers; not measured	• Researcher was informed that there was alignment through an interview with the Project manager; not measured

Table 9.1: The application of Step 1 of the PPE framework

Identify the proposed benefits of the new project process:

One of the prime reasons for selecting the Process Protocol as the basis to test the PPE framework was the researcher's personal involvement in the development of the second stage of the research project (see section 5.2.5.1.1). In particular, such a tool would be timely and useful tool to support the uptake of research. Nonetheless, it became clear at the onset of both case study investigations, that the researcher’s clear and concise insight into the ‘new’ project process affected the implementation of the PPE framework. The identification of the proposed benefits of the new project process was straightforward as the researcher was acutely aware of them. This insight from one stance can be viewed as positive, in that all benefits of the Process Protocol were fully understood and that no time was taken to undertake this process. However, this clear insight may have perhaps hindered the submission of this Step; if a project team member had applied the PPE framework in each case study, then perhaps the same yields/ key principles of the new project process may not have been suggested. In an attempt to reduce this inherent bias, the researcher therefore reviewed the relevant project documentation related to the selection and adoption of the process, and conducted a series of interviews with key team members to try to surmount this bias. Nonetheless, there is no evidence to determine the impact of the researcher’s knowledge of the process against the implementation of the framework. Moreover, the performance metrics as defined on the Castle Vale project are much more explicit than the Process Protocol’s key principles, thus suggesting that the researcher’s influence on the project was kept minimal.

Identify the stakeholders and their requirements:

The process of identifying the project stakeholders and their requirements was, by comparison, the same for each case study. In both instances, the management team helped to identify and arrange a series of workshops/ interviews with key project team members to ascertain their perquisites of the Process Protocol. However, the wording of this process is somewhat misleading and additional explanation was required to the project team members. Stakeholders can refer to those who are internal or external to the project; internal stakeholders are those parties who are directly involved in the development of the project, such as the client and the architect; external stakeholders include those who are going to be impacted by the result of the project, such as the local community. The PPE framework should refer only to internal/ project stakeholders, as they are in essence the only stakeholders who are involved in the selection of the project process. Therefore, it is recommended that this requisite needs to be made clearer in the model to allow the user to easily follow the Steps without any misunderstanding.

Confirm alignment between business strategy and new project process:

The confirmation of the alignment of the business strategy with the selection of the new project process was not conducted on either of the case study projects, although the researcher was assured of its accord by management in both instances. Access to the appropriate strategy documents was not granted to the researcher due to confidentiality and/ or they were not fully documented. However, the researcher felt that there was a need for this Step. It cannot always be assumed that there is always synergy between the selected process and the business strategy prior to the execution of the PPE framework. The adoption of a new project process may be a fad and its benefits may not entirely fit with the direction of the business strategy; or in the case of Britannia Walk, the government funded the execution of the Process Protocol in order to test its validity. Therefore, this Step requires further verification.

9.2.2. Step 2 analysis

The application of Step 2, as applied on the case study projects, is illustrated in Table 9.2.

Step 2: derive process performance measures for the project	Implementation at Castle Vale	Implementation at Britannia Walk
Translate organisational goals and requirements into process measures (consider the statement of need for selecting the	• Workshops with the design team and the contractors helped to define the metrics • The information	• Interviews with the Project and Process managers identified that only certain deliverables of the

new project process; consider best practice advice in the literature)	gathered in Step 1 formed the statement of need • Best practice advice on the process was not sought; the researcher already had a unique insight into the Process Protocol	Process Protocol was implemented on the project; these thus became the metrics • The information gathered in Step 1 formed the statement of need • Best practice advice on the process was not sought; the researcher already had a unique insight into the Process Protocol
Translate project process implementation issues into process measures (assess the project execution plan and its effective implementation; assess the communication of project process to the stakeholders)	• Workshops with project team identified some implementation issues and the lack of training for the operation of the system • No formal execution plan for the system was deployed and so was not measured. The assessment of the communication of the project process was achieved at the workshops (see also Step 4)	• The interviews with the Project and Process managers identified some implementation issues; these were further evidenced during the attendance of project team meetings • Both the effectiveness of the project execution plan and the communication of the project process were addressed in the design of the performance metrics
Define appropriate performance targets based on project requirements (identify any relevant known process capability; identify competitor performance; identify client and stakeholder	• No targets were identified	• No targets were identified

requirements)		
Identify data required	• Identified by the researcher	• Identified by the researcher
Determine frequency of measurement	• Irrelevant due to the time constraints of the project	• Irrelevant due to the time constraints of the project
Identify formula for data retrieval (identify source/ collection device to retrieve the required data; identify how to covert the data into the required format; identify method of storing and retrieving analysed metrics).	• Data retrieval involved interviews, workshops and telephone consultations with the system developer • The researcher identified the format of the data and the method of analysis during metric development • The storage of the metrics for future use and comparison was not conducted	• Data retrieval involved interviews and workshops, both identified by the researcher • The researcher identified the format of the data and the method of analysis during metric development • The storage of the metrics for future use and comparison was not conducted
Define who measures and responsibility for achieving targets	• The researcher conducted all measurement • No targets were identified	• The researcher conducted all measurement • No targets were identified

Table 9.2: The application of Step 2 of the PPE framework

Translate organisational goals and requirements into process measures:

In order to define the process measures for each case study, members of the team were consulted through workshops and interviews to discuss the potential barriers and opportunities of the new project process. Further, the need behind the selection of the new project process, as identified in Step 1, was translated into a statement of need and subsequently transformed into performance metrics.

Moreover, it is during this Step that best practice advice in the literature should be sought for a clearer understanding of the new project process. The researcher's clear insight into the model here proved to be a significant advantage as this was not necessary, thus saving time. However, as stated earlier in section 9.2.1, the same performance yields may not have been suggested if a project team member had applied the framework.

Translate project process implementation issues into project measures:

The second process in Step 2 of the PPE framework aimed to define metrics related to the efficacy of the implementation of the Process Protocol. These issues, which included the communication of the new project process to the project team, were identified through interviews, workshops and attending project meetings on both case study projects. The consideration of the effective implementation of the project/ process execution plan into metrics was also proposed during this process. However, as there was no plan in place at Castle Vale, it was not measured. This is where the implementation of the PPE framework differed on the case study projects.

The lack of a formal project/ process execution plan may have perhaps hindered the uptake of the new project/ communication process at Castle Vale. This was reflected by the requests of the workshop participants for the need of more training of how to use the legacy archive/ system; perhaps then the benefits of the Process Protocol would have been fully envisaged.

Define appropriate performance targets based on project requirements:

The third process of Step 2 in the PPE framework involved defining targets for each of the process performance metrics developed. This was not conducted on either case study projects, partly because measurement would only be executed once, at the end of each project, and so any improvement techniques could not be introduced as to reach the targets. In addition, it was difficult for the researcher to identify any known process capability and competitor performance as to form a basis for each target during the timescale of this thesis. Construction process performance is not usually measured, and so the researcher would have had to conduct a detailed and vigorous analysis of past and current projects similar to that of Castle Vale and Britannia Walk to ascertain relevant data to inform the generation of performance targets. Therefore, this step of the process also requires further evaluation, and the need for staged/ progressive targets would be confirmed.

Identify data required; determine frequency of measurement; identify formula for data retrieval; define who measures and responsibility for achieving targets:

The next four processes of Step 2 were conducted concurrently in the development of process performance metrics in each case study projects. The researcher identified the data required for each measure as it was derived, with assistance from the project team in both case studies. The frequency of measurement was dictated by the time constraints of the project; the researcher began investigation towards the end of each case study, therefore, measurement could only be carried out once. However, it would have been interesting to be able to compare the results of implementing the Process Protocol at the start of implementation and at the end of the project. The researcher perceives that this direct comparison would have clearly supported or refuted the adoption of the new project process.

The researcher determined the formula for the retrieval of the data with assistance from the project team. This involved identifying the source of the required information, and how to convert and analyse the data so that it provided succinct information to the project team. Unfortunately, due to the time constraints of both projects, the metrics were not stored in a manner that could easily be used in a continuous improvement programme that could inform and improve future projects. Again, this is an area that requires further verification, although this should have been incorporated at Castle Vale since the client was considering the use of the PIC on future projects.

It was agreed at the outset by management, that the researcher would conduct measurement on both case study projects. No intervention into the project process was undertaken, thus should have not significantly affected the course of the project (see Figure 5.3). Perhaps team involvement in this process would have increased process buy-in; according to Dixon et al (1990), greater team buy-in into the process occurs through team performance measurement.

9.2.3 Step 3 analysis

Table 9.3 illustrates the extent in which Step 3 of the PPE framework was implemented on the two case study projects.

Step 3: conduct project process measures	Implementation at Castle Vale	Implementation at Britannia Walk
Communicate strategic objectives, performance metrics and targets to project team	• The strategic objectives of the project were outside the remits of the researcher's involvement in the project; the extent to which this was deployed is unknown • The performance metrics developed by the researcher was not communicated to the project team; it was agreed with the Project manager, IT manager and the client at the outset of the investigation that any measurement would not affect the project and that	• The strategic objectives of the project were outside the remits of the researcher's involvement in the project; the extent to which this was deployed is unknown • The performance metrics developed by the researcher was not communicated to the project team; it was agreed with the Project manager, Process manager and a committee set by the DETR at the outset of the investigation that any measurement

	the team members would not change their behaviour • No targets for each metric were developed.	would not affect the project and that the team members would not change their behaviour • No targets for each metric were developed.
Ensure stakeholders understand their measurement role (ensure training requirements are met)	• Not applicable	• Not applicable
Measure and analyse the results	• Conducted by the researcher	• Conducted by the researcher

Table 9.3: The application of Step 3 of the PPE framework

Communicate strategic objectives, performance metrics and targets to project team:

Step 3 firstly involves communicating the strategic objectives, performance metrics and targets to the project team. Unfortunately, the client's strategic objectives of the project were not made apparent to the researcher on both case study projects, so its alignment with the project process or its deployment to the project team was outside the remits of the investigations (see Step 1). Further, no process performance targets were set and so were not relayed to the project team.

It was agreed at the onset with senior management on both case study projects, that the process performance measures would not be communicated to the project team. This was so that any measurement conducted by the researcher would not affect the course of the project and would not change the behaviours of the team members. This is perhaps a negative stance on performance. First and foremost, it is true that measurement should not significantly hinder the day-to-day operation of any project (Dixon et al, 1990). However, more positive results may have resulted with project team awareness of the metrics. Conversely, this awareness can cause dysfunctional behaviour (Brown, 1994) as the project team may work harder in the only areas of measurement. Peters and Waterman (1982) capture this stance in their infamous statement '…what gets measured gets done.' The negative or positive impact to the project is here yet concluded and thus contributes to the continuous performance debate.

Ensure stakeholders understand their measurement role; measure and analyse the results:

The following two processes of Step 3 of the PPE framework involved ensuring that the stakeholders understood their measurement role, and to measure and analyse the results. As the researcher conducted all measurement in both case study projects, the first of these processes was not apparent. Again, an improved project and performance buy-in and involvement may have occurred if the project team were involved in the measurement process. However, the risk of bias in the results is reduced with an external party administering the measurement. This factor, as stated earlier, remains undecided by experts in the performance management field.

9.2.4 Step 4 analysis

Step 4 of the PPE framework suggested continuously revising the project process measures derived in Step 2, so that best and improved process practice could occur during the current and any future projects (see Table 9.4).

Step 4: continuously revise project process measures	**Implementation at Castle Vale**	**Implementation at Britannia Walk**
Repeat step 2: identify and	• Metrics reviewed by the researcher and members of	• Metrics reviewed by the researcher and members of

implement any improvements to the process and metrics	the project management team • Identified that additional costing information was required	the project management team • Identified that an additional survey questionnaire was required
Repeat step 3	• Measurement was conducted for the additional metric	• Measurement was conducted for the additional metric
Communicate revised strategic objectives, performance metrics and targets to project team	• The strategic objectives of the project were outside the remits of the researcher's involvement in the project; the extent to which this was deployed is unknown • The revised performance metrics developed by the researcher was not communicated to the project team; it was agreed with the Project manager, IT manager and the client at the outset of the investigation that any measurement would not affect the project and that the team members would not change their behaviour • No targets for each metric were developed	• The strategic objectives of the project were outside the remits of the researcher's involvement in the project; the extent to which this was deployed is unknown • The revised performance metrics developed by the researcher was not communicated to the project team; it was agreed with the Project manager, Process manager and a committee set by the DETR at the outset of the investigation that any measurement would not affect the project and that the team members would not change their behaviour • No targets for each metric were developed

Table 9.4: The application of Step 4 of the PPE framework

Repeat step 2: identify and implement any improvements to the process and metrics:

In order to continuously revise the project process measures derived in Step 2, the definition of each metric was looked at again in each case study project in order to redefine its relevance. This also led to the identification of any measurement 'gaps.' In both case studies, a subcommittee, made up by members of management, reviewed the metrics to ascertain any improvements in the measuring process. At Castle Vale, it became apparent that additional costing information was required, and so each individual company was contacted for the appropriate data. In the case of Britannia Walk, it was decided that an attitudinal survey questionnaire was required to capture personal perceptions of the Process Protocol by the project team. Therefore, this process was key to the success of the framework.

Repeat step 3; communicate revised strategic objectives, performance metrics and targets to project team:

Once the improvements were identified, they were rolled-out to each project. For the same reasons as stated in Step 3, the strategic objectives and revised measures were not communicated to the project team.

However, the effect of the lack of the application of this Step was witnessed first hand on the Castle Vale project. As the majority of the project team was not aware of the work undertaken neither by the researcher, nor the results – the performance of the system – the full benefits of the project communication process were not fully reaped and envisaged. For example, through using the system, the contractors were faced with the printing costs of project documentation, perhaps for the first time ever on a construction project as the architect had usually supplied them. Therefore, from their perspective they saw that this was a significant drawback of using the tool. However, the overall savings envisaged by the client far outweighed this; costs were saved as project documents were only printed out as and when they were required. This method of printing out project documentation, a pull technique rather than the design team pushing/ printing out all documents for the whole team, fundamentally changed the 'typical' design and construction process. If the contractors were made aware of the results of the investigation and fully understood the implications of the system on the whole project, the system would be more readily adopted. Perhaps they could have been recompensed respectively as the architect's charges would have significantly dropped.

9.2.5 Step 5 analysis

Table 9.5 illustrates the application of Step 5 on the case study projects.

Step 5: use process findings to inform and improve current & future projects	Implementation at Castle Vale	Implementation at Britannia Walk
Develop and adopt a regular formalised review programme	• Not implemented	• Not implemented
Ensure findings are easily retrievable and in an appropriate format	• Not implemented	• Not implemented

Table 9.5: The application of Step 5 of the PPE framework

Develop and adopt a regular formalised review programme; ensure findings are easily retrievable and in an appropriate format:

Step 5 of the PPE framework stipulates the use of the process findings to inform and improve upon current and future projects. Improvements were suggested for each investigative case study, but were not subsequently implemented and reviewed due to the time constraints of the implementation projects. The researcher was asked, following the completion of the Castle Vale study, to repeat the investigation on another project. However, this was incompatible with the timescale of this thesis. Thus, the framework needs to be adopted by clients or project managers in order to be taken forward/ driven on future projects.

9.3 Cross case study analysis: the benefits of the Process Protocol

The Process Protocol was used in this thesis as a basis to test the value of the PPE framework. The model was selected for investigation because firstly, it is a 'new' design and construction process, and secondly, the researcher was actively involved in the second stage of its development. Although various companies had already adopted the model, it was anticipated that the findings from this research investigation would provide further empirical evidence on its effectiveness. Its key principles had already been validated on other projects (Process Protocol, 2002). The framework thus becomes a timely tool, and novel in that management approached the researcher on both case study projects for assistance in measuring the effectiveness of implementing the Process Protocol. The extent in which these key improvements or benefits of the Process Protocol were measured; the results are displayed in Table 9.6 and discussed below.

Key principles	**Castle Vale**	**Britannia Walk**
Whole project view	• Confirmed through attitudinal questionnaire	• Confirmed by the development of project process maps and attitudinal questionnaire
Progressive design fixity	• Not measured	• Confirmed by the grouping of design elements into deliverable sets
A consistent process	• Not measured	• Somewhat confirmed, introduced project process maps that helped to reiterate the nature of the Process Protocol
Stakeholder involvement/ teamwork	• Somewhat confirmed through attitudinal questionnaire, allowed greater team integration	• Confirmed by the development of a communication strategy (and subsequent aspects of an electronic legacy archive) and a stakeholder list
Co-ordination	• Confirmed by attitudinal questionnaire	• Confirmed by the development of project process maps and attitudinal questionnaire
Feedback	• Somewhat confirmed	• Not measured

	through attitudinal questionnaire	

Table 9.6: The measurement of the six key principles of the Process Protocol on the two case study projects

Whole project view:

The two case study projects confirmed that the Process Protocol did enable a whole project view, as proposed (see section 2.5.2.1). This was confirmed in both case studies through the use of an attitudinal survey questionnaire. Both project team members agreed that the Process Protocol fundamentally began to bring together the whole team, in particular, the designers and the constructors, encouraging buildability. This was suggested by Ettlie and Stoll (1990), Charney (1991), Smith and Reinerstein (1991) and Cooper and Klienschmidt (1994).

At Castle Vale, the ‘legacy archive’ enforced the consideration of all project documentation and allowed the users easy access to the project documentation. This helped to create a transparent ambience in the project; the team members could clearly see what work was being done in other areas of the scheme, where they would be contributing specifically and where their input would assist the development. Moreover, this visibility and transparency helped to increase project communication and co-ordination.

The development of various project process maps on Britannia Walk (high-level and a production map; see section 8.5.2) also enabled visibility of the whole project, enhancing communication and co-ordination. However, these maps would have substantially improved upon the performance of the project if they were live and were constantly updated. Moreover, the researcher perceives that this would not be an issue if the Process Protocol was fully applied on a single project, unlike that of Castle Vale and Britannia Walk that only adopted differing aspects of the model; additional testing would be required to either refute or confirm this perception.

Progressive design fixity:

The notion of progressive design fixity of the Process Protocol was not applied on the Castle Vale project. On the Britannia Walk project, however, the grouping of design elements into small deliverable sets, as to progressively fix the design so that it could be constructed, aided the development immensely. It helped to co-ordinate the various project team members on the multi-use mixed development. Therefore, it can be concluded through the Britannia Walk project, that this key principle was substantiated (see section 2.5.2.2).

A consistent process:

Again, the idea of a consistent process was not apparent to the Castle Vale project. This was because the legacy archive was merely a tool to aid the communication and co-ordination of project documentation and did not directly impact the nature of the process of design and construction. The use and development of the project process maps on the Britannia Walk project did exert a sense of consistency for future projects, as felt by the attitudinal survey questionnaire respondents. The project team members felt that the processes detailed were logical and ordered, as suggested by Kuczmarski (1992) to yields the most productive results. However, for this key principle to be fully confirmed (see section 2.5.2.3) the Process Protocol needs to be applied on more construction projects.

Stakeholder involvement/ teamwork:

The two case study projects both confirmed that the Process Protocol aided stakeholder involvement/ teamwork (see section 2.5.2.4). This was clearly evidenced by the ability of all project team members to openly view and comment on all project documentation via the legacy archive at Castle Vale, thus increasing in principle the buildability of the design (Monden, 1993; Womack et al, 1990) as highlighted in the attitudinal survey questionnaire. The adoption of a similar document management system at Britannia Walk also confirmed this principle. In addition, a communication strategy and a stakeholder list were also introduced at Britannia Walk that helped to increase stakeholder involvement/ teamwork. The stakeholder list relayed all of the people who were directly involved in the project, to which the communication strategy defined the methods in which they would correspond with each other. This set the scene for greater teamwork to reduce further the disputes among functions and to pre-empt problems (Griffin, 1997).

Co-ordination:

The use of survey attitudinal questionnaires proved that the Process Protocol did improve project co-ordination (see section 2.5.2.5) in both case study investigations. The legacy archive helped to control and monitor all data exchanges on the project, improving co-ordination by enabling all project documentation to be sent to the relevant parties. The development of project process maps helped to co-ordinate the project team on the numerous deliverables on the Britannia Walk project. Thus helping to effectively handle the interactions and complexities of a multi-disciplinary team approach as suggested by Howell (1999) and Baxendale et al (1996).

Feedback:

The notion of feedback to improve and inform current and future projects was partially confirmed on the Castle Vale project. The system allowed a greater response to project changes through commenting, thus, continuously improving the project (see section 2.5.2.6; Kartam, 1996; Kumaraswamy & Chan, 1998). However, this metric was not implemented on the Britannia Walk project. Further testing of this key principle of the Process Protocol is required.

9.4 Discussion

As a result from the cross case study analyses, it became clear that the following Steps of the PPE framework could not be fully implemented: -

- Step 1: ‘confirm alignment between business strategy and new project process’
- Step 2: ‘define appropriate performance targets based on project requirements’
- Step 2: ‘define who measures and responsibility for achieving targets’

- Step 3 and 4: ‘communicate strategic objectives, performance metrics and targets to project team’
- Step 3: ‘ensure stakeholders understand their measurement role’
- Step 5: ‘use process findings to inform and improve current and future projects’ (involving ‘develop and adopt a regular formalised review programme’ and ‘ensure findings are easily retrievable and in an appropriate format’)

A number of the above Steps of the PPE framework were not implemented on the case study project because they were outside the remits of the researcher’s boundaries. For example, ‘confirm alignment of the business strategy with the new project process.’ This was because the client’s business strategy was not made openly available in both instances. However, it can be argued that this process is redundant since it should have already been deployed once the new project process was selected. This process requires further testing. Also, the process ‘communicate strategic objectives, performance metrics and targets to project team’ was not performed since it was agreed on both studies by management that measuring would not affect or hinder the course of work. Again, this is an issue that needs further investigation, to clarify the degree to which awareness of a measurement process has a negative or a positive effect on the outcome of the project; this factor has been studied in other fields, such as psychology, and is outside the boundaries of this study.

Other Steps of the framework were not conducted at all on either of the case studies, such as ‘define appropriate performance targets based on project requirements.’ This was in part due to the time constraints of the researcher, and that management had not confirmed whether the Process Protocol would be implemented on future projects and so the value of setting targets for improvement would not be valid (measurement was conducted towards the end of each project and so the identification of performance targets was not imminent). Further, the lack of application of this process was transposed into ‘communicate strategic objectives, performance metrics and targets to project team’ and ‘use process findings to inform and improve current and future projects.' Again, these Steps require further testing and validation.

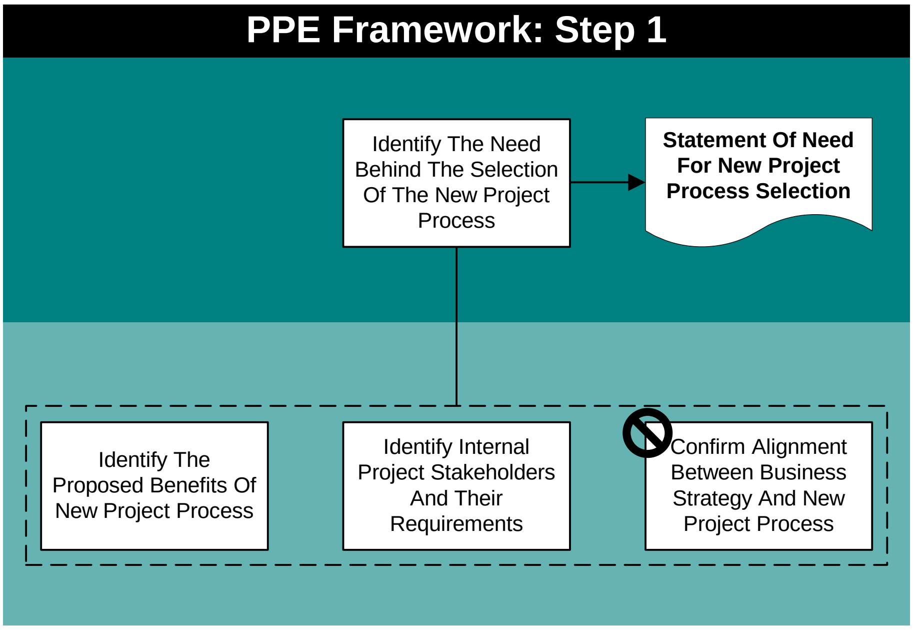
However, there were also Steps that were not fully tested as the researcher conducted all measurement; 'define who measures and responsibility for achieving targets' and 'ensure stakeholders understand their measurement role.' This was due to the time constraints of the researcher as she was deployed towards the end of both investigative projects, and that it was agreed by management at the onset that any investigation would not significantly hinder the course of the project. Involving the project team during the measurement process may have possibly increased buy–in and subsequently significantly improved productivity. Again, these Steps require further testing.

Therefore, in lieu of the number of Steps of the PPE framework that was not implemented during the case studies, it could be argued that there were more steps than were required for the testing of the effectiveness of new project processes. However, the PPE framework is similar in nature to the Process Protocol in that it should not be used as a prescriptive guideline - it does not aim to instruct or force uptake, but rather to allow individual project customisation. Framed in these terms, the Steps that were not utilised in the case studies may not be relevant to the cases tested. Without further implementation and analysis this proposition cannot be substantiated nor refuted.

Moreover, as a direct result of implementing the PPE framework, it became clear that the process: 'identify the stakeholders and their requirements' in Step 1 of the model should be modified to 'identify internal project stakeholders and their requirements.' This is to address the ambiguity of the word 'stakeholder'. There are both a number of internal (the client, contractor, architect etc; those who are directly involved in the development) and external (local authority, local community etc; those who may be impacted by the project) stakeholders in any project. The project process is usually only selected on the premise of internal project stakeholders, and therefore the framework should specifically make reference to this stance.

The researcher's unique insight into the Process Protocol did affect the application of the PPE framework. Moreover, this insight was positive in some instances, and negative in others. For example, time was saved in Step 1, 'identify proposed benefits of the new project process,' as the researcher was already aware of the key principles of the Process Protocol. However, perhaps all of the parameters of the model were not important to the project, and/ or perhaps other characteristics of the protocol were responsible for its selection. The researcher may not have considered these additional characteristics. This is particularly apparent in the Britannia Walk case study since the protocol was not fully implemented.

The revised steps of the PPE framework are shown below (see Figure 9.1, 9.2, 9.3, 9.4 and 9.5);  denotes that the process requires further testing analysis.



<u>Figure 9.1: Step 1 of the PPE framework (processes that require further validation are indicated)</u>

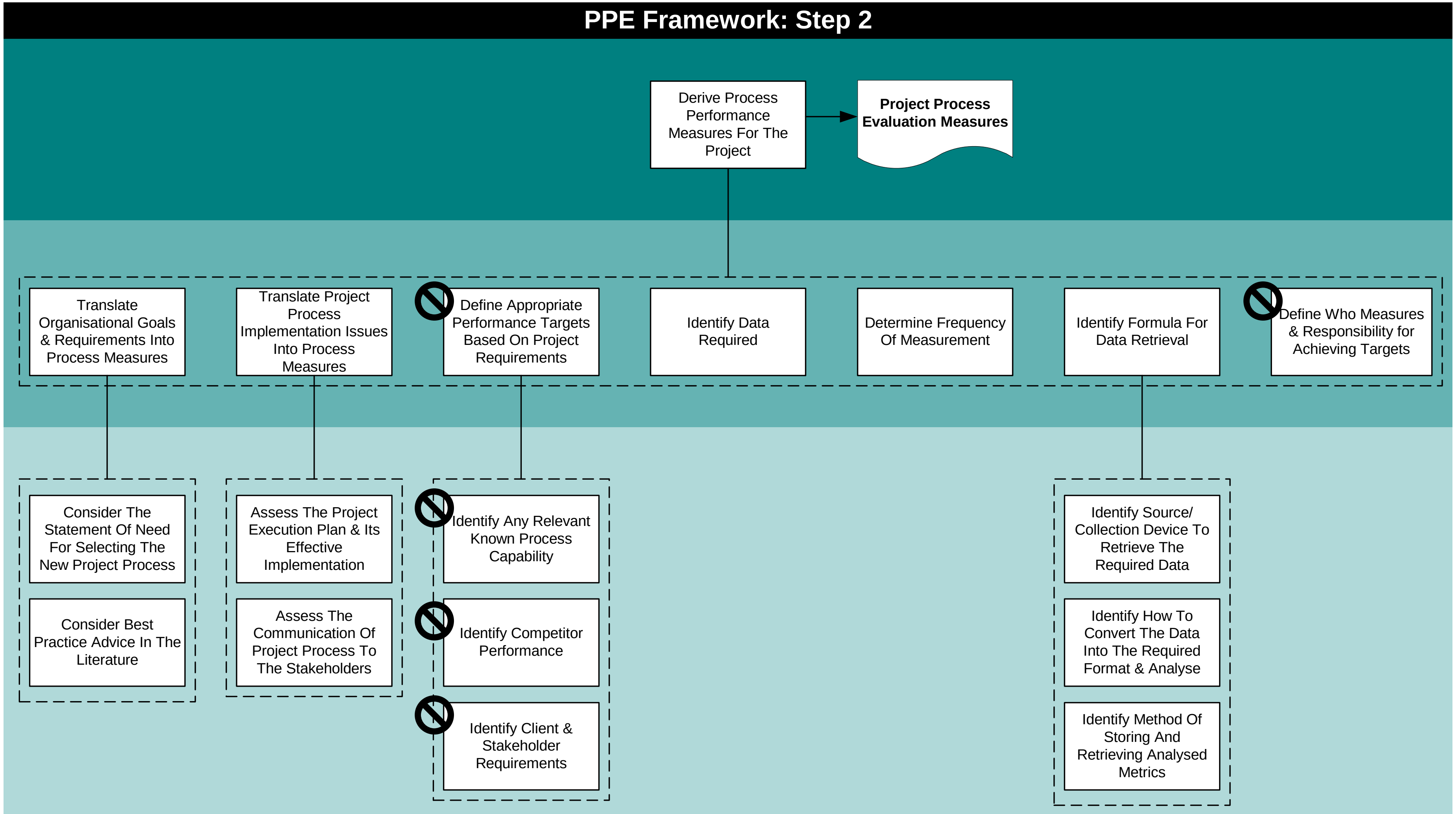


Figure 9.2: Step 2 of the PPE framework (processes that require further validation are indicated)

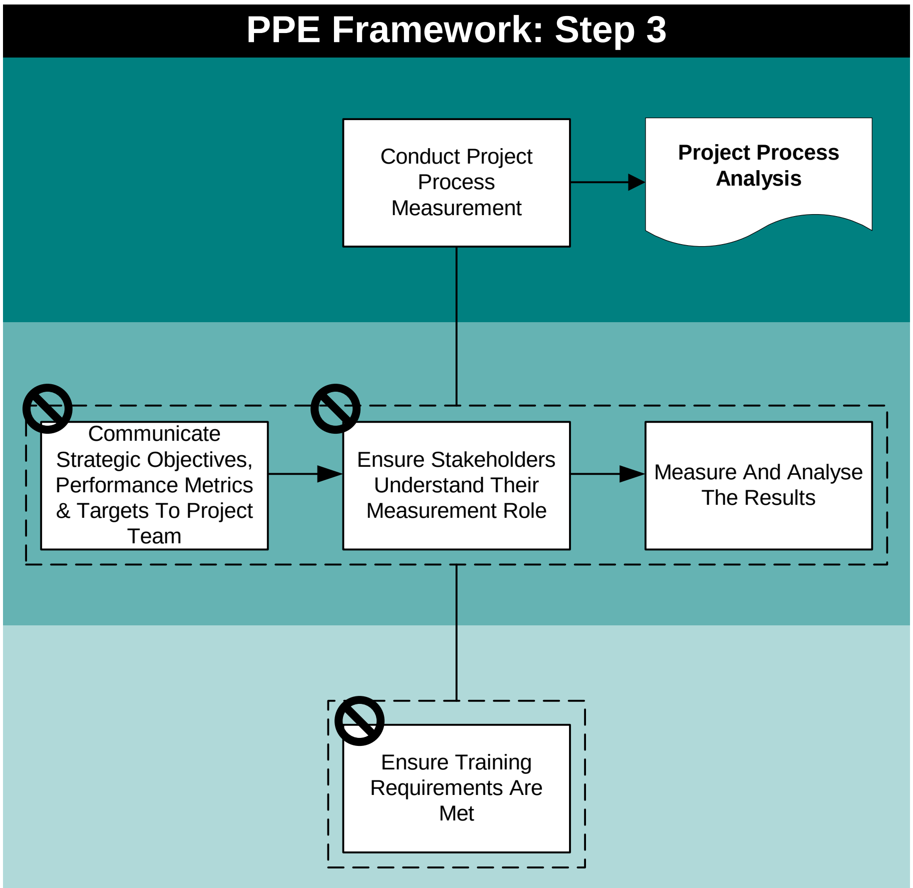


Figure 9.3: Step 3 of the PPE framework (processes that require further validation are indicated)

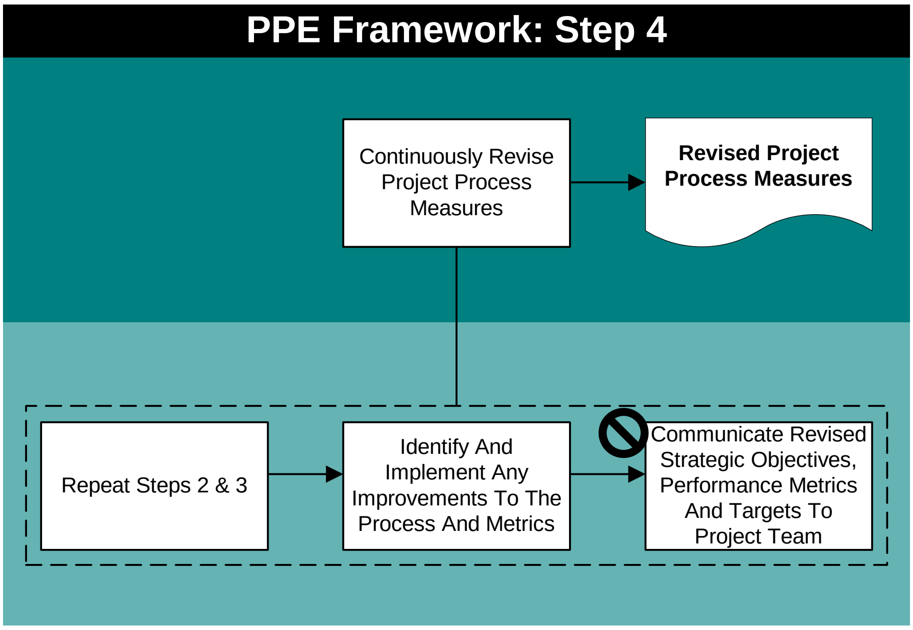


Figure 9.4: Step 4 of the PPE framework (processes that require further validation are indicated)

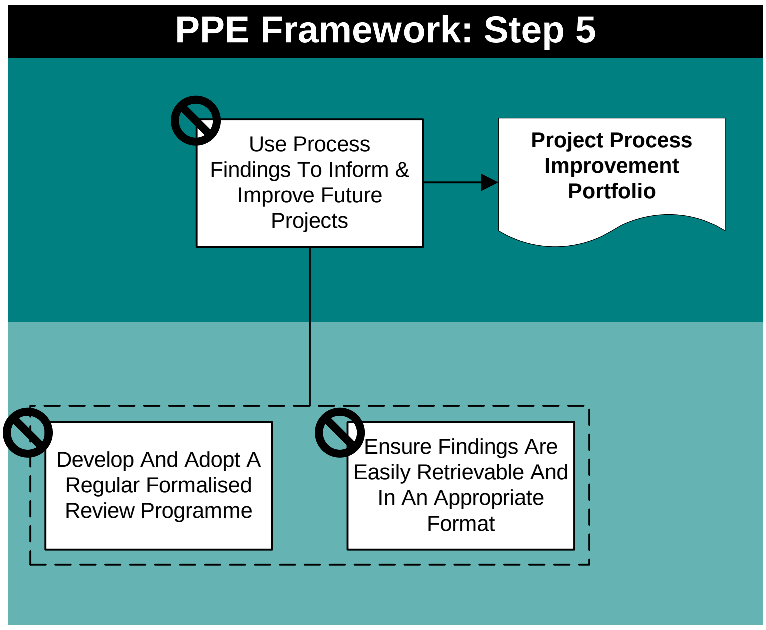


Figure 9.5: Step 5 of the PPE framework (processes that require further validation are indicated)

It is also worth noting here that the modelling method, borrowed from the Process Protocol II research project, particularly suits the PPE framework. The levels of process shown in each Step is dictated by the granular detail required to explain it without the conviction of a comprehensive glossary; level two of each Step is always depicted; level 3 is used where further clarity or definition is required of the corresponding upper level process. As stated earlier, it is anticipated, as with the Process Protocol, that users can customise the processes to suit their individual requirements. The high level steps of the model are illustrated in Figure 9.6; a full copy can be found in appendix D.1.

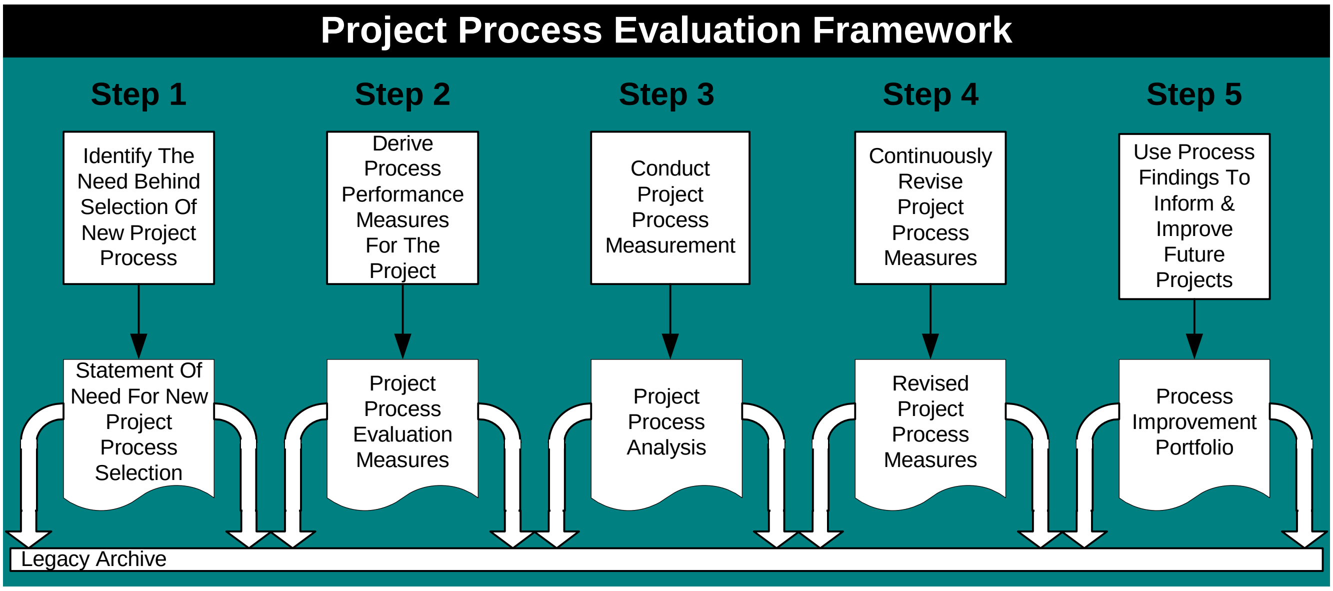


Figure 9.6: The PPE framework

The benefits/ key principles of the Process Protocol were also largely confirmed by the two case study projects. Although each of the six 'benefits' was not consistently applied or relevant to both investigations, of those that were applicable, the PPE framework did help to provide the empirical evidence to substantiate such. The degree in value of the benefits may be questioned though, as in some instances they were only partially confirmed. In order to fully test the propositions of the Process Protocol in future investigations, there are two significant issues that needs to be considered: -

- The implementation of the process: it is clear from the Britannia Walk project, for example, that only aspects of the Process Protocol was applied and therefore the full benefits of the model would not have been fully reaped
- The successful implementation of the process: the process may not have been fully or correctly applied. For instance, on the Britannia Walk project the idea of developing a stakeholder list was used, though the needs of the stakeholders were not fully captured nor their needs prioritised so that they would be accommodated for in the final product. This again limits the benefits of the Process Protocol

It is clear from the factors listed above, that appropriate guidelines and/ or training has to accompany any new project process in order to enhance its effectiveness (change management). This was made apparent in both case studies and was noted during the investigative workshops conducted by the researcher; the lack of training of the 'legacy archive' at Castle Vale, and that the lack of process implementation guidelines and understanding of the Process Protocol. This therefore reaffirms the conviction that project performance is not always directly attributable to process performance as discussed in Chapter 6. A well-organised and structured process may not always lead to project success, and likewise, a successful project may occur without the conviction of a fully planned process. Therefore, it is unwise to relate the effectiveness of a new project process on the success of the project, thus validating the need for the PPE framework.

9.5 Conclusion

This chapter reviewed and analysed the application of the PPE framework as it was applied on the two case study projects, Castle Vale and Britannia Walk (chapters 7 & 8). The need for the framework was identified in Chapter 1. The literature reviews on project processes (chapter 2) and performance management (chapter 3), and the scoping survey questionnaire (chapter 4) supported this research need. The framework was subsequently developed in chapter 6 and tested for its validity. Following the conclusion of the case studies, it appears that there should be a few minor amendments to be made to the model. Further, some processes were not implemented and consequently require further validation. However, their applicability can be argued, as there may be too many processes in the framework, or indeed they may not have all been relevant within each case study research context.

The value of the PPE framework was confirmed through the two case study investigations. In both instances, it was the project team that initiated the requirement and took the first step to recoup the assistance of the researcher to develop, conduct and analyse metrics that would measure the performance of the 'new' project process. Moreover, it is important to realise that the PPE framework developed and presented in this thesis is a tool to help the construction industry measure the success of implementing a new project process. It is crucial that the culture of the industry changes in order to implement fully the opportunities of process improvement, in that process performance is not always directly correlated to project performance.

The Process Protocol was also examined to determine if its key principles/ benefits it proposes were substantiated. The PPE framework helped to provide the empirical evidence to confirm the value of adopting the new process, so much so, that the client of the Castle Vale study subsequently implemented the ‘legacy archive’ on all of its building projects.

CHAPTER 10: CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

10.1 Introduction

This thesis aimed to develop a: -

> 'Project process evaluation (PPE) framework that will measure the effectiveness of implementing a new design and construction project process.'

This final chapter summarises the research findings from the literature reviews and the investigations conducted by the researcher as they are presented in this thesis. In doing so, the research methodology undertaken and research novelty is reviewed, and recommendations are made for future work. Thus, the chapter highlights how the research objectives (see section 1.3) of this investigation were addressed: -

- To gain a theoretical knowledge and understanding of the construction project process and how it is measured (achieved through undertaking comprehensive literature reviews; chapters 2 & 3)
- To investigate current and future thinking in process and performance related issues in manufacturing and construction sectors (achieved through a scoping study; chapter 4)
- To develop and implement an appropriate research methodology to undertake this research (chapter 5)
- To investigate the value of the PPE framework (chapters 6, 7 & 8)
- To provide the empirical evidence to support the benefits of implementing the Process Protocol (achieved through case studies; chapters 7 & 8)

10.2 Literature findings

In order to develop the PPE framework, this thesis began by reviewing the literature surrounding project processes and performance management, specifically focusing on the issue of what recommendations have been made regarding the design of metrics that can be used to assess the performance of new design and construction project processes. The emergence of new/ improved project processes in construction is currently the subject of much research, particularly in the UK. Its growing interest may be directly attributed to the broadened spectrum of performance requirements of the industry post the Latham (1994) and Egan (1998) reports. Such interest in process improvement through the years bought about new procurement contracts, and more recently, the development of the Generic Design and Construction Process Protocol (GDCPP), which borrowed ideas from manufacturing in attempt to change and improve the nature of the construction industry.

The onset of both the Latham (1994) and Egan (1998) reports also brought about the scrutiny of performance management in the industry, leading towards the adoption of frameworks in the performance arena, such as the BSC and KPIs/ benchmarking. Frameworks are undoubtedly valuable, but their adoption is often constrained by the fact that they can be too simple (Neely et al, 2000); they suggest some areas in which measures of performance might be useful, but provide little guidance on how the appropriate measures can be identified, introduced and ultimately used. This is a common criticism of both the balanced scorecard and EFQM model (see section 3.3.1.1 and 3.3.1.6). It has long been recognised that inadequately designed performance measures can result in dysfunctional behaviour (Brown, 1994), often because the method of calculating performance – the formula – encourages individuals to pursue inappropriate courses of action. Designing a performance measure, however, involves much more than simply specifying a robust formula. Despite the high level of academic and industrial interest in performance measurement, no one appears to have addressed the simple, yet fundamental question, what does a well-designed performance measure constitute? Indeed, even those authors that have discussed this issue have tended to offer superficial and rather generic guidelines as opposed to specific and actionable advice (Neely et al, 2000). As a result, the researcher set about to address this gap. More specifically, how does this apply to the adoption of new project processes? This thesis sought to answer this question.

This research was aimed at the identification of the conceptual dimensions and the constructive variables of modern performance measurement of new design and construction project processes, largely in an attempt to take part in the lively theoretical and managerial debate on the value of the Process Protocol. This debate has not yet been adequately supported by the research project by empirical evidence, and is particularly topical due to the researcher's involvement in the second stage of the research project. The great number of firms adopting the Process Protocol bears witness to the need of such a framework (this fact is heavily supported in the two case study projects – chapters 7 and 8 – in both instances the project management team approached the researcher for assistance in measuring the success of the Process Protocol). The PPE framework presented in this thesis can be used to design and audit performance measures that assess the effectiveness of adopting any new design and construction project process.

10.3 Investigative findings

An informing scoping study was deployed to build upon and support the findings in the literature reviews. Thus advising the researcher of the state of the UK construction industry with regards to process, performance and IT related issues. The survey questionnaire suggested a confused picture for construction in terms of the value and use of process, performance and IT related issues. It suggests that there is a need for a PPE framework to provide evidence of the impact of a new project process.

The information gleaned from the literature reviews and the scoping survey questionnaire was used as a basis for the construction of a framework designed to assess the effectiveness of implementing a new project process. The PPE framework was subsequently tested on two case study projects that adopted the various aspects of the Process Protocol (see chapters 7 & 8). These studies demonstrated the practical utility of the framework, although they also highlighted some ways in which it could be improved. Albeit the lack of implementation of certain processes/ steps of the framework, the case studies suggest that it is valuable because it facilitates the design of performance measures and provides evidence of the impact of effectiveness or otherwise of the adoption of a new project process.

10.4 Research methodology analysis

The research design employed in this thesis has proven to be successful in terms of achieving the development of the PPE framework. It firstly identified best practice and the gaps in the knowledge of the fields of project processes and performance management (chapters 2 & 3). The findings were supported and informed by the results of a scoping study (chapter 4). Both the literature reviews and scoping survey questionnaire was used to develop the stages and content of the framework. A case study research strategy was adopted for the testing of the PPE framework, in particular, a case study protocol developed, throughout which, a number of research methods such as interviews, workshops and survey questionnaires was used to ascertain both qualitative and quantitative data.

The testing of the PPE framework was performed on two case study projects; the benefits of testing real-world phenomena in the built and human environment on more than one enquiry was clearly laid out in section 5.2.5.1. However, it can be viewed that the overall testing of the Process Protocol was conducted on one case study, combining the elements on both studies i.e. differing aspects were adopted on each individual investigation. This was due to the inherent difficulty of determining various construction projects that adopted a new process within the timescale of this thesis. As investigating the benefits of the Process Protocol were a by-product of the research aim, this factor was not considered immediate.

The role the researcher undertook in this investigation of ‘observer as participant’ (see figure 5.3) was relatively small-scale intervention to examine the effects of real world intervention – through the adoption of a new design and construction project process. It is inevitable that the researcher will to a degree bias the results of the investigation through her participant involvement in the workshops and project meetings; the presence of the researcher may have affected the behaviour of the project team members. This bias however, was small scale in that interaction in the course of the process implementation project was limited. Also, the researcher's intervention with the application of the PPE framework was also minimal. For example, the communication of the strategic objectives, performance metrics and targets, in Steps 3 and 4, were not carried out. Although this restriction to the implementation of these processes was due to management on each case study, this restriction directly reduced inference of the new project process by the researcher. Further, the bias of examining and recording the effects of the researcher's interventions was greatly reduced by triangulating the data collected from various research methods within each case study (Yin, 1983).

10.5 Limitations of the work

A limitation of this research investigation could be considered to be the lack of the number of appropriate case studies to test the PPE framework. Only two projects were identified as suitable during the timeframe of this thesis, whereby a new design and construction project process had been adopted. Had the framework been tested on a greater number of case studies, it is anticipated that the validity of each step would have been greater, and the number of untested processes of the framework may have been reduced. Further, this factor also addresses the issue raised in chapter 9; the PPE framework is merely intended to help organisations to measure the effectiveness of a new project process, and like other such models (e.g. RIBA Plan of Work, Process Protocol, BAA project process, BSC), it enables individual project customisation – the processes can be added to, subtracted or edited. Framed in these terms, the untested Steps may merely be irrelevant for the Castle Vale and Britannia Walk case study projects. This poses the question: are all the Steps/ processes relevant, if not, what impact may occur with their omission? This question can only be answered if the framework was implemented on a vast number of projects. Currently, only regulatory processes govern the conduct of all processes in a model, such as ISO 9001; all tasks must be fulfilled before an organisation can be ISO 9001 certified (Johnson, 2001).

In addition, the framework was implemented towards the end of both case study projects. The validity of the framework may differ if it was implemented at the start of the project, as prescribed. Perhaps then the benefits of the new project process may have been significantly increased in lieu of any implementation prohibitors. In addition, no case study project fully implemented the protocol, possibly thus hindering the realisation of its full advantages. Further, the opportunity to enter the cycle of continuous process improvement through the framework would have also benefited the analysis of the framework, both within the same project and on future projects. In this way, both the full value of the framework and of the new project process would be realised.

The Process Protocol was selected as the base to test the PPE framework in this thesis. This was largely due to the researcher’s personal involvement in the second stage of the EPSRC funded research project. It would have been apt if the model could have been fully implemented on at least one single case study project, so that its true value will again be realised. Further, a more pressing limitation to this research is immediate, will different results be realised if different new project processes were implemented? The inherent bias that exists with the researcher’s involvement in the development of the Process Protocol and in implementing the framework may be explicated.

In addition to the number of case studies used to validate the benefits of the Process Protocol, the validity of the survey questionnaire response in the Britannia Walk project can also be questioned, in that there was a profound lack of sufficient sample to represent the views of the whole project team.

10.6 Research novelty

Despite the above limitations, the research reported in this thesis is both novel and valuable in that it addresses the question of how the effectiveness of new design and construction project processes can be measured. It does this by providing a framework that can be used to develop well-balanced performance measures. Although various authors propose performance measurement frameworks, few provide any insight into how these frameworks can be populated (Neely et al, 2000). Therefore, this work has implications for the field of performance management as well as for construction.

Construction project performance is not always directly correlated to process success. A well-organised and structured process may not always lead to project success, and likewise, a successful project may occur without the conviction of a fully planned process. There are a whole host of internal and external factors to a project that can significantly hinder the enactment of the process. According to Sidwell (1990), the success of construction projects largely hinge on the efficacy of the project process and the team enacting the work. Therefore, the PPE framework is timely to assess the effectiveness of implementing a new design and construction project process. It aims to help organisations to identify a balanced set of measures that will determine if the success or failure of the project lies with the project process itself or with its implementation - to understand what has changed and what works well. This aids project steerage and direction. For example, explicit recognition of the stage a process has reached provides guidance for effective management; a particularly troublesome process can be modified if it manifests into a range of undesirable behaviour. This is particularly apparent for new project processes, as usually the project team will endeavour with the process and unequivocally conclude that the problem lies elsewhere within the project. Often companies, especially in construction post the Latham (1994) and Egan (1998) reports, adopt new processes and support systems without considering how to evaluate the effectiveness of the new tool. In addition, a large number of companies are hesitant to move, say from the traditional RIBA Plan of Works to another process, in fear of negative impact it may on the business. With this in mind, the PPE framework also offers a way to assess the impact of the new process and encourage change, and hopefully improvement, industry-wide. Moreover, it can be used across a number of projects to assess performance. Framed in these terms, the PPE framework can be used to (Bond, 1999): -

- Maintain process status quo: to ensure a smooth flow of output according to the process/ schedule
- Improve upon the process: to continuously monitor and improve the process to produce the desired output
- Achieving process stability: less changes to the process enhances quality and productivity

Furthermore, the method used to model the PPE framework was particularly helpful since the steps were self-explanatory and like the Process Protocol model, allowed individual project customisation. This method of process decomposition may not be novel, but it has been rarely been adopted in the depiction of performance measurement frameworks. It was well received by the case study team members and the many industrialists whom the researcher has discussed the nature of this investigation with. Moreover, the findings of the case study investigation have not only provided empirical evidence to support the benefits of the Process Protocol, but it has also contributed to the initiation of two new key principles (Process Protocol, 2002): -

- Customisable process
    - '…the flexibility of the Process Protocol ensures that customised, specific protocols can be created to manage projects, generating team 'buy-in' to the process. At the same time it instils more collaborative and less adversarial practices as a result of the application of the customised process'
- Process flexibility
    - '…the flexibility of the Process Protocol system enables the alignment of the project process with existing business and operational processes. It further offers the ability to add or remove processes'

The above benefits became acute through the adoption of the PPE framework, particularly through the customisable and flexible nature of the framework itself. This thus contributes the lively debate of the validity of the processes in the framework that were not implemented in the case study investigations (see section 9.4).

10.7 Recommendations for future work

The question that remains is what next? Apart from validating all the processes of the framework that were not implemented on the case study projects and testing it using other new design and construction project processes, in the researchers opinion there is a very pressing answer to this question – Step 5 of the PPE framework. The process of designing a performance measurement framework is intellectually challenging, fulfilling and immensely valuable. Although once understood it is perhaps not the most difficult of tasks. In both case study projects, due to time constraints, it was impossible to use the findings generated by the PPE framework to inform and improve upon future projects. Therefore, the real challenge is to devise a method that will help improve and steer the project process towards greater effectiveness. It is often believed that as soon as managers seek to improve the process they encounter fear, politics and subversion. Individuals begin to worry that the measures might expose shortcomings. Different people seek to undermine the credibility of process measures in different ways. Some seek to game the system. Others seek to prevent changes from ever happening, as to dissipate potential job loses or an increased workload from more challenging targets for instance. Research into these issues, and particularly how they can be addressed, is much needed. In addition, how can managers ensure that the measures they use maintain their relevance as time passes? Although the PPE framework has touched upon these issues, the researcher envisages there is much depth underlying these issues. This is timely for the UK construction industry in that the benefits of process improvement, through CI or re-engineering, are becoming increasingly recognised and adopted. Therefore, the industry would endeavour to maintain its momentum in striving for improvement.

This is a full and challenging research agenda, and it is also a vital one. In addition to the processes themselves, numerous organisations are currently re-engineering the measurement systems their organisations are using. Few have any systematic process for doing so. Even fewer appear to be actively considering the issues associated with the implementation use, and ongoing maintenance of the measurement systems they are designing. Far too often measurement systems fail. Over time, their measurement systems become less and less valuable, as they become more and more complex. New measures are added, but obsolete measures are rarely deleted. Hence the importance of research into these four interlinked themes of performance management system design, implementation, use and ongoing management, and the people, processes, infrastructure and cultural issues associated with them. It is hoped that this work will provide a basis for which to move forward to address these other issues.

REFERENCES

Abetti, P. A. (1994) Impact of Technology on Functional Roles and Strategies. *International Journal of Technology Management*, 9(6), 529-546.

Adam, E. E. (1992) Quality Improvement as an Operations Strategy. *Industrial Management and Data Systems*, 92(4), 3-12.

Akintoye, A. (1995) Just-In-Time Application and Implementation for Building Material Management. *Construction Management and Economics,* 13(2), 105-113.

Alarcon, L. F. & Mardones, D. A. (1998) Improving the Design – Construction Interface. In *Proceedings of the 6th International Group of Lean Construction,* August, Brazil.

Alty, J. L. (1993) Information Technology and the Construction Industry: Another Tower of Babel. In *Management of Information Technology,* Mathur, S. K., Betts, P. M. & Tham, K. W. (ed.) World Scientific, Singapore, 3–15.

Amaratunga, D. & Baldry, D. (2001) The Debate about Quantitative and Qualitative Research in the Built Environment: A Question of Method or Epistemology? In *Proceedings of the 1st International Postgraduate Research Conference in the Built and Human Environment*, March, Salford, 129-148.

American Telephone & Telegraph Company (1993) *Moving Design into Production.* McGraw-Hill, United States of America.

Anderson, E. J. (1994) *Management of Manufacturing, Models and Analysis.* Addison-Wesley, Wokingham.

Aouad, G., Brandon, P., Brown, F., Child, T., Cooper, G., Ford, S., Kirkham, J., Oxman, R. & Young, B. (1995) The Conceptual Modelling of Construction Management Information. *Automation in Construction,* 3, 267-282.

Aouad, G., Hinks, J., Cooper, R., Sheath, D., Kagioglou, M. & Sexton, M. (1998a) An Information Technology (IT) Map for a Generic Design and Construction Process Protocol. *Journal of Construction Procurement,* November, 4(1), 132-151.

Aouad, G., Hinks, J., Cooper, R., Sheath, D., Kagioglou, M. & Sexton, M. (1998b) An IT Map for the Generic Design and Construction Process Protocol. *Journal of Construction Procurement,* 132-151.

Aouad, G., Kagioglou, M. & Cooper, R. (1999) IT in Construction: A Driver or and Enabler? *Journal of Logistics and Information Management*, 12, 130-137.

Aouad, G., Kirkham, J., Brandon, P., Brown, F., Cooper, G., Ford, S., Oxman, R., Sarshar, M. & Young, B. (1993) Information Modelling in the Construction Industry - The Information Engineering Approach. *Construction Management and Economics*, 11(5), 384-397.

Architects Journal (1999) AJ One Hundred. *Architects Journal*, 29th April, 41-50.

Ardhaldjian, R. & Fahner, M. (1994) Using Stimulation in the Business Process Re-engineering Effort. *Industrial Engineering,* 26(27), 60-61.

Arditi, D. & Gunaydin, H. M. (1998) Factors that Affect Process Quality in the Life Cycle of Building Projects. *Journal of Construction Engineering and Management,* 124(3), 194–203.

Ashton, C. (1997) *Strategic Performance Measurement: Transforming Corporate Performance by measuring and managing the Drivers of Business Success.* Business Intelligence Ltd, Wimbledon.

Atkinson, A. A., Waterhouse, J. H. & Wells, R. B. (1997) A Stakeholder Approach to Strategic Performance Measurement. *Sloan Management Review*, 38(3), 25-37.

BAA Plc. (1995) *The BAA Project Process.* BAA Plc., London.

Babbie, E. (1986) *The Practice of Social Research.* Wadsworth, Belmont.

Babbie, E. (1990) *Survey Research Methods.* 2nd ed. Belmont, Wadsworth.

Ball, M. (1988) *Rebuilding Construction: Economic Change in the British Construction Industry.* T. J. Press, Padstow.

Ballard, G. & Koskela, L. (1998) On the Agenda of Design Management Research. In *Proceedings of the 6th International Group of Lean Construction,* August, Brazil.

Banard, C. I. (1962) *The Functions of the Executive.* Harvard University Press, Cambridge, MA.

Banwell, H. (1964) *Report of the Committee on the Placing and Management of Contracts for Building and Civil Engineering Work.* HMSO, London.

Barlow, J. (1996) Partnering, Lean Production and the High Performance Workplace. In *Proceedings of the 4th International Group of Lean Construction,* Birmingham, UK.

Barrie, D. S. & Paulson, B. C. (1992) *Professional Construction Management.* 3rd ed. McGraw Hill International, New York.

Bartram, P. (1994) Re-engineering Revisited. *Management Today*, July, 62–63.

Bauly, J. A. (1994) Measures of Performance. *World Class Design to Manufacture,* 1(3), 37-40.

Baxendale, A., Dulaimi, M. & Tulley, G. (1996) Simultaneous Engineering and its Implications for Procurement. In *Proceedings of the W-92 Procurement Symposium: North meets South Developing Ideas,* University of Natal, South Africa, 21–31.

Beamon, B. (1999) Measuring Supply Chain Performance. *International Journal of Operations and Production Management,* 19(3), 275-292.

Becker, H. S. (1970) *Sociological Work: Method and Substance.* Transaction Books, Chicago.

Becker, H. S. (1986) *Writing for Social Scientists: How to Start and Finish your Thesis.* University Press of Chicago, Chicago.

Beckford, J. (1998) *Quality: A Critical Introduction.* Routledge, London.

Beer, M., Ruh, R., Dawson, J. A., McCaa, B. B. & Kavanagh, M. J. (1978) A Performance Management System: Research, Design, Introduction and Evaluation. *Personnel Psychology,* 31, 505-535.

Bendell, T., Boulter, L. & Kelly, J. (1993) *Benchmarking for Competitive Advantage.* Pitman, London.

Berger, M. A. (1983) In Defence of the Case Method: a Reply to Algyris. Academy of Management Review, 8(2), 329-386.

Berliner, C. & Brimson, J. A. ed. (1988) *Cost Management for Today's Advanced Manufacturing.* Harvard Business School Press, Boston.

Bettenhausen, K. N. D. & Murnighan, J. K. (1986) The Emergence of Norms in Competitive Decision-Making Groups. *Administrative Science Quarterly,* 30, 350-372.

Betts, M. & Ofori, G. (1993) Strategies for Technology Push: Lessons for Construction Innovation. *Construction Management and Engineering,* ACSE, 454–456.

Betts, M. & Wood-Harper, T. (1994) Re-engineering Construction: A New Management Research Agenda. *Construction Management and Economics,* 12, 551–556.

Bevan, S & Thompson, M. (1991) Performance Management at the Crossroads. *Personnel Management,* November, 36-39.

Bititci, U. S. & Carrie, A. S. (1998) *Integrated Performance Measurement Systems: Structures and Relationships.* Engineering and Physical Sciences Research Council research grant, final report, Swindon.

Bititci, U. S., Carrie, A. S. & McDevitt, L. (1997) Integrated Performance Measurement Systems: An Audit and Development Guide. *The TQM Magazine*, 9(1), 46-53.

Bititci, U. S., Turner, T. & Begemann, C. (2000) Dynamics of Performance Measurement Systems. *International Journal of Operations and Production Management*, 20(6), 692-704.

BIW (2001) http:///www.biw.com

Boer, H. (1994) Flexible Manufacturing Systems. In Storey, J. (ed), *New Wave Manufacturing Strategies,* Paul Chapman, London.

Bond, T. C. (1999) The Role of Performance Measurement in Continuous Improvement. *International Journal of Operations and Production Management,* 19(12), 1318-1334.

Bonsdorff, C. Von. & Andersin, H. E. (1995) Supporting the Business Process Paradigm by Means of Performance Measurements. In *Proceedings of CE96 Conference on Concurrent Engineering: A Global Perspective,* University of Vancouver, August, 151-153.

Bourne, M. & Neely, A. (1998) Why do Performance Measurement Initiatives Succeed and Fail. *In Performance Measurement – Theory and Practice.* Ed. Neely, A. Papers from the 1st International Conference on Performance Measurement, Cambridge, July, 165-172.

Bourne, M., Mills, J., Wilcox, M., Neely, A. & Platts, K. (2000) Designing, Implementing and Updating Performance Measurement Systems.

International Journal of Operations and Production Management, 20(7), 754-771.

Bradley, P. Browne, J. Jackson, S. & Jagdev, H. (1995) Business Process Reengineering (BPR) - a Study of the Software Tools Currently Available. *Computers in Industry,* 25, 309-330.

Brandon, P.S. and Betts, M. (1995), *Integrated Construction Information*, E&FN Spon, London.

Brierly, H. M. (1994) The Art of Relationship Management. *Direct Marketing,* September, 22–24.

Brignal, S. (1992) *Performance Measurement Systems as Change Agents: A Case for Further Research*. Warwick Business School Research Papers, No. 72, December.

British Property Federation (1983) *Manual of the BPF System for Building Design and Construction.* British Property Federation, London.

British Standards Institute (1989) *Guide to Monitoring Product Design.* HMSO, London.

Bromley, D. B. (1986) *The Case Study Method in Psychology and Related Disciplines.* Wiley, Chichester.

Brown, M. (1996) *Keeping Score: Using the Right Metrics to Drive World Class Performance.* Quality Resources, New York.

Brown, M. G. (1994) Is Your Measurement System Well Balanced? *Journal for Quality and Participation*, 17, 6-11.

Browne, J., Harhen, J. & Shivnan, J. (1988) *Production Management Systems: A CIM Perspective.* Addison-Wesley Publishing Company, Wokingham.

Browne, J., Sackett, P. J. & Wortmann, J. C. (1995) Future Manufacturing Systems – Towards the Extended Enterprise. *Computers in Industry*, 28(3), 235-254.

Bryman, A. (1993) *Quantity and Quality in Social Research.* Routledge, London.

Buffa, E. S. & Sarin, R. K. (1987) *Modern Production/ Operations Management: Eighth Edition.* Wiley, Canada.

Building (1998) Top 200 Consultants. *Building,* 2nd October, 40-56.

Building (1999) The Improving Performance of the UK Construction Industry: Report Published for National Construction Week. *Building,* April, 1-18.

Building (2000) Joining the Dot.Coms. *Building*, 18th February, 3-4.

Bulletpoint. (1996) *Creating a Change Culture – not about Structures, but Winning Hearts and Minds.* Wesley, New York.

Burbidge, J. L. (1996) *Period Batch Control.* Oxford University Press, Oxford.

Burdett, J. O. (1994) TQM and Re-engineering: The Battle for the Organisation of Tomorrow. *The TQM Magazine*, 6(2), 7–13.

Burgess, R. (1993) *In the Field: an Introduction to Field Research.* London, Routledge.

Busby, J. S. & Williamson, A. (2000) The Appropriate Use of Performance Measurement in Non-Production Activity. *International Journal of Operations and Production Management*, 20(3), 336-358.

Butler, R. (1994) What You Measure is What You Get – An Investigation into the Measurement of the Value Added by the Purchasing Department. In *Proceedings of the 4th International Annual Conference in the Service Sector in Manufacturing Procurement*, The University of Birmingham, April, 11-12.

Cameron, K. S. (1986) A Study of Organisational Effectiveness and its Predictors. *Management Science*, 32(1), 87-112.

Camp, R. C. (1989) *Benchmarking – The Search for Industry Best Practices that Lead to Superior Performance.* ASQS Quality Press, Milwaukee.

Carty, G. J. (1995) Construction. *Journal of Construction Engineering and Management*, September, 319–328.

Cavaye, A. L. M. (1996) Case Study Research: A Multi-Faceted Research Approach for IS. *Information Systems Journal*, 6(3), 227-242.

CBPP (1998) *Construction Industry Key Performance Indicators 1998 – Project Delivery and Company Performance.* Construction Best Practice Programme, Watford.

CBPP (1999a) *Construction Best Practice Programme.* http://www.cbpp.org.uk

CBPP (1999b) *Measure your Performance against these Key Performance Indicators: All Construction.* Construction Best Practice Programme wall chart, London.

CBPP (2002) *Respect for People: Key Performance Indicators.* Construction Best Practice Programme, Watford.

Chadwick, B. A., Bahr, H. M. & Albrecht, S. L. (1984) The Quality Era. *Journal of Geography in Higher Education*, 8(2), 163-167.

Champy, J. (1995) *Reengineering Management: The Mandate for New Leadership.* Harper Collins, London.

Chan, P. S. & Peel, D. (1998) Causes and Impact of Re-engineering. *Business Process Management Journal*, 4(1), 45–55.

Chandler, A. D. (1997) *The Visible Hand – Managerial Revolution in American Business.* Harvard University Press, Boston.

Chang, L. (1991) A Methodology for Measuring Construction Productivity. *Cost Engineering*, 3(10), 19-25.

Cherns, A. B. & Bryant, D. T. (1984) Studying the Client's Role in Construction Management. *Construction Management and Economics*, 2(6), 177–184.

Child, P. (1991) *The Management of Complexity.* Sloan Management Review, Autumn, 73–80.

Choi, C. F. & Chan, S. L. (1997) Business Process Re-engineering: Evocation, Elucidation and Exploration. *Business Process Management Journal*, 3(1), 39–63.

CIB (1996) *Constructing a Better Image.* A report by Working Group 7: Construction Industry Board. Thomas Telford, London.

Clark, F. (1996) *Leadership for Quality: Strategies for Action.* McGraw-Hill, Maidenhead.

Clark, K. (1994) Private Finance Initiatives. *New Builder & Civil Engineer*, July, 3-5.

Clark, K. B. & Fujimoto, T. (1991) *Product Development Performance, Strategy, Organisation and Management in the World Auto Industry.* Harvard Business Press, Boston, MA.

Clark, L. A., & Zirner, U. (1993) How to Design, Develop and Implement Successful Performance Measurement Systems. *Quality and Productive Management*, 10(3), 61-80.

Coates, J. (1997) *Topical Issues – Performance Management.* CIMA Publishing, London.

Cobb, I. (1993) *JIT and the Management Accountant: A Study of Current UK Practice.* CIMA, London.

Cohen, L & Manion, L. (1994) *Research Methods in Education.* Routledge, London.

Compton, W. D. (1992) Benchmarking. In Heim, J. A. & Compton, W. D. (ed.) *Manufacturing Systems: Foundations of World-Class Practice.* National Academy Press, Washington DC, pp. 100 - 106.

Construction Clients Forum (1999) Members database list as of the 7th May.

Construction News (1999) Top 100 Contractors. *Construction News,* 19th April, 19-22.

Contract Journal (2000) Honesty - Waring's Best Policy. *Contract Journal,* 1st March, 14-15.

Contract Journal (2000) Honesty - Waring's Best Policy. *Contract Journal,* 1st March, 14-15.

Coolican, H. (1990) *Research Methods and Statistics in Psychology.* Hodder and Stoughton, London.

Cooper, R. G. & Kleinschmidt, E. J. (1987a) New products: What Separates Winners from Losers? *Product Innovation Management Journal,* 4, 169-184.

Cooper, R. G. & Kleinschmidt, E. J. (1987b) Success Factors in Product Innovation. *Industrial Marketing Management Journal,* 7, 9-21.

Cooper, R. G. & Kleinschmidt, E. J. (1995) Benchmarking the Firm’s Critical Success Factors in New Product Development. *Journal of Product Innovation Management,* 12, 374–391.

Cooper, R. G. (1984) The Performance Impact of Product Innovation Strategies. *European Journal of Marketing,* 18(5), 223-229.

Cooper, R. G. (1990) Stage-Gate System: A New Tool for Managing New Products. *Business Horizons,* May-June, 44–54.

Cooper, R. G. (1993) *Winning at New Products: Accelerating the Process from Idea to Launch.* Addison-Wesley, Massachusetts.

Cooper, R. G. (1994) Third-Generation New Product Processes. *Journal of Product Innovation Management.* 10, 6-14.

Cooper, R. G. (1999) From Experience: The Invisible Success Factors in Product Innovation. *Journal of Production Innovation Management,* 16, 115-33.

Cooper, R., Kagioglou, M., Aouad, G., Hinks, J., Sexton, M. & Sheath, D. (1998) Development of a Generic Design and Construction Process. *European Conference on Product Data Technology,* BRE, 205–214.

Coughlan, P. D. (1991) Differentiation and Integration: The Challenge of New Product Development. In *Proceedings of the 5th Annual Conference of the British Academy of Management*, June 28th.

Craig, A. & Hart, S. (1991) *Where to Now in New Product Development Research?* University of Strathclyde, Glasgow.

Crawford, C. M. (1977a) *New Products Management.* Irwin, USA.

Crawford, C. M. (1977b) Product Development: Today's Most Common Mistakes. *University of Michigan Business Review,* 6, 7-8.

Crawford, C. M. (1992) The Hidden Costs of Accelerated Product Development. *Journal of Product Innovation Management,* 9(3), 161–176.

Crawford, K. M. & Fox, J. F. (1990) Designing Performance Measurement Systems for Just-In-Time Operations. *International Journal of Production Research,* 28(11), 2025-2036.

Das, T. H. (1983) Qualitative Research in Organisational Behaviour. *Journal of Management Studies,* 20(3), 311-325.

Davenport, D., Short, J. E. & Price, G. (1990) The New Industrial Engineering: Information Technology and Business Process Redesign. *Sloan Management Review,* 31(4), 11–27.

Davenport, T H (1994) Reengineering: Business Change of Mythic Proportions. *MIS Quarterly,* 6, 121-127.

Davenport, T. H. (1993) *Process Innovation – Reengineering Work through Information Technology.* Harvard Business School Press, Boston.

Davies, A. J. & Kochhar, A. K. (1999) Why British Companies don't do Effective Benchmarking. *Integrated Manufacturing Systems,* 10(1), 26–32.

De Meyer, A. (1992) An Empirical Investigation of Manufacturing Strategies in European Industry. In *Manufacturing Strategy.* Voss, C. A. Chapman & Hall, Oxford.

De Toni, A. & Tonchia, S. (1996) Lean Organisation, Management by Process and Performance Measurement. *International Journal of Operations and Production Management,* 16(2), 221-236.

De Toni, A., Nassimbeni, G. & Tonchia, S. (1995) An Instrument for Quality Performance Measurement. *International Journal for Production Economics,* 38, 199-207.

Debenham, M. (2001) Effective Process Management. *Quality World*, 7, 40-45.

Delargy, M. (1999) IT: Electronic Document Exchange – Off The Shelf. *Building*, 23rd July, 58-59.

Delmar, D. (1985) *Operations and Industrial Management: Designing and Managing for Productivity.* McGraw-Hill, USA.

DeLuzio, M. C. (1993) Management Accounting in a Just-In-Time Environment. *Journal of Cost Management,* 6(4), 6-15.

Denzin, H. (1984) *The Research Act.* Prentice Hall, Englewood Cliffs.

DeToro, I. & McCabe, T. (1997) How to stay Flexible and Elude Fads. *Quality Progress,* 30(3), 55–60.

Devinny, T. M. (1995) Significant Issues for the Future of Product Innovation. *Journal of Product Innovation Management,* 12, 70-75.

Dick, W. & Akintoye, A. (1996) Private Finance Initiative Procurement Method. In *Proceedings of the 6th COBRA Conference,* Royal Institution of Chartered Surveyors, London.

Dixon, J. R. & Arnold, P. (1994) Business Process Re-engineering: Improving in New Strategic Directions. *California Management Review,* 36(4), 93–107.

Dixon, J. R., Nanni, A. J. & Vollmann, T. E. (1990) *The New Performance Challenge – Measuring Operations for World-Class Competition.* Dow Jones-Irwin, Homewood.

Dolan, R. J. (1993) *Managing the New Product Development Process.* Addison-Wesley, USA.

Donnellon, A. (1993) Cross-Functional Teams in Product Development: the Structure to the Process. *Product Innovation Management Journal,* 18(6), 102-108.

Dorf, R. C. & Bishop, R. H. (1995) *Modern Control Systems.* 7th ed. Addison-Wesley Publishing, Chicago.

Driva, H. (1997) *The Role of Performance Measurement During Product Design and Development in a Manufacturing Environment.* PhD Thesis, Department of Manufacturing, Engineering and Operations, The University of Nottingham.

DTI (1994) *Time for real Improvement: Learning from Best Practice in Japanese Construction R&D.* Department of Trade and Industry, HMSO.

DTI (1998) *The 1998 UK R&D Scoreboard.* Department of Trade and Industry, Company Reporting, Edinburgh.

Duberley, J., Johnson, P., Cassel, C. & Close, P. (2000) Manufacturing Change: The Role of Performance Evaluation and Control Systems. *International Journal of Operations and Production Management*, 20(4), 427-440.

Duberley, J., Johnson, P., Cassel, C. & Close, P. (2000) Manufacturing Change: The Role of Performance Evaluation and Control Systems. *International Journal of Operations and Production Management*, 20(4), 427-440.

Duck, J. D. (1993) *Managing Change: The Art of Balancing.* Harvard Business Review, November, 110-118.

Earl, M. J., Sampler, J. L. & Short, J. E. (1995) Strategies for Business Process Reengineering: Evidence from Field Studies. *Journal of Management Information Systems,* 12(1), 31-56.

Easterby-Smith, M. (1991) *Management Research: An Introduction.* Sage, London.

Easterby-Smith, M., Thorpe, R. & Lowe, A. (1991) *Management Research Introduction.* Sage, London.

Eccles, R. G. & Pyburn, P. J. (1992) Creating a Comprehensive System to Measure Performance. *Management Accounting,* October, 41-44.

Edwards, C. & Peppard, J. W. (1994) Business Process Redesign: Hype, Hope or Hypocrisy? *Journal of Information Technology,* 9, 251-266.

Egan, J. (1998) *Rethinking Construction.* Report form the Construction Task Force, Department of the Environment, Transport and Regions, UK.

Eisenhardt, K. M. (1989) Building Theories from Case Study Research. *Academy of Management Review,* 14(41), 532-550.

Elmuti, D. & Kathawala, Y. (1997) An Overview of Benchmarking Process: A Tool for Continuous Improvement and Competitive Advantage. *Benchmarking for Quality Management and Technology,* 4(4), 229-243.

Elzinga, D. J., Horak, T., Chung-Yee, L. & Bruner, C. (1995) Business Process Management: Survey and Methodology. *IEEE Transactions on Engineering Management*, 24(2), 119–128.

Emmerson, H. (1962) *Studies of Problems before the Construction Industries.* HMSO, London.

EPSRC (1998) http://www.epsrc.ac.uk

Ettlie, J. E. & Stoll, H. W. (1990) *Managing the Design-Manufacturing Process.* McGraw-Hill, New York.

Evangelidis, K. (1992) Performance Measured is Performance Gained. *The Treasurer*, February, 45-47.

Evans, J. R. & Laskin, R. L. (1994) The Relationship Marketing Process: A Conceptualisation and Application Approach. *Industrial Marketing Management*, 23(5), 439–452.

Evans, J. R. (1993) *Applied Productions and Operations Management: Fourth Edition.* West Publishing, United States of America.

Fact Finders (1996) *Southwestern Bell Telephone Product Development Benchmarking Study*. Fact Finders Incorporated, California.

Fairclough, J. (2002) *Rethinking Construction Innovation and Research: A Review of Government R&D Policies and Practices.* Department of Transport Local Government Regions, HMSO.

Fazoop, P., Moselhi, O., Theberge, P. & Revay, S. (1988) Design Impact of Construction Fast-Track. *Construction Management and Economics*, 6(3), 195–208.

Fellows, R. & Lui, A. (1997) *Research Methods for Construction.* Blackwell Science, Oxford.

Fiedler, K. D., Grover, V. & Teng, J. T. C. (1994) Information Technology-Enabled Change: The Risks and Rewards of Business Process Redesign and Automation. *Journal of Information Technology*, 9, 267–275.

Filippini, R., Forza, C. & Vinelli, A. (1998) Trade-Off and Compatibility Between Performance: Definitions and Empirical Evidence. *International Journal of Production Research*, 36(12), 3379-3406.

Fitzgerald, L. & Moon, P. (1996) *Performance Measurement in Service Industries: Making it Work.* The Chartered Institute of Management Accounts, London.

Fitzgerald, L., Johnston, R., Brignall, S., Silvestro, R. & Voss, C. (1991) *Performance Measurement in Service Industries: Making it Work.* The Chartered Institute of Management Accounts, London.

Flapper, S. D. P., Fortuin L. & Stoop, P. P. M. (1996) Towards Consistent Performance Management Systems. *International Journal of Operations and Production Management,* 16(7), 27-37.

Fleet, T. (1995) Partnering in the Construction Industry 1 – Contractual Issues. *Construction Law,* 6(5), 175–177.

Fleury, A. (1995) Quality and Productivity in the Competitive Strategies of Brazilian Industrial Enterprises. *World Development,* 23(1), 73–85.

Flynn, B. B., Schroeder, R. D. & Sakakibara, S. (1994) A Framework for Quality Management Research and an Associated Measurement Instrument. *Journal of Operations Management,* 11, 339-366.

Fogarty, D. W., Hoffmann, T. R. & Stonebraker, P. W. (1989) *Production and Operations Management.* South Western Publishing, Ohio.

Formoso, C. T. (1997) Improvement Example from the 1990s. In *Proceedings of the International Transfer of Construction Management Practices Workshop,* June, Oslo, Norway.

Fowler, A. (1990) Performance Management: The MBO of the 90s? *Personnel Management,* July, 47-51.

Franks, J. (1990) *Building Procurement Systems: a Guide to Building Project Management.* 2nd Edition, CIOB, Ascot.

Fry, T. D. & Cox, J. F. (1989) Manufacturing Performance: Local versus Global Measures. *Production and Inventory Management Journal,* second quarter, 52-57.

Fry, T. D. (1995) Japanese Manufacturing Performance Criteria. *International Journal of Production Research,* 33(3), 933-954.

Fryer, B. (1997) *The Practice of Construction Management.* 3rd edition. Blackwell Science, Oxford.

Gaafar, H. K. & Perry, J. G. (1998) Limitation of Design Liability for Contractors. *International Journal of Project Management,* 17(5), 301–308.

Gable, G. (1994) Integrating Case Study and Survey Research Methods: An Example in Information Systems. *European Journal of Information Systems,* 3(2), 112-126.

Gadd, K. W. (1995) Business Self-Assessment: A Strategic Tool for Building Process Robustness and Achieving Integrated Management. *Business Process Re-engineering and Management Journal,* 1(3), 66-85.

Galbraith, J. R. & Kazanjian, R. K. (1986) *Strategy Implementation: Structure, Systems and Process.* 2nd edition. West, St Paul.

Gallimore, P., Williams, W. & Woodward, D. (1997) Perceptions of Risk in the Private Finance Initiative. *Journal of Property Finance,* 8(2), 164-176.

Galsworth, G. D. (1997) *Visual Systems: Harnessing the Power of a Visual Workplace.* AMACOM, Bristol.

Ghalayini, A. M. & Noble, J. S. (1996) The Changing Basis of Performance Measurement. *International Journal of Operations and Production Management,* 16(8), 63-80.

Gilgeous, V. & Gilgeous, M. (1999) A Framework for Manufacturing Excellence. *Integrated Manufacturing Systems,* 10(1), 33–44.

Gills, J. & Johnson, P. (1997) *Research Methods for Managers.* 2nd ed. Paul Chapman Publishing, London.

Globerson, S. (1985a) Issues in Developing a Performance Criteria System for an Organisation. *International Journal of Production Research,* 23(4), 639-646.

Globerson, S. (1985b) *Performance Criteria and Incentive Systems.* Elsevier, Bristol.

Goldense, B. L. (1994) Rapid Product Development. *World Class Design to Manufacture,* 1(1), 21-28.

Goold, M. & Quinn, J. J. (1990) The Paradox of Strategic Controls. *Strategic Management Journal*, 11, 43-57.

Goold, M. (1991) Strategic Control in the Decentralised Firm. *Sloan Management Review,* winter, 69-81.

Green, F. B., Amenkhienan, F. & Johnson, G. (1991) Performance Measures and JIT. *Management Accounting,* 72(8), 50-53.

Gregory, M. J. (1993) Integrated Performance Measurement: A Review of Current Practice and Emerging Trends. *International Journal of Production Economics,* 30, 281-296.

Griffin, A. & Hauser, J. R. (1996) Integrating R&D and Marketing: A Review and Analysis of the Literature. *Journal of Product Innovation Management,* 13, 191–215.

Griffin, A. (1993) Metrics for Measuring Product Development Cycle Time. *Journal of Product Innovation and Management,* 10, 112-125.

Griffin, A. (1997) PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices. *Journal of Product Innovation Management,* 14, 429–458.

Group EFO. (1995) *Innovation Survey: Report on New Products.* Group EFO Limited, Western.

Gunasekaran, A. & Love, P. E. D. (1998) Concurrent Engineering: A Multi-Disciplinary Approach for Construction. *Logistics Information Management,* 11(5), 295–300.

Gunasekaran, A., Forker, L. & Kobu, B. (2000) Improving Operations Performance in a Small Company: A Case Study. *International Journal of Operations and Production Management,* 20(3), 359-369.

Gupta, A. K & Wilemon, D. L. (1990) Accelerating the Development of Technology-Based New Products. *California Management Review,* 32(2), 22–32.

Gyles, R. (1992) *Royal Commission into Productivity in the New South Wales Building Industry.* R. Gyles QC, Government Printer, London.

Hackman, J. R. & Wageman, R. (1995) Total Quality Management: Empirical, Conceptual and Practical Issues. *Administrative Science Quarterly,* 40(2), 309-342.

Hague, P. (1994) *Questionnaire Design.* Kogan Page, London.

Hammer, M. & Champy, J. (1997) *Reengineering the Corporation: A Manifesto for Business Revolution.* 5th edition. Nicholas Brealey, London.

Hammer, M. & Stanton, S. A. (1995) *The Re-engineering Revolution.* Harper Business, New York.

Handfield, R. B. (1994) Effects of Concurrent Engineering on Make-To-Order Products. *IEEE Transactions on Engineering Management,* 41(4), 384–393.

Hanna, V. & Burns, N. D. (1997) *The Behavioural Implications of Performance Measures.* Macmillan Press, Houston.

Harper, J. (1984) *Measuring Business Performance: A Manager's Guide.* Institute of Manpower Studies, Gower, Hartlepool.

Harrington, H. J. (1991) *Business Process Improvement.* McGraw Hill, New York.

Harrington, H. J. (1999) Performance Improvement: A Total Poor-Quality Cost System. *The TQM Magazine,* 11(4), 221-230.

Harvey, J. P. (1971) *The Master Builders – Architecture in the Middles Ages.* Thames & Hudson, London.

Harvey-Jones, J. (1991) *Making it Happen: Reflections on Leadership.* Collins, London.

Hay, E. (1990) Implementing JIT Purchasing: Phase III – Selection. *Production and Inventory Management Review* with *APICS News,* 10(3), 28–29.

Hayes, R. H. & Abernathy, W. J. (1980) Managing our way to Economic Decline. *Harvard Business Review,* July-August, 67-77.

Hayes, R. H., Wheelwright, S. C. & Clark, K. B. (1988) *Dynamic Manufacturing: Creating the Learning Organisation.* Free Press, New York.

Hendry, L. C. (1998) Applying World Class Manufacturing to Make-to-Order Companies: Problems and Solutions. *International Journal of Operations and Production Management,* 18(11), 1086–1100.

Herbsman, Z. & Ellis, R. (1991) Research of Factors Influencing Construction Productivity. *Construction Management and Economics,* 8(1), 49-61.

Hill, T. J. (1991) Production and Operations Management: Text and Cases. 2nd ed. Prentice Hall, London.

Hill, T. J. (1992) Incorporating Manufacturing Perspectives in Corporate Strategy. In *Manufacturing Strategy.* Voss, C. A. Chapman & Hall, Oxford.

Hinks, J., Aouad, G., Cooper, R., Sheath, D., Kagioglou, M. & Sexton, M. (1997) IT and the Design and Construction Process: A Conceptual Model of Co-maturation. *The International Journal of Construction,* July, 56-62.

HM Treasury (1998) *Innovating for the Future.* Department of Trade and Industry, HMSO, London.

Hoffman, L, R. (1979) *The Group Problem Solving Process: Studies of a Valance Model.* Praeger, New York.

Hofstede, G. H. (1968) *The Game of Budget Control.* Tavistock, Cambridge.

Hopp, W. J., Spearman, M. L. & Woodruff, D. L. (1990) Practical Strategies for Lead-Time Reduction. *Manufacturing Review,* 3(2), 78–84.

Hopwood, A. G. (1984) *Accounting and Human Behaviour.* Prentice-Hall, Englewood Cliffs.

Horna, J. (1994) *The Study of Leisure.* Oxford University Press, Oxford.

Horne, C. A. (1987) Product Strategy and the Competitive Advantage. *P&IM Review,* December.

House, C. H. & Price, R. L. (1991) The Return Map: Tracking Product Teams. *Harvard Business Review,* January-February, 92-100.

Howell, D. (1999) Builders get the Manufacturers In. *Professional Engineer,* May, 24–25.

Hughes, G. D & Chafin, D. C. (1996) Turning New Product Development into a Continuous Learning Process. *Journal of Product Innovation Management,* 13, 89–104.

Hunt, J. (1995) Who's Sold on the PFI. *Property Week,* May, 20 – 21.

Imai, M. K. (1986) *The Key to Japan's Competitive Success.* McGraw-Hill, New York.

Jaafari, A. (1997) Concurrent Construction and Life Cycle Project Management. *Journal of Construction Engineering and Management,* 123(4), 427–436.

Jackson, J. & Hall, D. (1992) Speeding Up: New Product Development. *Management Accounting,* October, 265-268.

Jacobs, L. & Herbig, P. (1998) Japanese Product Development Strategies. *Journal of Business & Industrial Marketing,* 13(2), 132-154.

Jassawalla, A. R. & Sashittal, H. C. (1998) An Examination of Collaboration in High-Technology New Product Development Processes. *Journal of Product Innovation Management*, 15, 237–254.

Jick, T. D. (1979) Mixing Qualitative and Quantitative Methods: Triangulation Action. *Administrative Science Quarterly*, 11, 339-366.

Johansson, H. J., McHugh, P., Pendlebury, A. J. & Wheeler, W. A. (1993) *Business Process Re-engineering: Breakpoint Strategies for Market Dominance*. John Wiley & Sons, Chichester.

Johne, A. & Snelson, P. (1996) *Successful Product Development Management Practices in American and British Firms.* Basil Blackwell, Massachusetts.

Johnson, H. T. & Kaplan, R. S. (1987) *Relevance Lost – The Rise and Fall of Management Accounting.* Harvard Business School, Boston.

Johnson, H. T. (1994) Relevance Regained: Total Quality Management and the Role of Management Accounting. *Critical Perspectives on Accounting*, 5(2), 259-267.

Jones, D. T. (1992) Beyond the Toyota Production System: The Era of Lean Production in Voss, C. *Manufacturing strategy: Process and Content.* Chapman & Hill, New York, 188–210.

Jones, I. (1978) *Mixing Qualitative Research and Quantitative Methods on Sports Fan Research.* http://www.nova.edu/ssss/QR/QR3-4/nau.html

Kadefors, A. (1999) Client – Contractor Relations: How Fairness Considerations and Interests Influence Contractor Variation Negotiations. In *Proceedings of the 7th International Group of Lean Construction*, University of California, Berkeley, USA, 231-240.

Kagioglou, M. (1999) *Adapting Manufacturing Project Processes into Construction: A Methodology*. Unpublished PhD thesis, University of Salford, Salford.

Kagioglou, M., Cooper, R., Aouad, G., Hinks, J., Sexton, M. & Sheath, D. (1998a) *Final Report: Generic Design and Construction Process Protocol.* The University of Salford, Salford.

Kagioglou, M., Cooper, R., Aouad, G., Hinks, J., Sexton, M. & Sheath, D. (1998b) *A Generic Guide to the Design and Construction Process Protocol.* The University of Salford, Salford.

Kagioglou, M., Cooper, R., Aouad, G., Hinks, J., Sexton, M. & Sheath, D. (1998c) Cross-Industry Learning: The Development of a Generic Design and Construction Process Based on the Stage/Gate New Product Development Process found in the Manufacturing Industry. In *Proceedings of the Engineering Design Conference,* Brunel, UK.

Kaplan, R. S. & Norton, D. P. (1992) The Balanced Scorecard: Measures that Drive Performance. *Harvard Business Review,* January-February, 71-79.

Kaplan, R. S. & Norton, D. P. (1993) Putting the Balanced Scorecard to Work. *Harvard Business Review,* September-October, 134-147.

Kaplan, R. S. & Norton, D. P. (1996) *The Balanced Scorecard: Translating Strategy into Action.* Harvard Business School Press, Boston.

Kaplan, R. S. (1984) Yesterday's Accounting Undermines Production. *Harvard Business Review*, 62, 95-101.

Kartam, N. A. (1996) Making Effective Use of Construction Lessons Learned in Project Life Cycle. *Journal of Construction Engineering and Management,* March, 14–21.

Katzenbach, J. (1996) *Real Change Leaders.* Nicholas Brealey, London.

Kaydos, W. (1991) *Measuring, Managing and Maximising Performance.* Productivity Press, Portland Oregon.

Keegan, D. P., Eiler, R. G. & Jones, C. R. (1989) Are Your Performance Measures Obsolete? *Management Accounting,* June, 45-50.

Keppel, G. (1991) *Design and analysis: a Researcher's Handbook.* 3rd ed. Englewood Cliffs, Prentice Hall.

Kerssens-van Drongelen, I. C. (1998) Different Performance Measurement Procedures for Different Purposes. *In Performance Measurement - Theory and Practice. Ed*. Neely, A. Papers from the 1st International Conference on Performance Measurement, Cambridge, July, 584-591.

Khurana, A. & Rosenthal, S. R. (1998) Towards Holistic 'Front Ends' in New Product Development. *Journal of Product Innovation and Management,* 15, 57–74.

Kim, B. O. (1994) Business Process Re-engineering: Building a Cross-Functional Information Architecture. *Journal of Systems Management,* 45(12), 30-35.

King, N. (1996) *The Qualitative Research Review.* Sage, London.

Kirk, J. (2001) Business Improvement: The Continuous Cycle. *Quality World,* 7, 37-39.

Klapper, L. S., Hamblin, N., Hutchinson, L., Novak, L. & Vivar, J. (1999) *Supply Chain Management: A Recommended Performance Measurement Scorecard.* Logistics Management Institute, McLean.

Klein, M. M. (1994a) Reengineering Methodologies and Tools. *Information System Management,* Spring, 30-35.

Klien, M. M. (1994b) The Most Fatal Re-engineering Mistakes. *Information Strategy: The Executives Journal,* 10(4), 21–28.

Kmetovicz, R. E. (1992) *New Product Development: Design and Analysis.* Wiley-Interscience, Canada.

Knutt, E. (2000) Learn to Share. *Building,* 7th April, 54-55.

Kornelius, L. & Wamelink, J. W. F. (1998) The Virtual Corporation: Learning from *Construction. Supply Chain Management,* 3(4), 193–202.

Kosekla, L., Melles, B. & Wamelink, J. W. F. (1992) *Theme Report on Production Philosophies in Other Industries.* CIB W82 report, Technical Research Centre of Finland/Delft University of Technology.

Koskela, L. & Houvila, P. (1996) *On Foundations of Concurrent Engineering.* VTT Building Technology, Finland.

Koskela, L. (1991) State of the Art of Construction Robotics in Finland. In proceedings of the *8th International Symposium on Automation and Robotics in Construction,* Stuttgart, 65–70.

Koskela, L. (1992) *Application of the New Production Philosophy to Construction. Technical report no. 72.* Centre for Integrated Facility Engineering, Stanford University.

Koskela, L. (1999) Management of Production in Construction: A Theoretical View. In *Proceedings of the 7th International Group of Lean Construction,* University of California, Berkeley, USA, 241–252.

KPI Working Group (2000) *KPI Report for the Minister for Construction.* January, Department of the Environment, Transport and the Regions, HMSO.

Kuczmarski, T. D. (1992) *Managing New Products: the Power of Innovation.* Prentice Hall, USA.

Kuczmarski, T. D. (1994) *Winning New Product and Service Practices for the 1990's.* Kuczmarski & Associates, Chicago.

Kumaraswamy, M. M. & Chan, D. W. M. (1998) Contributors to Construction Delays. *Construction Management and Economics Journal,* 16(1), 17–29.

Kuwaiti, M. E. & Kay, J. M. (2000) The Role of Performance Measurement in Business Process Re-engineering. *International Journal of Operations and Production Management,* 20(12), 1411-1426.

Lahdenperra, P. (1995) *Reorganising the Building Process, the Holistic Approach.* VTT Building Technology, Finland.

Latham, M. (1994) *Constructing the Team: Joint Review of Procurement and Contractual Arrangements in the UK Construction Industry.* Department of the Environment, HMSO.

Lee, R. G. & Dale, B. G. (1998) Business Process Management: A Review and Evaluation. *Business Process Management Journal,* 4(3), 214–225.

Letza, S. R. (1996) The Design and Implementation of the Balanced Scorecard: An Analysis of Three Companies in Practice. *Business Process Re-engineering and Management Journal,* 2(3), 54-76.

Lewin, K. (1938) *The Conceptual Representation and the Measurement of Psychological Forces.* Duke University Press, Durham.

Li, H. & Love, P. E. D. (1998) Developing a Theory of Construction Problem Solving. *Construction Management and Economics,* 16, 721–727.

Lincoln, Y. S. & Guba, E. G. (1985) *Naturalistic Inquiry.* Sage Publications, Thousand Oaks.

Lingle, J. H. & Schiemann, W. A. (1996) From Balanced Scorecard to Strategy Gauge: Is Measurement Worth it? *Management Review,* March, 56-52.

Little, A. D. (1991) *The Arthur D. Little Survey on the Product Innovation Process.* Arthur D. Little, Cambridge.

Lockamy, A. & Cox, J. F. (1995) An Empirical Study of Division and Plant Performance Measurement Systems in Selected World Class Manufacturing Firms: Linkages for Competitive Advantage. *International Journal of Production Research,* 33(1), 221-236.

Lockamy, A. (1998) Quality Focused Performance Measurement Systems: A Normative Model. *International Journal of Operations and Production Management,* 18(8), 740-766.

Locke, L. F., Spirduso, W. W. & Silverman, S. J. (1993) *Proposals that Work: A Guide for Planning Dissertations and Grant Proposals.* Sage, Houston.

Love, P. E. D. & Gunasekaran, A. (1996) Towards Concurrency and Integration in the Construction Industry. *International Conference on Concurrent Engineering,* Toronto, Canada, August, 26–29.

Love, P. E. D. & Holt, G. D. (2000) Construction Business Performance Measurement: The SPM Alternative. *Business Process Management Journal,* 6(5), 408-416.

Love, P. E. D. & Li, H. (1998) From BPR to CPR – Conceptualising Re-engineering in Construction. *Business Process Management Journal,* 4(4), 291–305.

Love, P. E. D., Gunasekaran, A. & Li, H. (1998) Concurrent Engineering: A Strategy for Procuring Construction Projects. *International Journal of Project Management,* 6(6), 177–185.

Love, P. E. D., Smith, J. & Li, H. (1999) The Propagation of Rework Benchmark Metrics for Construction. *International Journal of Quality and Reliability Management,* 16(7), 638-658.

Lover, P. E. D. & Holt, G. D. (2000) Construction Business Performance Measurement: The SPM Alternative. *Business Process Management Journal,* 6(5), 408-416.

Low, S. P. (1993) The Application of Quantitative Methods for Just-In-Time Construction. *Building and Estate Management,* 22, 37–51.

Luck, R. & Newcombe, R. (1996) The Case for the Integration of the Project Participants' Activities within a Construction Project Environment. In Langford, D. A. & Retik, A. *The Organisation and Management of Construction: Shaping Theory and Practice: Volume II,* University Press, Oxford.

Luck, R., McGeorge, D., & Betts, M. (1997) *Research Futures: Academic Responses to Industry Challenges,* Construct IT Centre of Excellence, Salford.

Lynch, R. L. & Cross, K. F. (1991a) *Measure Up - The Essential Guide to Measuring Business Performance.* Mandarin, London.

Lynch, R. L. & Cross, K. F. (1991b) *Measure Up! Yard Sticks for Continuous Improvement.* Blackwell Business, Norwich.

Macpherson, I. (1995) Cutting Costs: Better by Half. *Building,* 10th February.

Makey, P. (1995) *Business Process Reengineering Strategies, Methods and Tools.* Butler group, Bath.

Manganelli, R. L. & Klein, M. M. (1994) Your Re-engineering Toolkit. *American Management Association,* 83(8), 26–30.

Mapes, J., New, C. & Szwejczewski, M. (1997) Performance Trade-Offs in Manufacturing Plants. *International Journal of Operations and Production Management,* 17(10), 1020-1033.

Marshall, C. & Rossman, G. B. (1989) *Designing Qualitative Research.* Sage, Houston.

Maskell, B. H. (1991) Performance Measurement for World Class Manufacturing. *Management Accounting,* May, 32-33.

Masterman, J. W. E. (1992) *An Introduction to Building Procurement Systems.* E&FN Spon, London

Matters, M. & Evans, A. (1997) The Nuts and Bolts of Benchmarking. http://www.ozemail.com.au/benchmark/nuts.bolts.html, February.

Maylor, H. & Grosling, R. (1998) The Reality of Concurrent New Product Development. *Integrated Manufacturing Systems,* 9(2), 69–76.

Maylor, H. (1997) Concurrent New Product Development: An Empirical Assessment. *International Journal of Operations and Production Management,* 17(12), 1196–1214.

McGarth, M. E. (1996) *Setting the Pace in Product Development.* Butterworth-Heinemann, Boston.

McKinnon, S. M. & Bruns, W. J. Jr. (1992) *The Information Mosaic*. Harvard Business School Press, Boston.

McMahon, C. & Browne, J. (1993) *Just-In-Time in CAD – CAM from Principles to Practice.* Addison-Wesley, Wokingham.

McNair, C. J. & Liebfried, K. H. J. (1992) *Benchmarking: A Tool for Continuous Improvement*. Oliver Wright, Essex.

McNair, C. J. & Mosconi, W. (1987) Measuring Performance in Advanced Manufacturing Environment. *Management Accounting,* July, 28-31.

Medori, D. & Steeple, D. (2000) A framework for Auditing and Enhancing Performance Measurement Systems. *International Journal of Operations and Production Management,* 20(5), 520-533.

Meister, D. (1985) *Behaviour Analysis and Measurement Methods.* John Wiley & Sons, Cambridge.

Mello, S. & Vermette, D. (1995) Developing Breakthrough Products: How the Best in Class do it. *Management Roundtable Conference on Product Development Best Practices for Defining Customer Needs,* New Orleans.

Meyer, C. (1994) How the Right Measures Help Teams Excel. *Harvard Business Review,* May-June, 95-103.

Meyer, M. W. & Gupta, V. (1994) The Performance Paradox. In Staw, B. M. & Cummins, L. L. (eds.) *Research in Organisational Behaviour.* JAI Press, Greenwich.

Milburn, I. (1992) A Race Against Time. *Manufacturing Breakthrough,* Jan/ Feb, 15–19.

Miles, M. B. & Huberman, A. M. (1984) *Analysing Qualitative Data: A Source Book for New Methods.* Sage, Houston.

Miles, M. B. (1979) Qualitative Data as an Attractive Nuisance: The Problem of Analysis. *Administrative Science Quarterly,* 24, 590-601.

Miles, R. & Ballard, G. (1997) Contracting for Lean Performance: Contracts and the Lean Construction Team. In *Proceedings of the 5th International Group of Lean Construction,* Gold Coast, Australia, July.

Mintzberg, H. (1973) *The Nature of Managerial Work.* Harper & Row, New York.

Mitchell Madison Group (1995) *New Product Development: Organisation and Process in Service Companies.* Mitchell Madison Group, New York.

Moenaert, R. K. & Souder, W. E. (1990) An Information Transfer Model for Integrating Marketing and R&D Personnel in New Product Development Projects. *Journal of Product Innovation Management,* 7, 91–107.

Mohamed, S. & Yates, G. (1995) Re-engineering Approach to Construction: A Case Study. In *Proceedings of the 5th East Asia Pacific Conference on*

Structural Engineering and Construction, Griffith University, Australia, 775–780.

Mohamed, S. (1996) Benchmarking and Improving Construction Productivity. *Benchmarking for Quality Management and Technology*, 3(3), 50-58.

Mohsini, R. A. & Davidon, C. H. (1992) Detriments of Performance in the Traditional Building Process. *Journal of Construction Management and Economics*, 10, 343-359.

Mondon, Y. (1983) *Toyota Production System.* Industrial Engineering and Management Press, Norcross, GA.

Moran, J. W. & Brightman, B. K. (1998) Effective Management of Healthcare Change. *The TQM Magazine*, 10(1), 27–29.

Morse, J. (1991) Approaches to Qualitative – Quantitative Methodological Triangulation. *Nursing Research*, 40(1), 23-27.

Motwani, J. (2001) Critical Factors and Performance Measures of TQM. *The TQM Magazine*, 13(4), 292-300.

Motwani, J., Kumar, A. & Novakoski, M. (1995) Measuring Construction Productivity: A Practical Approach. *Work Study*, 44(8), 18-20.

Muckler, F. A. & Seven, S. A. (1992) Selecting Performance Measures: Objective Versus Subjective Measurement. *Human Factors*, 34, 441-455.

Muhlemann, A., Oakland, J. & Lockyer, K. (1992) *Production and Operations Management.* 6th ed. Pitman, London.

Nadler, D, A. & Tushman, M, L. (1997) *Competing by Design: the Power of Organisational Architecture.* Oxford University Press, New York.

Nadler, D. A. (1980) *Feedback and Organisational Development: Using Data-Based Methods.* Addison-Wesley Publishing, Boston.

Nanni, A. J., Dixon, J. R. & Vollmann, T. E. (1990) Strategic Control and Performance Measurement – Balancing Financial and Non-Financial Measures of Performance. *Journal of Cost Management*, 4(2), 33-42.

Nau, D. (1994) *Mixing Methodologies: Can Bimodal Research be a Viable Post-Positivist Tool?* http://nova.edu/ssss/QR/QR2-3/nau.html

Neely, A. & Adams, C. (2000) *Perspectives on Performance: The Performance Prism.* http://www.cranfield.ac.uk/som/cbp/prismarticle.pdf

Neely, A. (1998) *Measuring Business Performance: Why, What and How*. Profile Books, Cranfield.

Neely, A. (1999) The Performance Measurement Revolution: Why Now and What Next? *International Journal of Operations and Production Management,* 19(2), 205-228.

Neely, A., Gregory, M. & Platts, K. (1995) Performance Measurement System Design. *International Journal of Operations and Production Management,* 15(4), 80-116.

Neely, A., Gregory, M. & Platts, K. (1996a) Performance Measurement System Design. *International Journal of Operations and Production Management,* 15(4), 80-116.

Neely, A., Mills, J., Gregory, M., Richards, H., Platts, K. & Bourne, M. (1996b) *Getting the Measure of your Business.* Findlay Publications, Holton Kirby.

Neely, A., Mills, J., Platts, K., Richards, H., Gregory, M., Bourne, M. & Kennerley, M. (2000) Performance Measurement System Design: Developing and Testing a Process-Based Approach. *International Journal of Operations and Production Management,* 20(10), 1119-1145.

Neely, A., Richards, H., Mills, J. & Platts, K. (1996c) What Makes a Good Performance Measure? In *Proceedings of the 2nd European Operations Management Association Conference,* Twente, Holland, May, 362-371.

Neely, A., Richards, H., Mills, J., Platts, K & Bourne, M. (1997) Designing Performance Measures: A Structured Approach. *International Journal of Operations and Production Management,* 17(11), 1131-1152.

Neo, R. B. (1995) Accounting for Waste in Construction. In *Proceedings of the 1st International Conference on Construction Project Management,* Nanyang Technological University, Singapore, January, 399–406.

Nesan, L. J. & Holt, G. D. (1999) Empowerment in Construction Organisations: The Way Forward for Performance Improvement. Research Studies Press, Somerset.

Oakland, J.S. (1995) *Total Quality Management: The Route to Improving Performance.* 2nd ed. Butterworth Heinemann Ltd, USA.

Olshavsky, R. W. & Spreng, R. A. (1996) An Exploratory Study of the Innovation Evaluation Process. *Journal of Product Innovation Management,* 13, 512–529.

Olson, E. M., Walker, O. C. Jr. & Ruekert, R. W. (1995) Organising for Effective New Product Development: The Moderating Role of Product Innovativeness. *Journal of Marketing Research,* 59, 31–45.

Otley, D. (1987) *Accounting Control and Organisational Behaviour.* Heinemann, Strassburg.

Ould, M A (1995). *Business Processes – Modelling and Analysis for Reengineering and Improvement,* Wiley & Sons, New York.

Ovenden, T. R. (1994) Business Process Re-engineering: Definitely Worth Considering. *The TQM Magazine,* 6(3), 56–61.

Page, A. L. (1994) Results from PDMA's Best Practices Study: The Best Practices of High Impact New Product Programs. In the *proceedings of the EEI/PDMA Conference on New Product Innovation.*

Paper, D. (1997) The Value of Creativity in Business Process Re-engineering. *Business Process Management,* 3(3), 218–231.

Parasuraman, A., Zeithmal, V. A. & Berry, L. L. (1990) *Delivering Service Quality: Balancing Customer Perceptions and Expectations.* Free Press, New York.

Parker, A. (1997) Engineering is not Enough. *Manufacturing Engineer,* 76(6), 267–271.

Parry, M. & Song, X. M. (1993) Determinants of R&D-Marketing Interface in high-tech Japanese firms. *Journal of Product Innovation Management,* 10, 4–22.

Peer, S. (1986) An Improved Systematic Activity Sampling Technique for Work-Study. *Construction Management and Economics,* 4(2), 151-159.

Peppard, J. & Rowland, P. (1995) *The Essence of Business Process Re-engineering.* Prentice Hall, Reading.

Peters, T. J. & Waterman, R. H. (1982) *In Search of Excellence.* Harper Collins, Boston.

Peters, T. J. & Waterman, R. H. (1982) *In Search of Excellence: Lessons from American Best-Run Companies.* Harper & Row, Cambridge.

Pheng, L. S. & Tan, S. K. L. (1998) How 'Just-In-Time' Wastages can be Quantified: Case Study of a Private Condominium Project. *Construction Management and Economics*, 16, 621–635.

Pigford, D. & Baur, G. (1995) *Expert Systems for Business: Concepts and Applications.* 2nd ed. Boyd & Fraser, Danvers, MA.

Pittiglio, C., Rabin, R., Todd, P. & McGrath, M. (1995) *Product Development Leadership for Technologhy-Based Companies: Measurement and Management – A Prelude to Action.* Pittiglio, Rabin, Todd & McGrath, Western.

Plossl, G. W. (1987) *Engineering for the Control of Manufacturing.* Prentice-Hall, New Jersey.

Plossl, G. W. (1991) *Managing in the New World of Manufacturing.* Prentice-Hall, Englewood Cliffs.

Poirier, C. C. & Tokarz, S. J. (1996) *Avoiding the Pitfalls of Total Quality.* ASQC Quality Press, Milwaukee.

Porter, L. J., Gadd, K. W. & Oakland, J.S. (1995) Adding up to the Right Result. *Self-Assessment – The Magazine of Continuous Quality Improvement*, July, 41-45.

Pritchard, R. D., Jones, S. D., Roth, P. L., Stuebing, K. K. & Ekeberg, S. E. (1988) Effects of Group, Goal Setting and Incentives on Organisational Productivity. *Journal of Applied Psychology*, 73, 337-358.

Pritchard, R. D., Roth, P. L., Jones, S. D. & Roth, P. G. (1991) Implementing Feedback Systems to Enhance Productivity: A Practical Guide. *National Productivity Review*, Winter, 57-67.

Process Protocol (2002) http://www.processprotocol.com

Puddicombe, M. S. (1997) Designers and Contractors: Impediments to Integration. *Journal of Construction Engineering and Management*, 123, (3), 245–252.

Ramabadron, E., Dean, J. W. Jr. & Evans, J. R. (1997) Benchmarking and Project Management: A Review and Organisational Model. *Benchmarking for Quality Management and Technology*, 4(1), 47-58.

Remenyi, D. & Williams, B. (1996) The Nature of Research: Qualitative or Quantitative, narrow paradigmatic. *International Journal of Information Systems,* 6(2), 131-146.

Remenyimi, D., Williams, B., Money, A. & Swartz, E. (1998) *Doing Research in Business and Management.* Sage Publications, London.

Revenaugh, D. L. (1994) Business Process Re-engineering: The Unavoidable Challenge. *Management Decision*, 32(7), 16–27.

RIBA (1991) *Architect's Handbook of Practice Management.* 4th ed. Royal Institute of British Architects publications, London.

RIBA. (1997) *RIBA Plan of Work for the Design Team Operation.* 4th ed. Royal Institute of British Architects Publications, London.

Riedel, J. C. K. H. & Pawar, K. S. (1997) The Consideration of Production Aspects During Product Design Stages. *Integrated Manufacturing Systems,* 8(4), 208–214.

Ritchie, B., Marshall, D. and Eardley, A. (1998) *Information Systems in Business.* International Thomson Business Press, New Jersey.

Robbins, S. R. (1996) *Organisational Behaviour: Concepts, Controversies and Applications.* Prentice Hall International, Houston.

Rockart, J. F. (1979) Chief Executives Define Their Own Data Needs. *Harvard Business Review,* 57, March-April, 81-93.

Rolstadas, A. (1998) Enterprise Performance Measurement. *International Journal of Operations and Production Management,* 18(9), 989-999.

Rook, J. & Medhat, S. (1996) Using Metrics to Monitor Concurrent Product Development. *Industrial Management and Data Systems,* 1, 3-7.

Rosenau, M. D. Jr. (1990) *Faster New Product Development.* AMACON, New York.

Rossman, G. B. & Wilson, B. L. (1991) Numbers and Words Revisited. *Evaluation Review,* 9(5), 627-643.

Rummler, G. & Brache, A. (1990) *Improving Performance: How to Manage the White Space on the Organisational Chart.* Jossey-Bass, San Francisco.

Ruskin, C. (1995) *The Product Champion tests his Vision.* MCB University Press, Cambridge.

Russell, R. (1992) The Role of Performance Measurement in Manufacturing Excellene. In proceedings of *27th Conference on Annual British Production and Inventory Control*, November, Birmingham.

Ryan, H. W. (1994) *Reinventing the Business. Information Systems Management,* 11(2), 77–79.

Sanger, M. (1998) Supporting the Balanced Scorecard. *Work Study,* 47(6), 197-200.

Santos, A. dos (1999) *Application of Production Management Flow Principles in Construction Sites.* Unpublished PhD thesis, University of Salford, Salford.

Santos, A. dos, Powell, J. & Formoso, C. T. (1999) Evaluation of Current use of Production Management Principles in Construction Practice. In *Proceedings of the 7th International Group of Lean Construction,* University of California, Berkeley, USA, 73–84.

Sapoutzis, P. (1995) *Use of Modern Manufacturing Techniques to improve the Operation of a Production Cell.* Unpublished MSc Advanced Manufacturing Systems dissertation, University of Salford, Salford.

Sayer, A. (1984) *Method in Social Sciences.* Routledge, New York.

Schmenner, R. W. & Vollmann, T. E. (1994) Performance Measures: Gaps, False Alarms and the 'Usual Suspects.' *International Journal of Operations and Production Management,* 14(12), 58-69.

Schonberger, R. J. (1982) *Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity.* Free Press, New York.

Schonberger, R. J. (1990) *Building a Chain of Customers.* Free Press, New York.

Schonberger, R. J. (1996) *World Class Manufacturing: The Next Decade.* The Free Press, New York.

Schriver, W. & Bowlby, R. (1984) Changes in Productivity and Composition of Output in Building Construction. *Review of Economics and Statistics,* 67, 318-322.

Scott, G. M. (1995) Downsizing Business Process Re-engineering and Quality Improvement Plans: How are they Related? *Information Strategy: The Executive Journal,* 11(3), 18–34.

Senge, P. M. (1990) *The Fifth Discipline: The Art and Practice of the Learning Organisation.* Century Business, London.

Serpell, A. (1999) Integrating Quality Systems in Construction Projects: The Chilean Case. *International Journal of Project Management,* 17(5), 317–322.

Serpell, A. Alarcon, L. F. (1998) Construction Process Improvement Methodology for Construction Projects. *International Journal of Project Management,* 16(4), 215–221.

Sethi, A. K. and Sethi, S. P. (1990) Flexibility in Manufacturing: A Survey. *International Journal of Flexible Manufacturing Systems,* 2(4), 289-328.

Seymour, D. & Rooke, J. (1995) The Culture of the Industry and the Culture of Research. *Construction Management and Economics,* 13(6), 511–523.

Shadur, M. A., Rodwell, J. J. & Bamber, G. J. (1995) Factors Predicting Employee's Approval of Lean Production. *Human Relations,* 48(12), 1403–1423.

Sheath , D. M., Woolley, H., Cooper, R., Hinks, J. & Aouad, G. (1996) A Process for Change: The Development of a Generic Design and Construction Process Protocol for the UK Construction Industry. In P*roceedings of the CIT Conference,* Institute of Civil Engineers, April, Sydney, Australia.

Shingo, S. (1988) *New-Stock Production: The Shingo System for Continuous Improvement.* Productivity Press, Japan.

Shingo, S. (1989) *A Study of the Toyota Production System from an Industrial point of View.* Translated by Dillon, A. P. Productivity Press, Japan.

Shinohara, I (1988) *New Production System: JIT Crossing Industry Boundaries.* Productivity Press, Cambridge.

Sidwell, A. C. (1990) Project Management: Dynamics and Performance. *Construction Management and Economics,* 8, 159-178.

Simister, S. (1995) Case Study Methodology for Construction Management Research. In *proceedings of the 11th annual ARCOM conference,* York, 4, 16-18.

Simmonds, K. (1981) Strategic Management Accounting. *Management Accounting,* April, 26-29.

Simon, E. (1944) *The Placing and Management of Building Contracts.* HMSO, London.

Simons, R. (1995) Control in the age of Empowerment. *Harvard Business Review*, 73(2), 80-88.

Sinclair, D. & Zairi, M. (1995a) Effective Process Management through Performance Measurement: Part II – Benchmarking Total Quality Based Performance Measurement for Best Practice. *Business Process Re-engineering and Management Journal,* 1(2), 58-72.

Sinclair, D. & Zairi, M. (1995b) Effective Process Management through Performance Measurement: Part III – An Integrated Model of Total Quality Based Performance Measurement. *Business Process Re-engineering and Management Journal,* 1(3), 50-65.

Sink, D. S. & Tuttle, T. C. (1989) *Planning and Measurement in your Organisation of the Future.* Industrial Engineering and Management Press, Norcross.

Sink, D. S. (1985) *Productivity Management: Planning, Measurement and Evaluation, Control and Improvement.* John Wiley & Sons, Milton Keynes.

Sink, D. S. (1986) Performance and Productivity Measurement: The Art of Developing Creative Scoreboards. *Industrial Engineer,* January, 86-90.

Skinner, W. (1974) The Decline, Fall, and Renewal of Manufacturing. *Industrial Engineering,* October, 32-38.

Skoyles, E. R. (1976) *Material Wastage – A Misuse of Resources.* Building Research Establishment, Garston, UK.

Skoyles, E. R. (1978) *Site Accounting for Materials.* Building Research Establishment, Garston, UK.

Slack, N. (1991) *The Manufacturing Advantage.* Mercury Books, London.

Smith, P. G. & Reinerstein, D. G. (1991) *Developing Products in Half the Time.* Van Nostrand Reinhold, New York.

Song, X. M. & Parry, M. E. (1997) The Determinants of Japanese New Product Success. *Journal of Marketing Research,* 34, 64–76.

Song. X. M., Thieme, R. J. & Xie, J. (1998) The Impact of Cross-Functional Joint Involvement across Product Development Stages: An Exploratory Study. *Journal of Product Innovation Management,* 15, 289–303.

Sower, V. E., Motwani, J. & Savoie, M. J. (1997) Classics in Production and Operations Management. *International Journal of Operations and Production Management,* 17(1), 15–28.

Spekman, R. (1988) Strategic Supplier Selection: Understanding long-term Buyer Relationships. *Business Horizons,* 31(4), 75–81.

Spivey, W. A, Munson, J. M. & Wolcott, J. H. (1997) Improving the New Product Development Process: a Fractal Paradigm for High-Technology Products. *Journal of Product Innovation Management,* 14, 203–218.

Stake, R. (1995) *The Art of Case Research.* Sage Publications, Thousand Oaks.

Stalk, G. E. P. & Shulman, L. (1992) Competing on Capabilities: The New Rules of Corporate Strategy. *Harvard Business Review*, March/April, 57–69.

Steier, F. (1991) Introduction: Research as Self-Reflexivity - Self-Reflexivity as a Social Process. *In Research and Reflexivity.* Ed. Steier, F. Sage Pubications, Hamel-Hampsted, 1-11.

Strauss, A. & Corbin, J. (1990) *Basics of Qualitative Research: Grounded Theory Procedures and Techniques.* SAGE Publications, Newbury Park.

Sumanth, D. J. (1985) *Productivity Engineering and Management.* McGraw-Hill, Singapore.

Susman, G, I. (1992) *Integrating Design and Manufacture for Competitive Advantage.* Oxford University Press, New York.

Swenson, D. W. & Cassidy, J. (1993) The Effect of JIT on Management Accounting. *Journal of Cost Management for the Manufacturing Industry,* 7(1), 39-47.

Syrett, M. & Lammiman, J. (1997) *From Lean to Fitness: Developing Corporate Muscle.* Cromwell Press, Wiltshire.

Takeuchi, H & Nonaka, I. (1986) *The New Product Development Game.* Harvard Business Press, USA.

Takeuchi, H. & Quelch, J. A. (1983) Quality is more than making a Good Product. *Harvard Business Review*, 61(4), 139-145.

Tellis, W. (1997a) Introduction to the Case Study. *The Qualitative Report*, 3(2). http://www.nova.edu/ssss/qr/qr3-2/tellis1.html

Tellis, W. (1997b) Application of a Case Study Methodology. *The Qualitative Report*, 3(3). http://www.nova.edu/ssss/qr/qr3-3/tellis2.html

Tellis, W. (1997c) Results of a Case Study on Information Technology at a University. *The Qualitative Report*, 3(4). http://www.nova.edu/ssss/qr/qr3-4/tellis3.html

Teng, J. T. C., Grover, V. & Fiedler, K. D. (1994) Business Process Re-engineering: Charting a Strategic Path for the Information Age. *California Management Review*, 37(7), 9–31.

Thomas, R. J. (1995) *New Product Success Stories: Lessons from Leading Innovators.* John Wiley & Sons, New York.

Tidd, J., Bessant, J. & Pavitt, K. (1997) *Managing Innovation.* John Wiley & Sons, Chichester.

Toni, A. de & Tonchia, S. (2001) Performance Measurement Systems. *International Journal of Operations and Production Management*, 21(1/2), 46-70.

Trafford Park Development Corporation Manchester (1997) *Company Census of the Trafford Park Urban Development Area.* Clucas Ward Forster, Manchester.

Tsang, A. H. C., Jardine, A. K. S. & Kolodny, H. (1999) Measuring Maintenance Performance: A Holistic Approach. *International Journal of Operations and Production Management*, 19(7), 691-715.

Turney, P. B. B. & Anderson, B. (1989) Accounting for Continuous Improvement. *Sloan Management Review*, 30(2), 37-48.

Tutesigensi, A. (1999) *Managing Project Identification: An Investigation into the Effective Management of the Identification Phase of Building Projects in Uganda.* Unpublished PhD thesis, University of Leeds.

Tutesigensi, A. (1999) *Managing Project Identification: An Investigation into the Effective Management of the Identification Phase of Building Projects in Uganda.* Unpublished PhD thesis, University of Leeds.

Ulrich, K. T. & Eppinger, S. D. (1995) *Product Design and Development.* McGraw-Hill, Singapore.

United Nations (1959) *Government Policies and the Cost of Building.* ECE, Geneva.

Upton, D. (1998) Just-In-Time and Performance Measurement Systems. *International Journal of Operations and Production Management,* 18(11), 1101-1110.

Vakola, M. & Rezgui, Y. (2000) Critique of Existing Business Process Re-engineering Methodologies: The Development and Implementation of a New Methodology. *Business Process Management Journal*, 6(3), 238-250.

Venegas, P. & Alarcon, L. F. (1997) Selecting Long-Term Strategies for Construction Firms. *Journal of Construction Engineering and Management,* 123(4), 388–398.

Venetucci, R. (1992) Benchmarking: A Reality Check for Strategy and Peformance Objectives. *Production and Inventory Management Journal,* 33(4), 32-36.

Vokurka, R. J., Choobineh, J. & Vadi, L. (1996) A Prototype Expert System for the Evaluation and Selection of Potential Suppliers. *International Journal of Operations and Production Management,* 16(12), 106–127.

Vonderembse, M. A. & White, G. P. (1996) *Operations Management: Concepts, Methods and Strategies.* West Publishing, New York.

Voordijk, J. (1994) *Towards Integrated Logistics in Supply Chains: Developments in Construction.* University Press Maastricht, Netherlands.

Voss, C. A. ed. (1995) *Manufacturing Strategy: Process and Content.* Chapman & Hall, London.

Voss, C. A., Ahlstrom, P. & Blackmon, K. (1997) Benchmarking and Operational Performance: Some Empirical Results. *International Journal of Operations and Production Management,* 17(10), 1046–1058.

Voss, C. A., Russell, V. & Twigg, D. (1990) Implementation Issues in Simultaneous Engineering. *International Journal of Technology Management,* 6(4), 293–302.

Wallen, N. E. & Frankel, J. R. (1991) *Educational Research: a Guide to the Process.* New York, McGraw Hill.

Walsh, W. J. (1990) Get the Whole Organisation behind New Product Development. *Research Technology Management,* 33(6), 32-36.

Ward, S. C., Curtis, B. & Chapman, C. B. (1991) Objectives and Performance in Construction Projects. *Journal of Construction Management and Economics,* 9, 343-353.

Waterman, R. H. (1987) *The Renewal Factor.* Bantam Press, Chicago.

Waters, M. (1995) *Globalisation.* Routeledge, London.

Wheelwright, S. C. & Clark, K. B. (1992) *Revolutionising Product Development: Quantum Leaps in Speed, Efficiency and Quality*. The Free Press, New York.

White, A. (1996) *Continuous Quality Improvement: A hands-on Guide to setting up and sustaining a Cost Effective Quality Programme.* Judy Piakus, Gloucester.

Winch, G. & Campagnac, E. (1995) The Organisation of Building Projects: An Anglo/French Comparison. *Construction Management and Economics,* 13, 3–14.

Winch, G., Usmani, A. & Edkins, A. (1998) Towards Total Project Quality: A Gap Analysis Approach. *Construction Management and Economics*, 16, 193–207.

Wisner, J. D. & Fawcett, S. E. (1991) Link Firm Strategy to Operating Decisions through Performance Measurement. *Production and Inventory Management Journal,* third quarter, 5-11.

Womack, J. P. & Jones, D. T. (1996a) *Beyond Toyota: How to Root out Waste and Pursue Perfection.* Harvard Business Press, USA.

Womack, J. P. & Jones, D. T. (1996b) *Lean Thinking.* Simon & Schuster, Oxford.

Womack, J. P., Jones, D. T. & Roos, D. (1990) *The Machine that Changed the World.* Rawson Associates, New York.

Yan, H. S. & Jiang, J. (1999) Agile Concurrent Engineering. *Integrated Manufacturing Systems,* 10(2), 103–112.

Yin, K. (1984) *Case Study Research.* Sage Publications, Beverly Hills.

Yin, R. (1989) *Case Study Research.* Sage, Newbury.

Young, S. M. & Selto, F. H. (1991) New Manufacturing Practices and Cost Management: A Review of the Literature and Directions for Research. *Journal of Accounting Literature,* 10, 265-298.

Yung, W. K. C. (1997) A Stepped Composite Methodology to Redesign Manufacturing Processes through Re-engineering and Benchmarking. *International Journal of Operations and Production Management,* 17(4), 375–388.

Zairi, M. (1994) *Measuring Performance for Business Results.* Chapman & Hall, London.

Zairi, M. (1995) The Integration of Benchmarking and BPR: A Matter of Choice or Necessity? *Business Process Re-engineering and Management Journal*, 1(3), 3-9.

Zairi, M. (1996) *Benchmarking for Best Practice.* Butterworth-Heinemann, Oxford.

Zairi, M. (1997) Business Process Management: A Boundary-Less Approach to Modern Competitiveness. *Business Process Management*, 3(1), 64–80.

Zha, X. F, Lim, S. Y. E. & Fok, S. C. (1998) Integrated Intelligent Design and Assembly Planning: a Survey. *International Journal of Advanced Manufacturing Technology*, 14, 664-685.

APPENDIX A

A.1 Response of scoping survey questionnaires testing

This section summarises the suggestions and subsequent changes made to the layout and content during the validation of the scoping survey questionnaire by twelve nominated practitioners (see Table A.1). Through further discussion with the practitioners, some of the comments were not actioned upon as change was not deemed necessary.

Section	Comment	Action
1	The term 'stage-gate' should be defined or not used, as not everybody is familiar with it.	Term removed
	'Building contractors' should be enlisted in the generation of a new project proposal in the construction questionnaire.	Term added
	Term of 'stakeholder' should be defined. There needs to be a definition of stakeholders Should 'stakeholder' be listed in determining the parties involved in the generation of a new project proposal since all the others listed are indeed stakeholders?	Term removed
	An example of the formal project processes that are used should be given as a prompt for the respondent to list.	Done
	Instead of just identifying who are involved in the project proposal, perhaps it would be beneficial to find out when they are involved as well.	Change was not felt to be justified
	The list of criteria for reviewing new project proposals should be more thorough and focused, possibly including CDM, risk etc.	Done
	The question determining the percentage of projects that go through a consistent process should be moved to execution, since 'consistent process' is not defined at this stage, and the section it lies in is about general background and not specific questions.	Change was not felt to be justified
2	There are more issues that the business strategy covers, there should be a space provided to do such.	Done

	Some questions are tenuous and do not specifically relate to strategy.	Some questions removed
3	If a company already has an explicit process then the main project activities will already be identified but may be unknown.	Comment considered
	What value is there in just identifying if there are sufficient project resources; possibly how do you identify appropriate resources. Do you need the question of are there sufficient project resources?	Question removed
	Instead of asking if a client satisfaction assessment is performed at the front-end, possibly include when and what.	Change was not felt to be justified
	Does project requirements are always documented efficiently mean setting a baseline?	Comment considered
	Need to determine how risk is managed though the whole course of the project.	Done
	Do you really need to find out if customer and end-user needs are prioritised at the front-end?	Question removed
	Industry does not do a customer satisfaction assessment.	Comment considered
	Questions relating the changes in the design specification should be moved to process execution section.	Done
	'Management' in reviewing project proposals should be more specific. Who is the management who is responsible for reviewing new project proposals? Do you need this question?	Question removed
4	Are project requirements being documented efficiently or effectively? There are two questions here and more is needed. Should be project requirements are always clearly defined rather than documented efficiently or effectively.	Question removed
	'Changes to the project process are quick/easy' – there are two questions here. The question relating to changes to the project process are quick/easy should be moved to align with other related process questions.	Question divided into two and moved
	The project process can be improved and changed.	Term changed
5	Format of questions took a few seconds to understand.	Comment considered
	The client should be included in the list of undertaking measures in the construction questionnaire.	Done

	Instead of the standards, it should read 'the critical success factors were agreed by everyone.'	Done
	The project manager undertakes all measures – is there a need to have a separate question?	Comment considered
6	What is project simulation?	Comment considered
	What is product-based case-retrieval?	Comment considered
	Cost planning should be further defined as estimating.	Done
	Accounting should be further defined as Commercial Management.	Done
	Integrated databases may be better defined as 'integrated information systems.'	Change was not felt to be justified
	The extent that IT is used for must be considered.	Done
	The IT questions should be combined together. Is the Likert scale is relevant here? Section needs to be shortened.	Done
7	Took 15 minutes to complete and is adequate. Took 15 minutes to complete. The questionnaire took 15/20 minutes to complete. Many questions are ambiguous and took a lot longer than 15 minutes to complete. Took 30 minutes to complete with thorough understanding of questions.	Comments considered
	Questionnaire currently needs a glossary at the moment, but if the questions were further defined then it would counter-balance this. Possibly needs a glossary to explain some definitions. There is a good balance of questions, the use of English is clear and it will be easy to obtain the key data. Glossaries tend to be tedious, best not to use one. Difficult to align trail of thought with certain questions. Possibly need a glossary.	Terms simplified
	Response types used are adequate - Likert scale deems appropriate.	Comment considered
	Do people still continue if they do not have a process? Are two questionnaires required? Need to define if the respondent is considering one project or all of them. A clause should be included to clarify that the respondent should skip the question if uncertain.	Comment considered

	Some questions were quite far reaching. Some questions are inappropriate, needs to be shortened in terms of appearance. There are also far too many questions, try to condense number of responses.	Done
	The questionnaire seems to be largely based on fact, and the questions relating to future vision should be moved to a section at the end as not to confuse respondents.	Change was felt to be not justified
	Need to define output/ purpose and differentiation of the questionnaire at the outset.	Done in covering letter

Table A.1: Changes and comments made by the validating practitioners during the testing of the scoping survey questionnaire

In lieu of the changes that resulted from the testing of the scoping survey questionnaire, all parties involved felt that no further validation was required as there were only relatively minor changes, and the questionnaires had been adapted from an already existing validated survey questionnaire.

A.2 Manufacturing scoping survey questionnaire

A.3 Construction scoping survey questionnaire

A.4 Covering letter of manufacturing scoping survey questionnaire

«FirstName» «LastName»
«Company»
«Address1»
«Address2»
«City»
«PostalCode»

Dear «FirstName» «LastName»,

RE: MANUFACTURING INDUSTRY PROCESS PERFORMANCE.

I am currently leading a research programme, in collaboration with Loughborough University, entitled 'Process Protocol' which aims to improve the performance of the construction industry by drawing upon initiatives from the new product development process (please see the enclosed leaflet for more information).

Your company has been identified as one that is leading the field in the new product development process. Therefore, I am writing to you for your help in undertaking our research. We are currently trying to collect data on best practice and would be very grateful if you could help us by completing the enclosed questionnaire, which will examine a number of issues relating to the new product development process, including understanding, implementation and performance measurement. We are also conducting a similar survey with the construction industry, in which we anticipate to make a direct comparative analysis.

The results of the survey will be presented in statistical terms and therefore your input (which is confidential) will not be attributed to your company. We will be producing a summary report of the entire research for you upon completion, or we can provide you with your company's specific report should you return more than 20 questionnaires.

Again I would be very grateful if you could help by completing the enclosed questionnaire (please could you return it to the above address by 10^{th} September, and if you have any questions please do not hesitate to contact me. I thank you in anticipation and look forward to hearing from you in the near future.

Yours sincerely,

Angela Lee

PS: Although every effort has been made to target the most appropriate people within the participating companies, if you believe that somebody else, in addition or instead of yourself, should complete the questionnaire please feel free to copy it or ask us to provide you with

A.5 Covering letter of construction scoping survey questionnaire

«Title» «FirstName» «LastName»
«Company»
«Address1»
«Address2»
«City»
«Postcode»

Dear «Title» «LastName»,

RE: CONSTRUCTION INDUSTRY PROCESS PERFORMANCE.

I am currently leading a research programme, in collaboration with Loughborough University, entitled 'Process Protocol' which aims to improve the performance of the construction industry by focusing upon the whole design and construction process (please see the enclosed leaflet for more information).

Your company has been identified as one that is interested in design and construction performance. Therefore, I am writing to you for your help in undertaking our research. We are currently carrying out a survey of the industry in response to Sir Michael Latham's report on 'Constructing the Team,' and more recently the 'Construction Task Force' report by Sir John Egan, to identify best practice. We would be very grateful if you could help us by completing the enclosed questionnaire, which will examine a number of issues relating to the design and construction process, including understanding, implementation and performance measurement. We are also conducting a similar survey with the manufacturing industry, in which we anticipate to make a direct comparative analysis.

The results of the survey will be presented in statistical terms and therefore your input (which is confidential) will not be attributed to your company. We will be producing a summary report of the entire research for you upon completion, or we can provide you with your company's specific report should you return more than 20 questionnaires.

Again, I would be very grateful if you could help by completing the enclosed questionnaire and return it to me at the above address by 10th September, and please do not hesitate to contact me if you have any queries. I thank you in anticipation and look forward to hearing from you in the near future.

Yours sincerely,

Angela Lee

PS: Although every effort has been made to target the most appropriate people within the participating companies, if you believe that somebody else, in addition or instead of yourself, should complete the questionnaire please feel free to copy it or ask us to provide you with more copies. For more information on the project, please contact my research team or me at the above address (direct line: 0161-2956171), or alternatively please visit our website: http://pp2.dct.salford.ac.uk.

A.6 Section 1 results - background information

This section details the results of respondents to the background information section of the survey questionnaire.

A.6.1 Formal development processes

Table A.2 illustrates the types of project development processes that are used by the respondent's company, both in manufacturing and construction industries. It is clear that the majority of manufacturers adopt the phase review approach, and although this type of process is agreed by constructers too, their response is much more varied and inconsistent, initiating that there is no standard development process for construction.

	Frequency	Percent
Manufacturing response		
No response	6	15.8
Phase Review	21	55.3
Stage-Gate	7	18.4
In-house NPD	2	5.3
ISO 9000/1	2	5.3
Total	*38*	*100.0*
Construction response		
No Response	24	39.3
Phase Review	18	29.5
Risk/ In-house	4	6.6
Financial	3	4.9
ISO 9001	2	3.3
Quality Management System	6	9.8
RIBA/ Design	4	6.6
Total	*61*	*100.0*

Table A.2: Formal development processes used in manufacturing and construction companies

A.6.2 Percentage of projects that go through a consistent project process

The bar chart in Figure A.1 clearly shows that the construction industry's response to the percentage of projects that go through a consistent project process is similar to that of manufacturing. Both industries agree that 80-100% of their projects follow a constant pattern. However, this result is contrary to the general belief that the construction industry has a consistent project process, and this is reaffirmed in section A.6.1 and later in section A.9.1. Therefore, the construction response to this question can somewhat be queried.

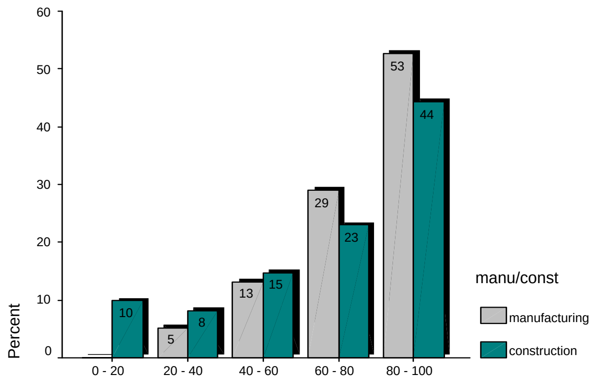


Figure A.1: Manufacturing and construction industry response to the percentage of projects that go through a consistent project process

A.6.3 The generation of a new project proposals

Table A.3 details the people who are involved in the generation of a new project proposal in both manufacturing and construction industries. The results are as typically expected; in manufacturing the marketing/ sales, engineering/ manufacturing, finance and customers are all commonly actively involved in the process; and client/ project sponsors, end-user/ occupier and finance for construction. Further, 16.4% of construction professionals commented that architects were a key player in the generation of new project proposals, relaying that they were brought on board to define the client's need.

		Yes	No
Marketing/ Sales Department	Man.	100.0%	0
Engineering/ Manufacturing Department	Man.	97.4%	2.6%
Clients/ Project Sponsors	Con.	91.8%	8.2%
Customers	Man.	78.9%	21.1%
End-Users/ Occupiers	Con.	63.9%	36.1%
Suppliers	Man.	55.3%	44.7%
Contractors	Con.	47.5%	52.5%
Finance	Man.	78.9%	21.1%
	Con.	60.7%	39.3%
Services	Man.	44.7%	55.3%
	Con.	31.1%	68.9%

In addition, 10 (16.4%) of the construction respondents stated that architects were involved in the generation of a new project proposal.

Table A.3: The people who are involved in the generation of new project proposals, both in the manufacturing and construction industries

A.6.4 Determining new projects

To determine a new project, numerous activities are usually conducted (see Table A.4). In manufacturing, these commonly include feasibility studies, preliminary technical assessment and a business/ financial assessment, and although customer/ market tests, trial sell, trial production and a pre-launch business analysis are often conducted as well, their application is not paramount across all the respondent's companies. This result is quite surprising as many manufacturing process models clearly detail links in the chain of market tests, trial sell and trial production. For construction, all respondents were largely in agreement to having feasibility studies, a preliminary technical assessment and a business/ financial assessment before a new project is determined. To conclude, both industries are aligned in these criteria.

Activities		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Feasibility Studies	Man.	2.6%	0	0	44.7%	52.6%
	Con.	0	1.6%	4.9%	34.4%	59.0%
Preliminary Technical Assessment	Man.	0	0	2.6%	23.7%	73.7%
	Con.	0	3.3%	9.8%	55.7%	31.1%
Business/ Financial Analysis	Man.	2.6%	0	5.3%	26.3%	65.8%
	Con.	0	4.9%	6.6%	34.4%	54.1%
Customer/ Market Tests of Products	Man.	2.6%	13.2%	23.7%	28.9%	31.6%
Trial Sell	Man.	21.1%	39.5%	15.8%	13.2%	10.5%
Trial Production	Man.	13.2%	13.2%	18.4%	31.6%	23.7%
Pre-Launch Business Analysis	Man.	5.3%	7.9%	18.4%	34.2%	34.2%

Table A.4: Manufacturing and construction activities that are conducted when determining new projects

A.6.5 Reviewing new project proposals

The following criteria, detailed in Table A.5, are used for reviewing new project proposals. In manufacturing and construction there is clear alignment and agreement in that reviews are based on technical capability/ competence, financial considerations/ business case, the market size/ growth/ potential, time scale/ target dates, and distribution and support. In addition, 23.7% of the manufacturing respondents stated that the probability of success was another major criterion.

Criteria		Strongly Disagree	Disagree	Uncertain	Agree	Strongly agree
Business Strategy	Con.	1.6%	1.6%	11.5%	45.9%	39.3%

Technical Capability/ Competence	Man.	0	0	5.3%	44.7%	50.0%
	Con.	0	0	16.4%	45.9%	37.7%
Financial Considerations/ Business Case	Man.	0	0	10.5%	18.4%	71.1%
	Con.	0	0	9.8%	24.6%	65.6%
Market Size/ Growth/ Potential	Man.	0	0	15.8%	31.6%	52.6%
	Con.	1.6%	6.6%	34.4%	32.8%	24.6%
Time Scale/ Target Dates	Man.	0	0	13.2%	28.9%	57.9%
	Con.	0	4.9%	9.8%	49.2%	36.1%
Distribution and Support	Man.	0	23.7%	28.9%	23.7%	23.7%
Risk	Con.	0	9.8%	9.8%	29.5%	50.8%

In addition, 9 (23.7%) of manufacturing respondents stated that the probability of the project being a success was used to review new project proposals.

Table A.5: Manufacturing and construction criteria for reviewing new project proposals

A.7 Section 2 results - project strategy

The following section details the responses regarding the project strategy ascertained by both the manufacturing and construction company respondents.

A.7.1 Clear business strategy for developing a new project

Figure A.2 illustrates both manufacturing and construction response to 'there is a clear business strategy for developing a new projects.' It is clear from the bar chart that both industries are aligned in agreement to this criterion, although the construction response is slightly more varied. Further, this result is surprising since clients, who should already have a business strategy in place before approaching construction professionals, generate the majority of construction projects (Howell, 1999). Perhaps this is an area whereby improvement for the industry is required.

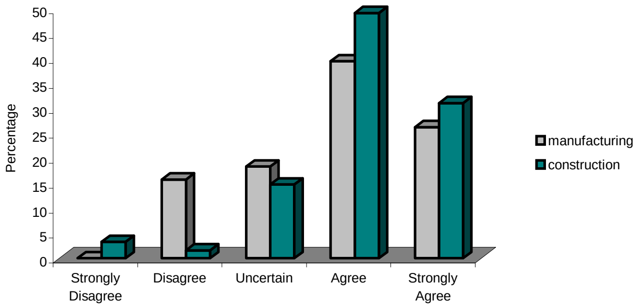


Figure A.2: Bar chart to show the manufacturing and construction response to a clear business strategy for developing a new project

A.7.2 New project proposals are always consistent with the overall business strategy

Figure A.3 shows that there is a degree of alignment between manufacturing and construction companies in that their new project proposals are always consistent with the overall business strategy. Further, these results typically mirror the responses to 'there is a clear business strategy for developing a new project' as detailed in section A.7.1. However, it is alarming that 31% of construction respondents did respond to this question.

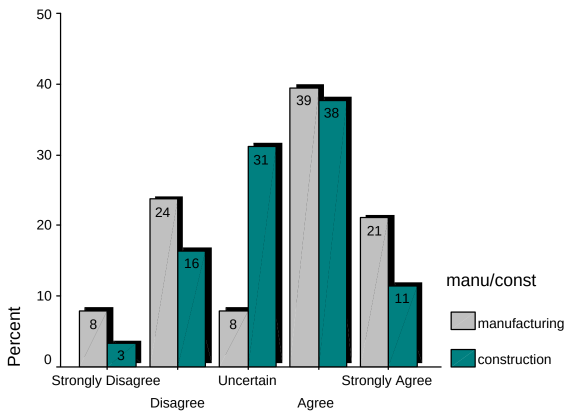


Figure A.3: Manufacturing and construction response to new project proposals are always consistent with the overall business strategy

A.7.3 The business strategy is the main criteria for making approval decisions in the project process

Figure A.4 shows that there is an alignment between the two industries in that 'the business strategy is the main criteria for making approval decisions in the project process.' Both industries were in agreement to the statement although there was a certain degree of uncertainty. Further, the construction result is consistent and typically reflects the response to 'the business case is used to review new project proposals' as in section A.6.5.

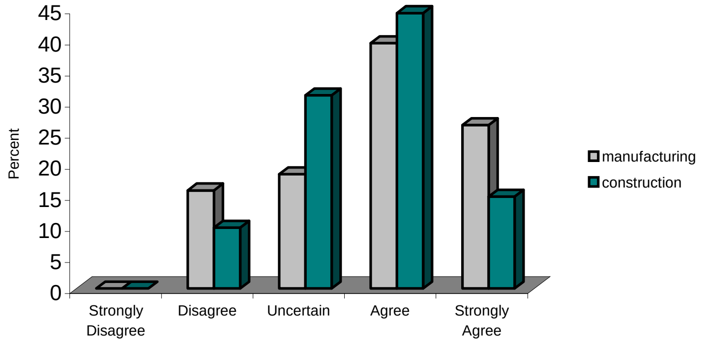


Figure A.4: Manufacturing and construction response to 'the business strategy is the main criteria for making approval decisions in the project process'

A.7.4 Business strategy contents

The business strategy, in both manufacturing and construction companies, generally covered the same criteria, including finance and the client/ customer/ end-user needs. Further, manufacturing business strategies also included aspects such as market positioning, product portfolio and technology based/ driven issues, and some construction respondents also identified that operational needs and risk related issues were also detailed. The results are displayed in Table A.6.

Contents		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Financial Issues	Man.	0	0	5.3%	34.2%	60.5%
	Con.	0	0	4.9%	42.6%	52.5%
The Customer Needs	Man.	0	2.6%	2.6%	44.7%	50.0%
Client's Needs	Con.	0	4.9%	16.4%	34.4%	44.3%
End-user's Needs	Con.	3.3%	11.5%	26.2%	29.5%	29.5%
Market Positioning	Man.	2.6%	0	10.5%	28.9%	57.9%
Product Portfolio	Man.	0	2.6%	15.8%	34.2%	47.4%
Technology Based/ Driven Issues	Man.	0	10.5%	13.2%	52.6%	23.7%

In addition, 7 (11.5%) of the construction respondents stated that business strategy contained operational needs information, and 5 (8.2%) stated that it contained risk related issues.

Table A.6: Manufacturing and construction business strategy contents

A.7.5 Business criteria for making decisions in the project process

Table A.7 details the results of the business criteria that the respondents of both manufacturing and construction companies listed that were used for making decisions in the project process. The results are not conclusive and are varied across each industry because respondents. This may be due to the fact that it was an open-ended question whereby the respondents were asked themselves to list their answers, and each respondent may not have thought of all the relevant criteria. However, it is surprising that the majority of manufacturing respondents rated finance, including pay back time, as important, whereas just over half of the construction respondents did so.

Criteria	Listed

Finance	Man.	68.4%
	Con.	57.4%
Pay Back time	Man.	57.9%
Safety	Con.	13.1%
Market Conditions/ Product Technology/ Definition	Man.	57.9%
Quality/ Market Conditions	Con.	27.9%
Risk/ Time to Market	Man.	44.7%
	Con.	36.1%
Resources/ Manufacturing Capability	Man.	39.5%
Resources/ Repeat Business	Con.	49.2%

Table A.7: Manufacturing and construction list of business criteria for making decisions

A.8 Section 3 results - project definition

The following section details the manufacturing and construction response to questions related to their company's project definition.

A.8.1 The main project elements/ activities are identified in the project proposal

Both manufacturing and construction respondents either agreed or strongly agreed that the main project elements/ activities were identified in their project proposal, as Figure A.5 clearly illustrates.

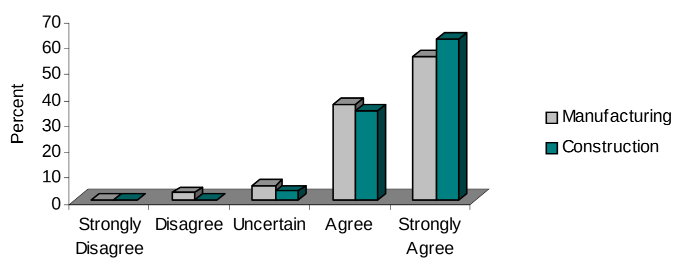


Figure A.5: Manufacturing and construction response to 'the main project elements/ activities are identified in the project proposal'

A.8.2 The main project elements/ activities should be identified in the project proposal

Figure A.6 illustrates that both industries agree or strongly agree that the main project elements/ activities should be identified in the project proposal. Further, the manufacturing result reflects typically their current situation, as detailed in

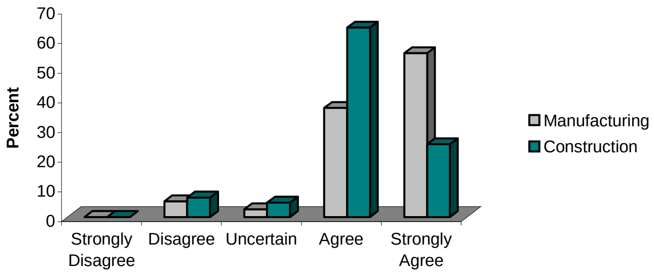


Figure A.5, though on comparison the construction industry needs to improve in this area.

Figure A.6: Manufacturing and construction response to 'the main project elements/ activities should be identified in the project proposal.'

A.8.3 Reviews of new project proposals

Figure A.7 illustrates that both the manufacturing and construction industry are typically aligned in that they do not review new project proposals by 'gut-feel.' Further, this result is enhanced by the result in section A.6.5, whereby the respondents generally agreed that a number of different criteria, including strategy and technical capability, were used for reviewing new projects.

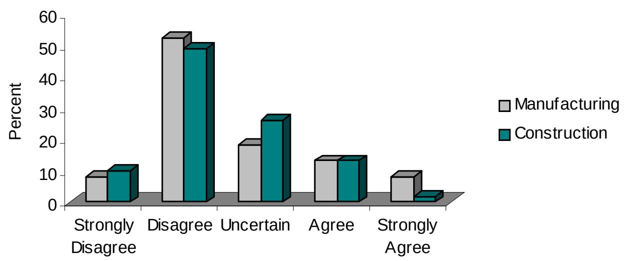


Figure A.7: Manufacturing and construction response to 'new project proposals are reviewed by 'gut-feel'

A.8.4 Project plans

At the front-end, the project plans in both manufacturing and construction companies generally included market conditions/ position, technical elements/ solutions and resource issues. However, as Table A.8 illustrates, a significant number of construction respondents were not fully certain as of the contents of the project plans, but this factor may be due to problems in understanding terminology; what is perceived as the project plan may not be called as such in the respondent company.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Market Conditions/ Position	Man.	0	5.3%	13.2%	26.3%	55.3%
	Con.	0	8.2%	26.2%	52.5%	13.1%
Technical Elements/ Solutions	Man.	0	5.3%	2.6%	44.7%	47.4%
	Con.	0	1.6%	16.4%	55.7%	26.2%
Resources	Man.	0	5.3%	13.2%	44.7%	36.8%
	Con.	1.6%	1.6%	18.0%	49.2%	29.5%

In addition, 10 (26.3%) of manufacturing and 11 (18.0%) of the construction respondents stated that the project plans at the front-end contained risk/ value assessments.

Table A.8: Manufacturing and construction contents of the project plan at the front-end

A.8.5 Project resource allocation

Table A.9 details that sufficient project resources are not usually allocated in both manufacturing and construction industries for requirements capture, market research, project feasibility or benchmarking. Clearly, this is an area that requires further research.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Requirements Capture	Man.	0	21.1%	34.2%	31.6%	13.2%
	Con.	1.6%	13.1%	31.1%	41.0%	13.1%
Market Research	Man.	2.6%	34.2%	23.7%	31.6%	7.9%
	Con.	3.3%	29.5%	45.9%	18.0%	3.3%
Project Feasibility	Man.	0	5.3%	5.3%	78.9%	10.5%
	Con.	0	16.4%	14.8%	45.9%	23.0%
Benchmarking	Man.	0	34.2%	39.5%	21.1%	5.3%
	Con.	6.6%	36.1%	39.3%	14.8%	3.3%

Table A.9: Manufacturing and construction response to 'sufficient project resource allocation'

A.8.6 Clear plan for capturing project requirements

Figure A.8 shows that both manufacturing and construction industries are generally unsure as to whether there is a clear plan for capturing project requirements. The majority of manufacturing respondents either agree or strongly agree, but 26% are uncertain to this factor. The construction response is uniform across disagree, uncertain and agree. Further, this is an area that requires additional research and investigation, but maybe merely attributed to the fact that sufficient project resources are not allocated at the outset, as evidenced in section A.8.5.

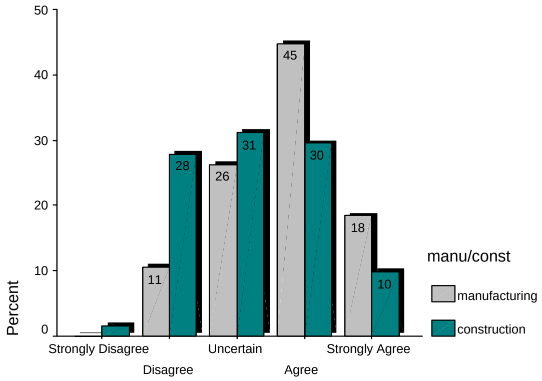


Figure A.8: Manufacturing and construction response to 'there is often a clear plan for capturing project requirements'

A.8.7 Project requirements capture responsibility

The project requirements of manufacturing projects are captured mainly both the marketing/ sales and engineering departments, although this process is aided by some of its customers. For construction, the designer/ architect takes this role, though too is sometimes assisted by the contractor, client's agent and the client/ customer. These results are as expected and are displayed in Table A.10.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Marketing/ Sales	Man.	0	2.6%	15.8%	52.6%	28.9%
Designer/ Architect	Con.	3.3%	8.2%	11.5%	55.7%	21.3%
Engineering	Man.	2.6%	5.3%	15.8%	60.5%	15.8%
Contractor	Con.	9.8%	26.2%	24.6%	27.9%	11.5%
Client's Agent	Con.	3.3%	14.8%	36.1%	37.7%	8.2%
Customers	Man.	2.6%	7.9%	26.3%	47.4%	15.8%
Client/ Customer	Con.	0	8.2%	31.1%	36.1%	24.6%

Table A.10: Manufacturing and construction response to the person responsible for capturing project requirements

A.8.8 Project requirements identification

The majority of manufacturing companies agree that the project requirements are always clearly identified, however, this is not the consensus of construction companies (see Figure A.9). The construction respondents disagree to the statement, and these responses generally mirror the response to 'there is a clear plan for capturing project requirements,' as in Figure A.8. Clearly, this is an area that construction professionals need to address.

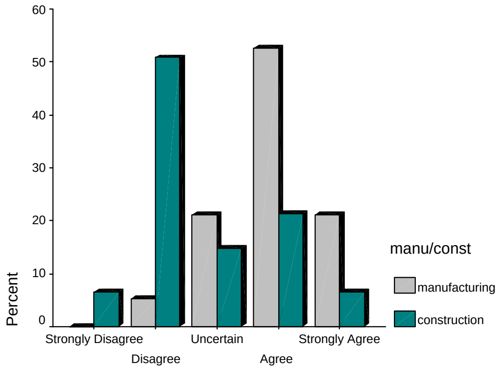


Figure A.9: Manufacturing and construction response to 'the project requirements are always clearly identified'

A.8.9 Project requirements timescale

Both manufacturing and construction companies were aligned in their response to the statement 'it usually takes too long to define a project's requirements,' as Figure A.10 shows. Further, the response of this question is directly related to sections A.8.5 through to A.8.8. Although there is a clear plan for capturing project requirements, insufficient resources are allocated in practice. However, this result seems to be contradictory to the construction response in section A.8.8. Clearly, if the project requirements are not always clearly identified, then this is an area for construction improvement since good requirement capture is positively related to project success (Wootton & Cooper, 1999).

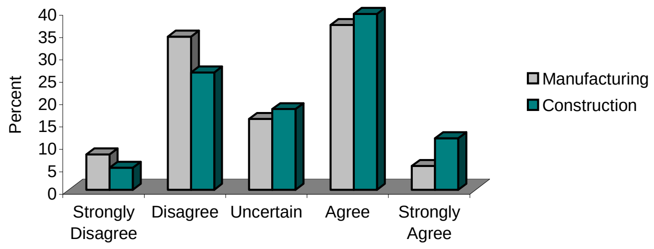
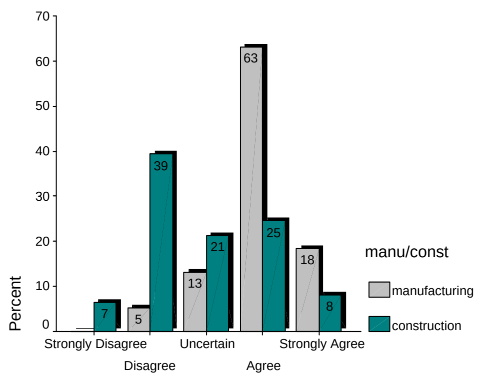


Figure A.10: Manufacturing and construction response to 'it usually takes too long to define a project's requirements'

A.8.10 Adequate project requirements capture before detailed design

The result of Figure A.11 typically mirrors the result of Figure A.9, and subsequently affirms the two responses. The manufacturing companies generally agree that the project requirements are always clearly identified and that they are usually well defined before moving to detailed design. More too, the construction companies believe that the project requirements are not always clearly identified, and that they are not well defined before moving to detailed design. Again, this is



an area that requires much improvement.

Figure A.11: Manufacturing and construction response to 'project requirements are adequately captured before moving to detailed design'

A.8.11 Front-end identification criteria

At the front-end of the project, both manufacturing and construction respondents generally agreed that the client/ project sponsor's and end-user/ occupier's needs were usually identified (see Table A.11). However, 45.9% of construction respondents were in strong disagreement, disagreement or uncertain as to whether the end-user/ occupier needs were captured, and this fact may be attributed to the type of construction project considered. The 45.9% of construction professionals may be referring to property developers, in which case the end-user/ occupier is usually unknown or their needs are not fully considered because the use of the building will change over time.

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
Client/ Project Sponsor's Needs	Man.	0	5.3%	10.5%	39.5%	44.7%
	Con.	1.6%	8.2%	8.2%	54.1%	27.9%
End-User/ Occupier's Needs	Man.	2.6%	0	13.2%	47.4%	36.8%
	Con.	4.9%	23.0%	18.0%	32.8%	21.3%

Table A.11: Manufacturing and construction response to the identification of needs at the front-end

A.8.12 Front-end assessments

At the front-end of the project, both manufacturing and construction companies were aligned in that they agreed that a technical, financial and risk assessment was usually performed (see Table A.12). However, the response to conducting a 'client/ project sponsor satisfaction assessment' was also aligned between the two industries, but they were also inconsistent across the selection criteria. Further, this result is particularly surprising, though perhaps reflective, of the construction industry; clients initiate the majority of construction projects so surely their satisfaction should be assessed.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Client/ Project Sponsor Satisfaction Assessment	Man.	10.5%	34.2%	18.4%	31.6%	5.3%
	Con.	13.1%	37.7%	19.7%	23.0%	6.6%
Technical Assessment	Man.	0	0	2.6%	60.5%	36.8%
	Con.	1.6%	3.3%	18.0%	57.4%	19.7%
Financial Assessment	Man.	0	0	0	52.6%	47.4%
	Con.	0	3.3%	6.6%	59.0%	31.1%
Risk Assessment	Man.	0	7.9%	10.5%	57.9%	23.7%
	Con.	0	4.9%	13.1%	55.7%	26.2%

Table A.12: Manufacturing and construction response to the completion of assessments at the front-end

A.8.13 Benchmarking

Figure A.12 illustrates the manufacturing and construction response to 'the project specifications are usually benchmarked against those of our competitors.' It is clear from the bar chart that the two industries are not aligned in their response. The manufacturing responses were fairly spread across the selection criteria, signifying that some companies do benchmark and likewise, some don't. The construction response was more consistent, but portrayed that the majority of construction companies do not benchmark. Clearly, this is an area for construction improvement, and is particularly surprising since the recent launch of government's performance benchmarking exercise, Key Performance Indicators (CBPP, 1998).

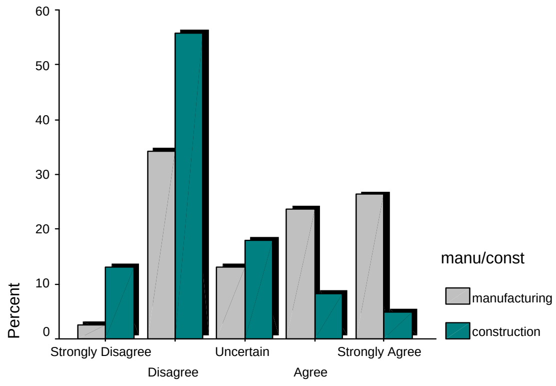


Figure A.12: Manufacturing and construction response to 'the project specifications are usually benchmarked against our competitors'

A.9 Section 4 results - process execution

The following section details the responses to process execution related questions.

A.9.1 Consistent project process

Figure A.13 illustrates the manufacturing and construction response to the statement 'there is a consistent project process within our company.' 90% of the manufacturing respondents agreed to the statement, compared to that of 59% of construction. Further, this result can be analysed against section A.6.2, where respondents were asked the percentage of projects that went through a consistent project process. The manufacturing response here mimics that of section A.6.2, but this does not reflect the construction industry (Howell, 1999). Wilcoxon signed rank test was used to compare the two responses (see Table A.13).

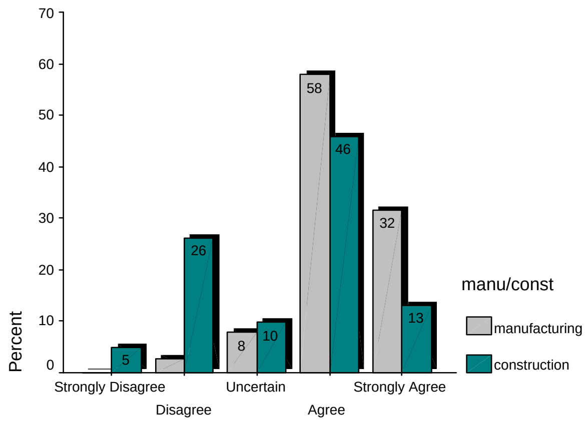


Figure A.13: Manufacturing and construction response to 'there is a consistent project process within our company'

Ranks	N	Mean rank	Sum of ranks
Negative ranks	32a	21.94	702.00
Positive ranks	11b	22.18	244.00
Ties	18c		
Total	*61*		

a There is a consistent project process < consistent process percentage

b There is a consistent project process > consistent process percentage

c There is a consistent project process = consistent process percentage

There is a consistent project process > consistent process percentage - test statistic b	
Z	-2.901a
Asymp. Sig. (2-tailed test)	0.004

a Based on positive ranks

b Wilcoxon signed rank test

Table A.13: Wilcoxon signed rank test results comparing manufacturing and construction response to ‘there is a consistent project process’ against ‘consistent process percentage’

A.9.2 Changes to the consistent project process

Figure A.14 details the manufacturing and construction response to 'there are often changes to the consistent project process.' The two industries are at complete opposites here and the bar chart clearly shows that their responses are mirrored; the majority of manufacturers agree to the statement whereas the constructors disagree. However, the responses reflect typically as what would be expected. Manufacturers usually produce repeat products or vary slightly the operation of their production line to manufacture similar products. Constructors, on the other hand usually produce different types of facilities that are also procured in different ways.

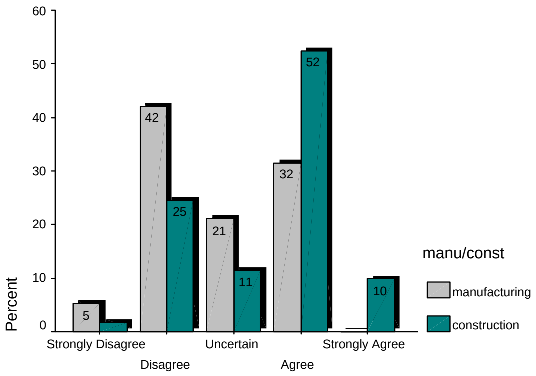


Figure A.14: Manufacturing and construction response to 'there are often changes to the consistent project process'

A.9.3 Adapting the consistent project process

The manufacturing and construction respondents were similar in the statement 'we adapt the consistent project process for each individual project.' Figure A.15 illustrates that although both industries generally agreed the manufacturing respondents were more widespread. Further, this result reflects typically the findings in section A.9.2. Manufacturing companies tend to manufacture the same or similar products, and so only sometimes have to adapt the consistent project process. Whereas, the construction industry has to change their consistent project process in accordance to the building type, environment, procurement method etc.

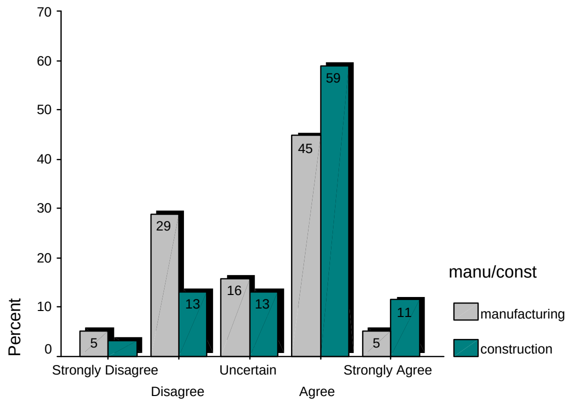


Figure A.15: Manufacturing and construction response to 'we adapt the consistent project process for each individual project'

A.9.4 Changes to the project process are quick

Figure A.16 illustrates that both the manufacturing and construction industries are aligned in their response to 'changes to the project process are quick.' The response is uniform across the selection criteria of disagree, uncertain and agree, signifying that changes are directly related to the type of change and can either be quick or long.

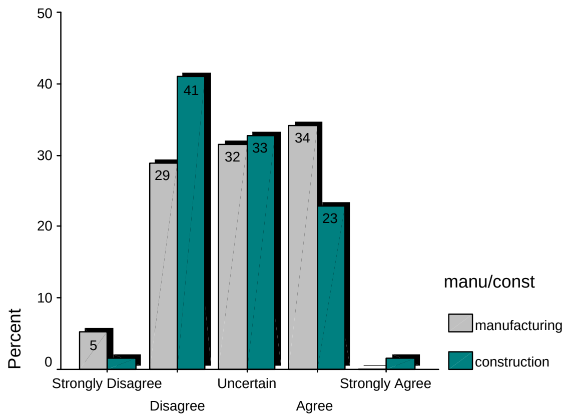


Figure A.16: Manufacturing and construction response to 'changes to the project process are quick'

A.9.5 Changes to the project process are easy

Figure A.17 illustrates the manufacturing and construction response to 'changes to the project process are easy.' Again, both industries are aligned; they both generally disagree to the statement, although there is a proportion that does agree. Further, this response relates to that of section A.9.4. Changes to the project process can either be quick or long, and be easy or hard depending on the type of change.

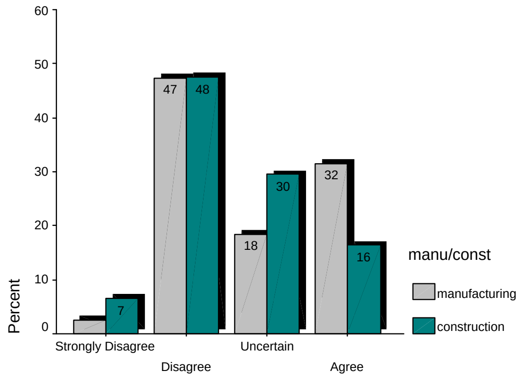


Figure A.17: Manufacturing and construction response to 'changes to the project process are easy'

A.9.6 Defining the project process

Figure A.18 details that manufacturing and construction are not aligned in defining their project process at the beginning of a project. Typically the responses are at opposite ends of the selection criteria. The majority of the manufacturing respondents agree to the statement, and although a high proportion of construction respondents also agree, the majorities disagree. This result is as expected. Manufacturing companies tend to plan the whole process of design and production at the outset of a new project, but this type of planning in construction companies is dependent on the discipline of the respondent. The majority of clients and architects for example, are usually unsure of the procurement process at the beginning of the project unless they are repeat projects, and so the type of procurement has already dictated the role of the project team, as in design and build for instance. However, when contractors and suppliers are appointed to the project team, the process is usually already defined.

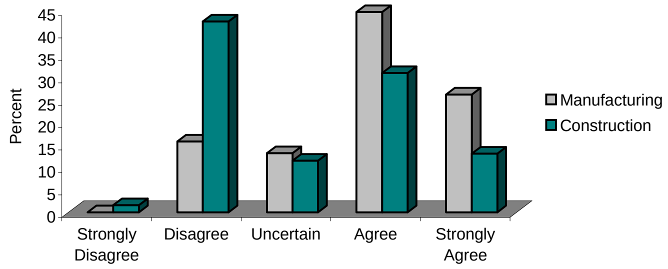


Figure A.18: Manufacturing and construction response to 'the project process is always defined at the beginning of a project'

A.9.7 Omitted steps from the process

The manufacturing and construction respondents were aligned in their response to 'we never omit any steps from the pre-determined project process,' as Figure A.19 details. Both industries disagree to the statement, signifying that there are large numbers of changes to the determined project process. This result again is as expected. Manufacturing companies have to change their business in response to the changing market conditions, as do the construction industry, but who also have added factors such as the weather, which famously leads to long delays. Further, these circumstances have contributed to the development/introduction of phase-review or stage-gate processes, which allow the progressive fixity of certain elements and other elements to continue if there are particular minor delays.

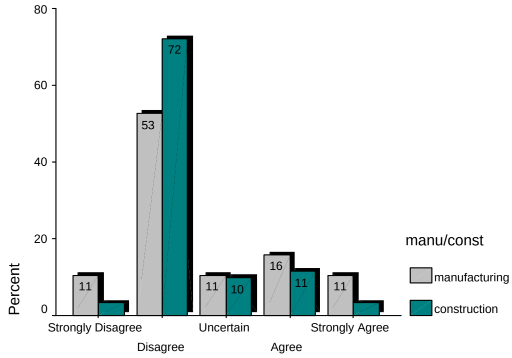


Figure A.19: Manufacturing and construction response to 'we never omit any steps from the pre-determined project process'

A.9.8 Management of the project process

The manufacturing and construction industries are not aligned in the way in which 'it is always clear at the front-end of the project process how it will be managed (see Figure A.20). Manufacturing companies, having usually planned the complete design and production of a product at the outset, agree that they know how the project is going to be managed. On the other hand, the construction response is much more varied. The majority of respondents disagree to the statement particularly if the procurement of the project is not defined during the front-end, but there is also a degree of agreement, perhaps with repeat projects or projects with a pre-defined procurement route in lieu of the client's preference.

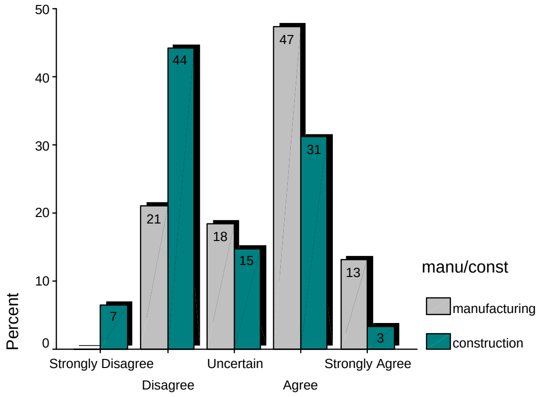


Figure A.20: Manufacturing and construction response to 'it is always clear at the front-end how the project process will be managed'

A.9.9 Project reviews

The manufacturing and construction industries are aligned in that both have 'regular project reviews …throughout the project process.' Figure A.21 shows that both industries hold regular reviews; 95% of manufacturing companies and 86% of construction companies either agree or strongly agree to the statement. This result is encouraging as both industries analyse the progress of their projects.

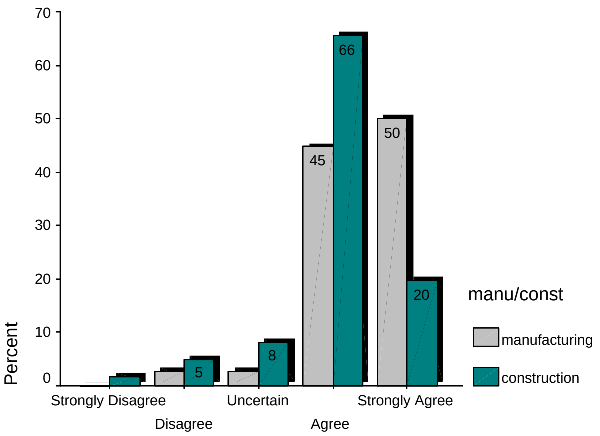


Figure A.21: Manufacturing and construction response to 'regular project reviews are held throughout the project process'

A.9.10 Cross-functional teams

The use of cross-functional teams is varied in comparison of the manufacturing and construction industries. The majority of the manufacturing respondents encourage multi-discipline work, as evidenced in Figure A.22, and reflects the initiatives of merging the marketing, design and engineering departments. However, construction has far to follow and is inconsistent. The construction response is fairly uniform across disagree, uncertain, agree and strongly agree criteria, and signifies this is an area for radical improvement in lieu of the Latham (1994) and Egan (1998) reports.

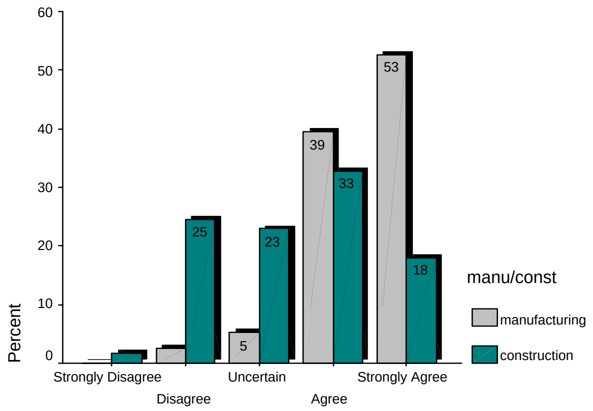


Figure A.22: Manufacturing and construction response to 'cross-functional teams are always used throughout the project'

A.9.11 Project manager allocation upon a new project

The allocation of a project manager as soon as a new project proposal is approved is varied across the manufacturing and construction respondents. Figure A.23 illustrates, the majority of manufacturers agree to the statement, whereas construction does not. Again, this result is as to be expected. Manufacturing projects involve a lot of planning, and planning is usually completed before work begins and so factors such as management allocation are arranged at the onset. Construction projects, however, usually evolve around a problem, and the project team and managers are appointed as and when required.

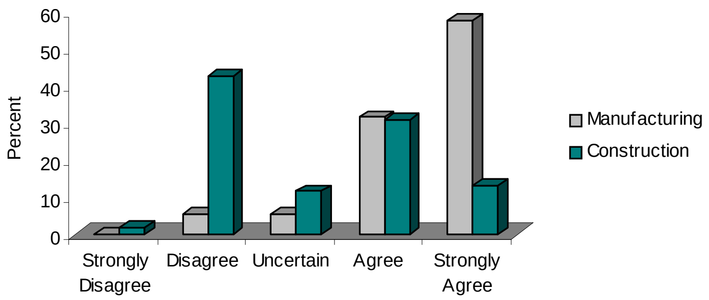


Figure A.23: Manufacturing and construction response to 'a project manager is always allocated as soon as a new project proposal is approved'

A.9.12 Presence of process managers/ owners

Figure A.24 details the manufacturing and construction response to 'we have a process manager/ owner.' The industries are fairly aligned from the bar chart below, and this is particularly surprising since the term is borrowed from manufacturing and has not been widely introduced into the construction industry. The author believes that this response may be attributed to a terminology misunderstanding.

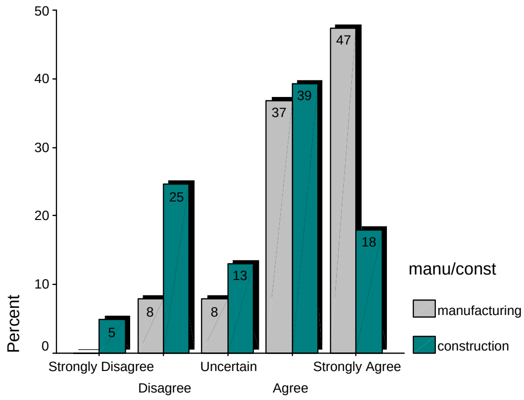


Figure A.24: Manufacturing and construction response to 'we have a process manager/ owner'

A.9.13 Importance of the presence of process mangers/ owners

Figure A.25 details the manufacturing and construction response to ' we should have a process manager/ owner.' Both industries are either agreement or strong agreement to the statement and reflect the result of 'we have a process manger/ owner' as in section A.9.12. The manufacturing respondents, who usually have a process manager/ owner already in place, value the role. However, as explained in section A.9.12, the term is relatively new or misunderstood in construction, and so this result is misleading. It appears from the bar chart below that the industry recognise the improvement that a process manager/ owner may bring, which is encouraging for the Process Protocol research, but reflecting on the previous response, this result may expound upon the misunderstanding of the term.

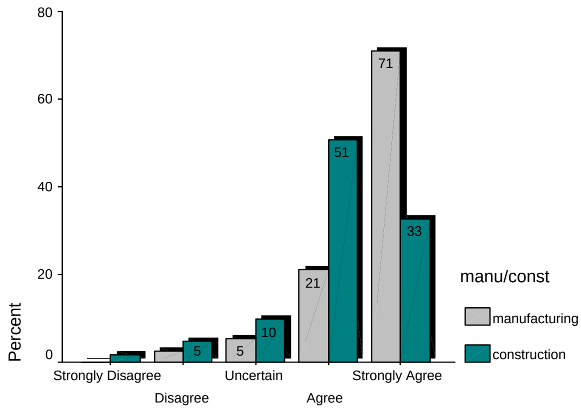


Figure A.25: Manufacturing and construction response to 'we should have a process manager/ owner'

A.9.14 Project/ process manager allocation

A Project/ process manager should be allocated at the pre-concept, concept and feasibility phases in both manufacturing and construction companies, as Table A.14 illustrates. Although both industries are generally aligned, their responses are both also widespread during the pre-concept and concept phases. This inconsistency may be due to a lack of terminology misunderstanding. During the pre-concept phase, there may be an internal (client) based manager appointed to investigate the opportunity even though there is no guarantee there will be a project at this stage, and this may be confused with the project/ process manager of the whole project. Again, this misunderstanding is possibly reflected in the concept phase for manufacturing but less so for construction as this is a defined stage whereby architects/ designers are usually appointed.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Pre-Concept Phase	Man.	2.6%		18.4%	28.9%	26.3%
	Con.	3.3%	14.8%	19.7%	36.1%	26.2%
Concept Phase	Man.	0	21.1%	7.9%	34.2%	36.8%
	Con.	3.3%	11.5%	18.0%	44.3%	23.0%
Feasibility Phase	Man.	0	10.5%	15.8%	28.9%	44.7%

	Con.	4.9%	8.2%	14.8%	39.3%	32.8%

Table A.14: Manufacturing and construction project/ process manager allocation

A.9.15 Project process changes/ improvements

Table A.15 illustrates the manufacturing and construction response to the changes/ improvement of the project process. Generally, the process or project manager changes or improves the manufacturing project process, although senior board members sometimes complete this task. However, all responses to these criteria are not fully conclusive. For construction, clients or project managers take this lead, and again the results are inconsistent across the whole selection criteria. This construction inconsistency is further reflected with the process manager, but this may also be attributed to the misunderstanding of the term as reflected earlier in sections A.9.12 and A.9.13.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Senior Board Members	Man.	0	42.1%	15.8%	28.9%	13.2%
Client	Con.	1.6%	19.7%	21.3%	42.6%	14.8%
Process Manager	Man.	2.6%	18.4%	10.5%	60.5%	7.9%
	Con.	3.3%	23.0%	41.0%	29.5%	3.3%
Project Manager	Man.	0	21.1%	10.5%	52.6%	15.8%
	Con.	1.6%	16.4%	34.4%	44.3%	3.3%

Table A.15: Manufacturing and construction response to the responsibility of changes/ improvements to the project process

A.9.16 Project communication

Good communication between project team members is not reflective across the manufacturing and construction industry, as illustrated in Figure A.26. They are true in the manufacturing responses, but the response is typically uniform across disagree, uncertain and agree. This result may be attributed the response to the use of cross-functional teams as in section A.9.10. The manufacturing industry encompasses cross-functional teams, and the team members do communicate well. However, the construction industry does not currently adopt a multi-disciplinary approach and this result seems to be reflected in their ineffective communication with other team members. Clearly, this is an area that requires improvement for the industry.

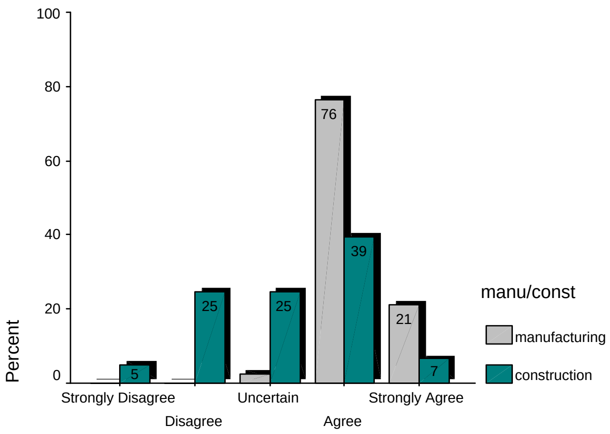


Figure A.26: Manufacturing and construction response to 'there are good communications between the project team participants throughout the project process'

A.9.17 Collaboration

Table A.16 illustrates that there is close collaboration with the client/ project sponsor in both manufacturing and construction industries although about a quarter of construction respondents were either unsure or disagreed with this statement. This factor may be attributed to the respondent, since companies lower down the supply chain usually do not interact with the client/ project sponsor. Manufacturers agree that there is a good relationship with their suppliers, but the construction response is fairly uniform across disagree, uncertain and agree criteria. This response maybe again related to the discipline of the respondent. The collaboration relationship between the end-users is aligned; both industries responded uniformly across disagree, uncertain and agree. Further, this particular result is as expected since the end-users may not be identified at the outset.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Client/ Project Sponsor	Man.	2.6%	0	7.9%	52.6%	36.8%
	Con.	0	11.5%	14.8%	62.3%	11.5%
Suppliers	Man.	0	5.3%	23.7%	52.6%	18.4%
	Con.	1.6%	32.8%	19.7%	39.3%	6.6%
End-User	Man.	0	26.3%	31.6%	31.6%	10.5%
	Con.	3.3%	36.1%	26.2%	31.1%	3.3%

Table A.16: Manufacturing and construction response to close collaboration between the parties

A.9.18 Project responsibilities

The manufacturing and construction response to 'the necessary project responsibilities are not being allocated at the outset' is detailed in Figure A.27 below. The industries are not aligned. The manufacturing respondents disagree to the statement, which details that the responsibilities are detailed at the start of a project. Construction responsibilities are not identified at the start of the project. This result is mimicked in section A.9.8, whereby respondents were asked to detail their agreement or disagreement to the statement 'it is always clear at the front-end how the project will be managed.'

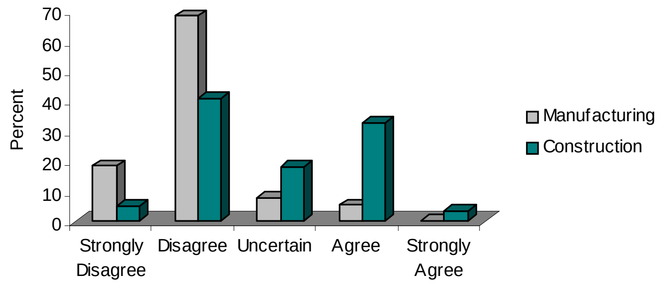


Figure A.27: Manufacturing and construction response to 'the necessary project responsibilities are not being allocated at the outset'

A.9.19 Design specification changes before production

Figure A.28 illustrates alignment between the manufacturing and construction industry in their response to the statement 'there are too many design specification changes before production.' The majority of respondents agree that there are too many changes, but there are nearly equal responses in the disagreement and uncertain categories.

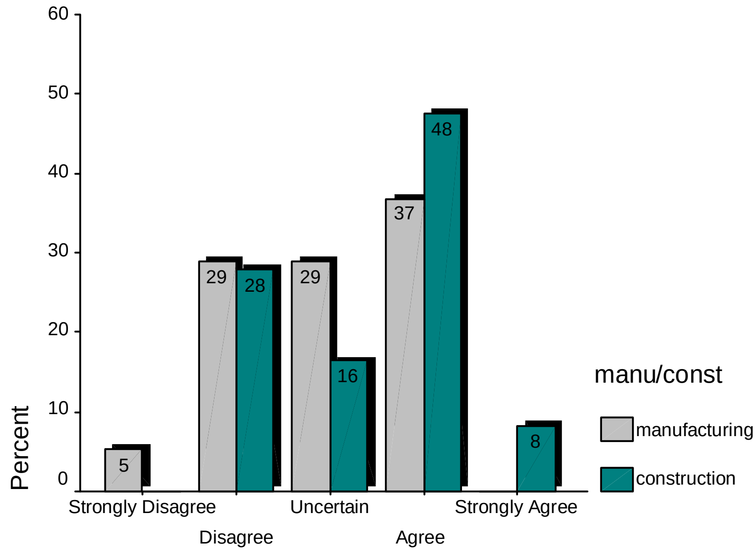


Figure A.28: Manufacturing and construction response to 'there are too many design specification changes before production'

A.9.20 Design specification changes after production

Figure 4.29 details the manufacturing and construction response to 'there are too many design specification changes during production.' Clearly, the two industries are not aligned, unlike that of section A.9.19 whereby respondents were asked if there were too many changes before production. Although 37% of the manufacturing respondents agreed to statement, the majority disagreed signifying that the product was well planned and well defined during the front-end. 77% of construction respondents agreed to the statement and that this may be directly attributed to the industry's poor performance, as reported by Latham (1994) and Egan (1998).

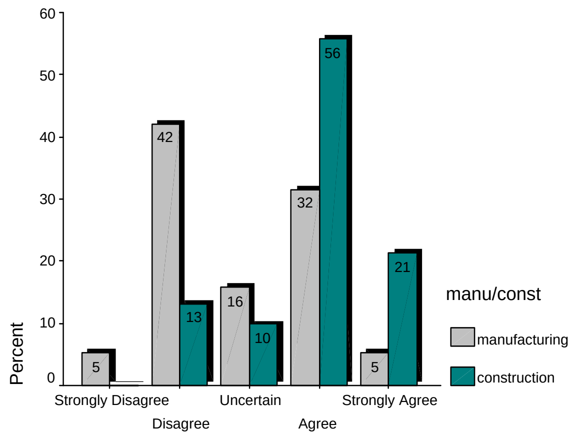


Figure A.29: Manufacturing and construction response to 'there are too many design specification changes during production'

A.10 Section 5 results - performance measurement

The following section details the survey questionnaire response to performance management related issues.

A.10.1 Critical success factors

Figure A.30 illustrates the manufacturing and construction response to ‘the critical success factors of the project were agreed by everyone at the outset.’ It is clear from the bar chart that the majority of manufacturing companies agree to this statement whereas the construction companies are less consistent. Although 51% of the respondents either agree or strongly agree, there is still a high degree unclarity amongst the remaining 49%. Further, since performance metrics are strongly associated with the requirements of the project, Figure 4.30 typically mirrors the result in Figure A.9 whereby respondents were asked if their project requirements are always clearly identified.

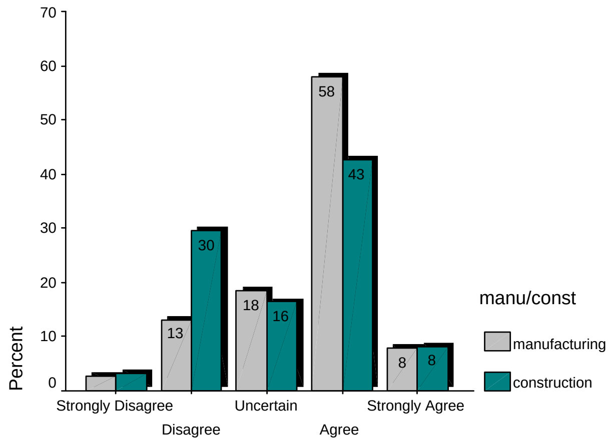


Figure A.30: Manufacturing and construction response to 'the critical success factors of the project were agreed by everyone at the outset'

A.10.2 Reasons for taking measures

Both the majority manufacturing and construction respondents agreed that the principal reason for taking performance measures was to inform the client/ customer, benchmark the project and to manage resources (see Table A.17). However, a significant number of manufacturing companies disagreed to 'inform the client/ customer,' and a significant number of construction clients disagreed to 'benchmark the project.' This was as to be expected. Manufacturers usually produce products in anticipation that there will be a market threshold and so the client will ultimately be the consumer, in which case it is not usually apparent to inform them of the production performance of the product.

The recent introduction of the governments KPIs (key performance indicators) in 1998, over a year after this survey questionnaire was conducted, has contributed to a furry of benchmarking in the construction field (CBPP, 2001), and this may be reflected in the results in Table A.17. However, according to Ball (1988) construction projects are still often considered as a unique and therefore it is difficult to directly compare them against each other, as supported by 24.6% of negative and 19.7% of uncertainty response to the statement. More investigation should follow in this area to ascertain whether companies were benchmarking internally of externally.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Inform the Client/ Customer	Man.	2.6%	39.5%	13.2%	44.7%	0
	Con.	0	11.5%	19.7%	54.1%	14.8%
Benchmark the Project	Man.	0	7.9%	18.4%	68.4%	5.3%
	Con.	1.6%	23.0%	19.7%	47.5%	8.2%
Manage Resources	Man.	0	0	5.3%	78.9%	15.8%
	Con.	0	4.9%	16.4%	62.3%	16.4%

In addition, 3 (7.9%) of manufacturing respondents stated that feedback was a reason for taking measures, and 4 (10.5%) stated that monitoring and controlling risk was a factor; 7 (11.5%) of construction respondents stated that feedback was a reason for taking measures, and 10 (16.4%) stated that it is to monitor and control risk.

Table A.17: Manufacturing and construction response to the reason for taking measures

A.10.3 Alignment of measurement system with the business strategy

The alignment of the measuring system to the business strategy is critical for project success (Globerson, 1985; Dixon et al, 1990; Kaplan & Norton, 1992), though it is not being fully implemented by both manufacturing and construction industries (see Figure A.31). Nearly half of construction respondents (44.7%) were uncertain as to whether this factor was in practice, which is alarming since commercial construction projects, which accounts for nearly all the work of the large construction respondents, would have emerged as a direct result from the need determined in the client's business case. Further, this lack of consistency is reiterated elsewhere in the survey questionnaire (Figure A.3) where respondents were asked if 'new project proposals are always consistent with the overall business strategy' or their organisation. In manufacturing, the response was somewhat uniform across the disagreed, agreed and strongly agreed; and similarly in construction, the response was seemingly uniform across the whole selection criteria. Therefore, this is a key area for consideration for both industries, especially construction.

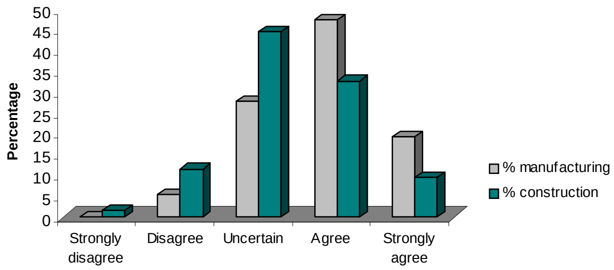


Figure A.31: Manufacturing and construction response to 'our measuring system is aligned to our business strategy'

A.10.4 Time of data collection

Table A.18 illustrates that the manufacturing and construction company responses are aligned in terms of when they collect particular measures. Time is measured every week. Cost every month. Quality every phase review, although the construction respondents were quite widespread in this response and seemed to be uniform over collating quality measures every week, month and phase review. Manufacturers assessed the time-to-completion of a project at each phase review, whereas construction did so every month, and likewise this similar pattern emerged with the metrics of time through each phase of development, total cost against estimated cost, and phase cost against estimated cost. The client/ end-user/ customer satisfaction was always collated at the end of the project in each industry, and 40% of manufacturing respondents claimed that the project team's satisfaction was never assessed and 33% in construction. The process effectiveness/ execution was measured at the end of the project or at the phase review, and the number of changes in the process was never measured although virtually equal construction respondents stated that it was done every month. However, this seems contradictory to a statement elsewhere in the questionnaire that asked respondents if there was a consistent project process within their company (Figure A.13). Although 45.9% of construction respondents agreed, it seemed somewhat questionable against the general belief that there is a consistent construction process and this is highlighted in the 31.1% of respondents who were in disagreement or strong disagreement to the statement. Manufacturers were all in agreement or strong agreement in terms of having a consistent project process. Innovation within the process is again hardly ever measured, and is a possible area to consider for improvement in both industries as highlighted by Kaplan and Norton's balanced scorecard (1992; 1993; 1996). Conclusively, most construction companies assessed the success of their tender submissions every month but what is more alarming, 13.1% never rated their performance in respect of what was perceived against a common metric.

The following data is collected every:		Week	Month	Phase Review	End of Project	Never
Time	Man.	50.0%	39.5%	10.5%	0	0
	Cons.	52.5%	41.0%	3.3%	3.3%	0
Cost	Man.	7.9%	52.6%	36.8%	2.6%	0
	Cons.	14.8%	73.8%	9.8%	1.6%	0
Quality	Man.	7.9%	28.9%	60.5%	0	2.6%
	Cons.	31.1%	29.5%	31.1%	8.2%	0
Time-to-Completion	Man.	13.2%	13.2%	50.0%	23.7%	0
	Cons.	31.1%	54.1%	4.9%	6.6%	3.3%
Time through each phase of development	Man.	5.3%	18.4%	71.1%	2.6%	2.6%
	Cons.	26.2%	42.6%	24.6%	3.3%	3.3%
Total Cost against Estimated Cost	Man.	5.3%	36.8%	39.5%	18.4%	0
	Cons.	8.2%	72.1%	8.2%	9.8%	1.6%
Phase Cost against Estimated Cost	Man.	2.6%	21.1%	57.9%	10.5%	7.9%
	Cons.	4.9%	65.6%	24.6%	4.9%	0
Client Satisfaction	Cons.	4.9%	11.5%	36.1%	44.3%	3.3%

End-User Satisfaction	Cons.	3.3%	3.3%	18.0%	49.2%	26.2%
Customer Satisfaction	Man.	2.6%	5.3%	34.2%	42.1%	15.8%
Team Satisfaction	Man.	2.6%	7.9%	26.3%	23.7%	39.5%
	Cons.	1.6%	6.6%	27.9%	31.1%	32.8%
Process Effectiveness/ Execution	Man.	5.3%	2.6%	31.6%	52.6%	7.9%
	Cons.	1.6%	11.5%	32.8%	34.4%	19.7%
Commercial Success	Man.	0	7.9%	15.8%	68.4%	7.9%
Number of Changes in the Process	Man.	0	2.6%	21.1%	18.4%	57.9%
	Cons.	16.4%	31.1%	9.8%	16.4%	26.2%
Innovation within the Process	Man.	2.6%	0	23.7%	31.6%	42.1%
	Cons.	3.3%	11.5%	27.9%	26.2%	31.1%
Tender Awards against Tenders Submitted	Cons.	6.6%	39.3%	31.1%	9.8%	13.1%

In addition, 6.6% of construction respondents stated that they collected measures relating to safety and environmental issues.

Table A.18: Manufacturing and construction response to the time of data collection

A.10.5 Undertaking of measures

The project team or the project manager conducted most of the measuring in both industries, as detailed in Table A.19, which is encouraging since the literature cites that measurement should involve all employees to enhance performance. What is questionable in these results is the number of metrics that was collated by process managers in construction, as this seems contrary to the belief that there are process managers currently in place. Elsewhere in the questionnaire construction respondents were asked if they already had a process manager (See Figure A.24); 29.5% agreed or strongly agreed that they did, whereas 47.3% disagreed or strongly disagreed leaving the rest of 13.1% uncertain. Another alarming result in the above table is the number of construction clients, more than the manufacturing clients, who actually conduct the measuring. Surely the organisation providing the service to the client should also provide the empirical evidence to them of their success or failure. Perhaps, but more importantly, this result reiterates the lack of efficient, effective and consistent performance measurement in the industry.

The following measures are undertaken by:		N/A	Project Team	Process Manager	Project Manager	External Party	Client
Time	Man.	0	26.3%	5.3%	68.4%	0	0
	Cons.	0	44.3%	3.3%	49.2%	1.6%	1.6%
Cost	Man.	0	26.3%	10.5%	57.9%	5.3%	0
	Cons.	0	42.6%	4.9%	42.6%	6.6%	3.3%
Quality	Man.	2.6%	34.2%	21.1%	28.9%	10.5%	2.6%
	Cons.	0	57.4%	4.9%	31.1%	1.6%	4.9%
Time-to-Completion	Man.	0	7.9%	21.1%	65.8%	2.6%	2.6%
	Cons.	3.3%	41.0%	4.9%	45.9%	1.6%	3.3%
Time through each Phase of Development	Man.	2.6%	13.2%	21.1%	60.5%	2.6%	0
	Cons.	3.3%	39.3%	6.6%	45.9%	0	4.9%
Total Cost against Estimated Cost	Man.	0	21.1%	13.2%	57.9%	7.9%	0
	Cons.	1.6%	45.9%	4.9%	37.7%	6.6%	3.3%
Phase Cost against Estimated Cost	Man.	7.9%	13.2%	10.5%	63.2%	5.3%	0
	Cons.	0	47.5%	4.9%	39.3%	4.9%	3.3%
Client Satisfaction	Cons.	3.3%	39.3%	3.3%	34.4%	8.2%	11.5%
End-User Satisfaction	Cons.	26.2%	24.6%	3.3%	24.6%	6.6%	14.8%
Customer Satisfaction	Man.	15.8%	18.4%	7.9%	31.6%	18.4%	7.9%
Team Satisfaction	Man.	39.5%	23.7%	10.5%	21.1%	5.3%	0
	Cons.	32.8%	31.1%	0	32.8%	1.6%	1.6%
Process Effectiveness/ Execution	Man.	7.9%	18.4%	31.6%	36.8%	5.3%	0
	Cons.	19.7%	29.5%	13.1%	31.1%	4.9%	1.6%
Commercial Success	Man.	7.9%	10.5%	7.9%	42.1%	26.3%	5.3%
Number of	Man.	57.9%	7.9%	13.2%	18.4%	2.6%	0

Changes in the Process	Cons.	26.2%	34.4%	3.3%	32.8%	1.6%	1.6%
Innovation within the Process	Man.	42.1%	13.2%	21.1%	18.4%	2.6%	2.6%
	Cons.	31.1%	24.6%	9.8%	27.9%	4.9%	1.6%
Tender Awards against Tenders Submitted	Cons.	13.1%	50.8%	1.6%	27.9%	4.9%	1.6%

Table A.19: Manufacturing and construction responses detailing who conducts the project's measurement

A.11 Section 6 results - Information Technology

The following section details the manufacturing and construction responses to the survey questionnaire relating to IT.

A.11.1 Integrated IT system to support communication

Figure A.32 illustrates that an integrated IT system is used to support communication in both industries. The results are generally aligned across the whole selection criteria. However, the results are questionnaire since the statement is open to much interpretation. Further, this interpretation may have led to a significant number of agreement and strong agreement in the construction response. It appears to the researcher that IT does not fully support project team communication since there are major compatibility issues that interplay between the project participants, further, this factor has contributed to the emergence of information management systems (Lee et al, 2001).

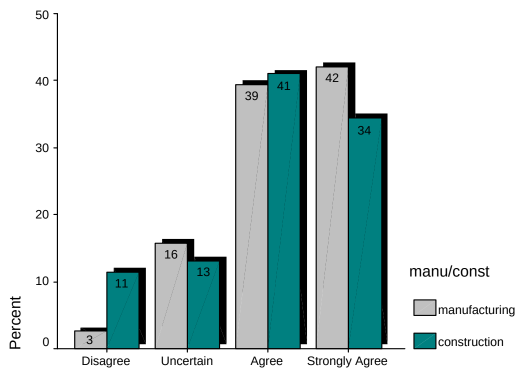


Figure A.32: Manufacturing and construction response to the use of an integrated IT communication system

A.11.2 The use of advanced technologies

Table A.20 illustrates the manufacturing and construction response to the use of advanced technologies. Both industries significantly agreed that integrated databases, document management systems and inter/ intra/ extranet applications would assist in project success. However, the response to the use of artificial intelligence was rather bewildered for both industries, and this may be attributed to the lack of understanding from the survey questionnaire respondents. The use of artificial intelligence is somewhat limited in use compared to the other three criteria, which are all actively apparent. This needs to be further investigated.

		Strongly Disagree	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
Integrated Databases	Man.	0	2.6%	5.3%	63.2%	28.9%
	Con.	0	3.3%	1.6%	55.7%	39.3%
Document Management Systems	Man.	0	5.3%	2.6%	60.5%	31.6%
	Con.	0	1.6%	1.6%	47.5%	49.2%
Artificial Intelligence	Man.	7.9%	21.1%	39.5%	18.4%	13.2%
	Con.	0	13.1%	55.7%	21.3%	9.8%
Inter/ Intra/ Extranet Applications	Man.	2.6%	5.3%	5.3%	52.6%	34.2%
	Con.	1.6%	3.3%	13.1%	52.5%	29.5%

Table A.20: Manufacturing and construction response to the use of advanced technologies

A.11.3 Where IT is used in the project process

Table A.21 details the results of the survey questionnaire of where IT is currently used in the project process. It is apparent that both industries are typically aligned in the criteria excepted in the issue of risk, project-based case-retrieval and what-if analysis.

		Agree	Uncertain	Disagree
Economic Appraisal	Man.	76.3%	13.2%	10.5%
	Con.	73.8%	11.5%	14.8%
Risk Analysis	Man.	39.5%	26.3%	34.2%
	Con.	68.9%	11.5%	19.7%
Project Simulation	Man.	55.3%	15.8%	28.9%
	Con.	52.5%	23.0%	24.6%
Project-Based Case-Retrieval	Man.	28.9%	39.5%	31.6%
	Con.	44.3%	23.0%	32.8%
Quantity Take-Off	Man.	52.6%	26.3%	21.1%
	Con.	83.6%	8.2%	8.2%
Cost Planning/ Estimating	Man.	81.6%	5.3%	13.2%
	Con.	95.1%	1.6%	3.3%
Accounting/ Commercial Management	Man.	92.1%	5.3%	2.6%
	Con.	100%	0	0
2D/ 3D Visualisation	Man.	89.5%	2.6%	7.9%
	Con.	73.8%	16.4%	9.8%
Project Planning	Man.	92.1%	2.6%	5.3%
	Con.	98.4%	0	1.6%
Virtual Reality Based Prototyping	Man.	36.8%	21.1%	42.1%
	Con.	36.1%	21.3%	42.6%
Electronic Data Interchange	Man.	73.7%	15.8%	10.5%
	Con.	82.0%	9.8%	8.2%
Resource Management	Man.	65.8%	21.1%	13.2%
	Con.	60.7%	29.5%	9.8%
'What If' Analysis	Man.	55.3%	21.1%	23.7%

	Con.	39.3%	27.9%	32.8%
Manufacturability	Man.	47.4%	28.9%	23.7%
Buildability	Con.	14.8%	36.1%	49.2%
Robotics	Man.	23.7%	28.9%	47.4%
Robotics Based Site Analysis	Con.	6.6%	26.2%	67.2%
Maintenance Management	Man.	36.8%	42.1%	21.1%
	Con.	36.1%	34.4%	29.5%

Table A.21: Manufacturing and construction response to the use of IT in the project process

A.11.4 Where in the project process IT should be used

Table A.22 details the manufacturing and construction response to where IT should be used in the project process. Again, both industries are aligned in agreement, except in the process of robotics.

Processes		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Economic Appraisal	Man.	0	2.6%	10.5%	39.5%	47.4%
	Con.	0	1.6%	3.3%	39.3%	55.7%
Risk Analysis	Man.	0	5.3%	10.5%	44.7%	39.5%
	Con.	0	4.9%	8.2%	42.6%	44.3%
Project Simulation	Man.	0	7.9%	13.2%	36.8%	42.1%
	Con.	0	0	13.1%	47.5%	39.3%
Project-Based Case-Retrieval	Man.	0	2.6%	28.9%	39.5%	28.9%
	Con.	0	1.6%	19.7%	45.9%	32.8%
Quantity Take-Off	Man.	0	2.6%	23.7%	44.7%	28.9%
	Con.	0	0	4.9%	49.2%	45.9%
Cost Planning/ Estimating	Man.	0	2.6%	2.6%	50.0%	44.7%
	Con.	0	0	0	42.6%	57.4%
Accounting/ Commercial Management	Man.	0	0	2.6%	39.5%	57.9%
	Con.	0	0	0	39.3%	60.7%
2D/ 3D Visualisation	Man.	5.3%	2.6%	0	44.7%	47.4%
	Con.	0	3.3%	13.1%	34.4%	49.2%

Project Planning	Man.	2.6%	0	0	36.8%	60.5%
	Con.	0	0	0	45.9%	54.1%
Virtual Reality Based Prototyping	Man.	2.6%	7.9%	21.1	34.2%	34.2%
	Con.	1.6%	3.3%	26.2%	39.3%	29.5%
Electronic Data Interchange	Man.	5.3%	0	2.6%	34.2%	57.9%
	Con.	0	0	3.3%	39.3%	57.4%
Resource Management	Man.	2.6%	0	2.6%	44.7%	50.0%
	Con.	0	1.6%	6.6%	55.7%	36.1%
'What If' Analysis	Man.	2.6%	0	0	55.3%	42.1%
	Con.	0	3.3%	16.4%	47.5%	32.8%
Manufacturability	Man.	2.6%	2.6%	13.2%	36.8%	44.7%
Buildability	Con.	1.6%	8.2%	31.1%	41.0%	18.0%
Robotics	Man.	5.3%	10.5%	28.9%	34.2%	21.1%
Robotics Based Site Analysis	Con.	0	19.7%	42.6%	21.3%	16.4%
Maintenance Management	Man.	0	0	31.6%	34.2%	34.2%
	Con.	0	6.6%	18.0%	47.5%	27.9%

Table A.22: Manufacturing and construction response to where in the project process IT should be used

APPENDIX B

B.1 Castle Vale survey questionnaire

B.2 Letter to organisations requesting costing information

Wednesday, 24 May 2000

Dear <Title> <Surname>,

Re: Study of the JS Data Stream on the Sainsburys Castle Vale project, Birmingham.

I am currently undertaking a research project, entitled Process Protocol, which aims to improve the performance of the construction industry by focusing upon the whole design and construction process (please see the enclosed leaflet or visit our website for more information http://www.processprotocol.com). In particular, we are concentrating on the performance aspect of construction projects and have been subsequently enlisted through Jim Woolcott (Sainsburys), Duncan Robertson and Russell Crewe (Schal), and Brandon Parks (Building Information Warehouse) to help analyse the benefits of the JS Data Stream as it is applied on the Castle Vale project.

The study aims to gather empirical data from the JS Data Stream's access reports, and as you are probably aware, attitudinal responses from the questionnaire that has been published on the system. However, we also need to investigate the possibility that the project's printing costs have been distributed elsewhere across the project team. Therefore, we would be very grateful if you could answer the following questions, which will examine your company's printing costs whilst using the JS Data Stream against that of the traditional method of operation. If you feel you cannot answer the following questions, please could you pass on this letter to an appropriate person in your company: -

- Approximately how much money do you think the JS Data Stream has cost or saved your company to print out project documents (in terms of paper and ink cartridges)?

- Approximately how much would you have expected a project of this type to cost in terms of printing out project documents (in terms of paper and ink cartridges)?

The results of the study will be presented in statistical terms and therefore your input (which is confidential) will not be attributed to you or your company. We will be producing a summary report of the entire research on completion of the project and it will be available via the JS Data Stream. We would be very grateful if you could help by completing the above questions and either return it to us at the above address or email a.lee@salford.ac.uk or facsimile 0161 295 6174 your response by no later than 12th June. Please do not hesitate to contact us if you have any queries or would like more information on the Process Protocol (direct line 0161 295 6171). We thank you in anticipation and look forward to hearing from you.

Yours sincerely,

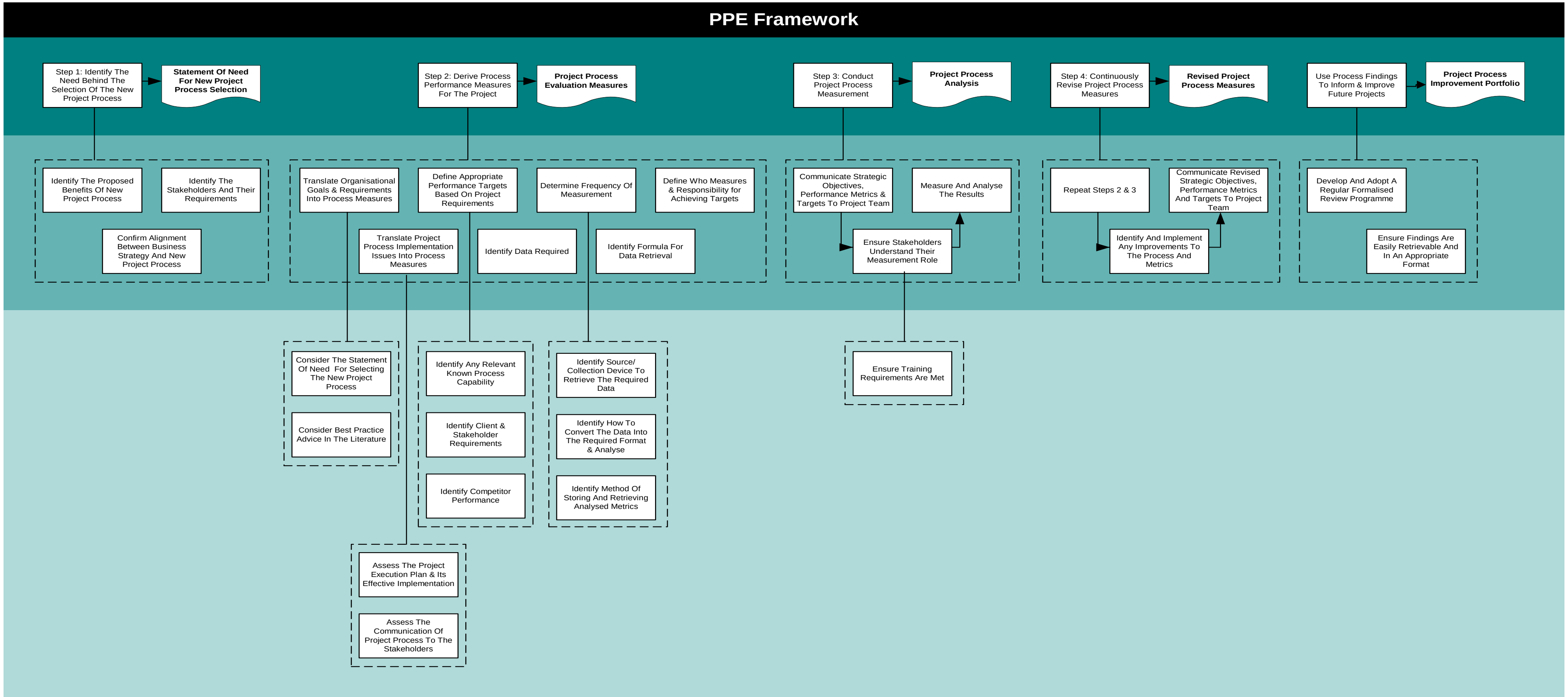
Angela Lee - Researcher

APPENDIX C

C.1 Britannia Walk survey questionnaire

APPENDIX D

D.1 PPE framework



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