THE DEVELOPMENT OF AN INNOVATIVE SUSTAINABLE TOTAL PLANNING AND CONTROL SYSTEM FOR CONSTRUCTION PROJECTS

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DECLARATION

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ABSTRACT

The management of construction projects has been heavily criticised by government institutions, academics and practitioners for delays, cost overruns and suboptimum performance. Numerous studies have identified project planning as the main problem with both the management methodology and conventional project planning techniques deemed insufficient. It has been established that only fifty per cent of the planned work is completed as scheduled. This is consistent with the findings of this study, which again confirms the insufficiency of the techniques available to the general practitioner.

This research explores operational problems associated with project planning and control, and develops an innovative and holistic planning and control system to deliver sustainable construction projects. A qualitative strategy was adopted for this study utilising interviews and multiple case study methods, which are complementary approaches. In total, four case studies were selected from the predominant UK construction industry and 81 interviews were conducted for this study. Given the criticisms of qualitative research as methodologically weak, this study develops a research process that addresses the specific objectives of the study.

This research contributes to Project Management (PM) knowledge by developing and implementing an innovative Total Planning and Control (TPC) system to enhance the current practice and to deliver sustainable projects. The TPC system is a holistic, simple, effective and efficient approach for project planning and control in the 'real world' construction industry. It was developed through a practice informed theory approach, which make it more applicable to actual construction projects. The implication of the TPC system is to overcome the limitations of planning and managing construction projects, which also improves communication, workflow and sets foundation for related functions such as, logistic, cost, risk, collaborative and early warning planning. The TPC system comprises of the development of a 4Es (Economic, Effectiveness, Efficiency, and Ethics) management and performance model, project and PM constraints, construction PM managerial process, as well as a sustainable model, 4Es and 4Poles (Technology, Economy, Society and Environment). This study is concerned with the enhancement of construction PM practice. It also enables a deeper understanding of project planning and control in contrast to the conventional planning system which focuses mainly on scheduling.

DEDICATION

To God be the Glory, Great things He has done and Greater things He will do, Amen.

This thesis is dedicated to my dearest wife, Lordina, my children, Prince-Daniel and Elrod Shane, and my Mum and Dad, Comfort and Daniel. I love you and remain blessed.

Epigram

"Wisdom will protect you just like money; knowledge with good sense will lead you to life"

The Holy Bible: Ecclesiastes 7:12
(*Contemporary English Version*)

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ABBREVIATIONS LIST

4Es	Economic, Effectiveness, Efficiency and Ethical
4Poles	Economy, Environment, Society and Technology
5Ws & H	What, When, Where, Whom, Why and How
ABC	Activity Based Costing
ADePT	Analytical Design Techniques
APM	Association for Project Management
BoK	Body of Knowledge
BRE	Building Research Establishment
BREEM	Building Research Establishment Assessment Method
CIOB	Chartered Institute of Building
BSI	British Standard Institution
CPM	Critical Path Method
CPMMP	Construction Project Management Managerial Process
CS	Case Study (thus e.g. CS-01 means Case Study One)
CS-01-SSR1	Case Study One, Semi Structured Respondent One
CS-02-USR2	Case Study Two, Unstructured interview Respondent Two
DBS	Deliverable Breakdown Structure
DCPM	Decision critical Path Method
FIPS	Federation Information Process Standard
GDCPP	Generic Design and Construction Process Protocol
GERT	Graphical Evaluation and Review Techniques
H & S	Health and Safety
HIPO	Hierarchy Plus – Input – Process – Output
ICAM	Integrated Computer Aided Manufacturing
ICOM	Input, Control, Output and Mechanism
IDEF0	Integrated Definition zero
IGLC	International Group of Lean Construction
IUNC	International Union for Conservation of Nature
LC	Lean Construction
LoB	Line of Balance
LPS	Last Planner System™
MMT	Million Metric Tons
PDP	Project Delivery Planning (also as Project Planning)
PERT	Program Evaluate Review Technique
PM	Project Management
PMI	Project Management Institute
PMMP	Project Management Managerial Process
PPC	Percentage Plan Completion
PRINCE2	Project in Controlled Environment
RICS	Royal Institution of Chartered Surveyors
SADT	Structured Analysis Design techniques
TCQ	Time, Cost and Quality
TFV	Transformation, Flow and Value theory
TPC	Total Planning and Control system
UML	Unified Modelling Language
VfM	Value for Money
WBS	Work Breakdown Structure

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

This chapter provides the background to the research and the problem being reviewed and investigated. It also gives an overview of the work done, methodology used, the findings and contributions to knowledge. This chapter is structured into six sub-sections. The first section presents the context and the rationale of the study. The second is the aim, objectives and the research questions, the third, fourth and the fifth sections present the overview of the work-done, methodology, and findings and contribution to knowledge respectively. The sixth section presents the structure of the thesis.

1.2 CONTEXT AND RATIONALE OF THE RESEARCH

1.2.1 The Context of the Research

Kibert (2008) and Burgan and Sansom (2006) all agree that a strong, successful and world-class construction industry is vital to social, environmental and economic success. They established that the construction industry contributes significantly to every economy; for example, it contributes around 10% and 8% Gross Domestic Product (GDP) to the European and USA economies respectively. In parallel, construction accounts for significant carbon dioxide emissions; thus, 'sustainability' seems to be vital to construction projects. However, the construction industry has been criticised by both researchers and governmental organisations for its excessive delays, cost overruns and suboptimal performance, which is mainly attributed to a lack of effective project management (Sweis *et al.* 2008, Atkinson 1999, Koskela and Howell 2002a, 2002b). They believe Project Management (PM) is essential for designing, delivering and managing projects. According to the Chartered Institution of Building (CIOB), formal principles of PM were adopted into the construction industry circa five decades ago (CIOB 2002). Before this time, architects and engineers managed construction projects formally. This adoption of formal PM is attributed to the establishment of PM societies and the wider spread and general acceptance of PM principles in many other industries. PM principles were formally recognised from the publication of the Project Management Body of Knowledge (PM BoK) and Association of Project Management Body of Knowledge (APM BoK) and others, which are discussed in detail in chapter two of this thesis. These principles have been adopted and generally accepted into the construction industry. But the question is being asked: **whether a construction project and its management is the same as any other project**?

Howell and Koskela (2000 p. 1) have challenged these PM principles from the construction perspective that there is no underlying theory or basis for these principles. They assert that "project management as taught by professional societies and applied in current practice must be reformed because it is inadequate today and its performance will continue to decline". They also claimed that PM is failing because of the flaws in assumptions. They presented two main issues: firstly, is the faulty understanding of the nature of work in construction projects and secondly, is the implicit theoretical stance. Later in their publication "the underlying theory of project management is obsolete", they proposed the Transformation, Flow and Value generation theory (Koskela and Howell 2002b). This theory was first proposed by Lauri Koskela in 1992 and 1999 and later in his PhD thesis in 2000, which is discussed in detail in chapter five of this thesis (Koskela, 1992, 1999 and 2000). Since then literature has been scant in the development of the concept and understanding of a construction project and its management process.

Many researchers of PM, such as Wateridge (1995), Bowen *et al.* (2000), Wit (1988), Reiss (1995, 2007), have critiqued the concept of construction PM based on Time, Cost and Quality (TCQ), and sometimes performance (PM BoK and APM Bok). In the publications of Reiss (1995 and 2007), he ascertained that this approach of management based on TCQ is like juggling three balls of time, cost and quality, which allows trade-offs between them. Although some studies such as Ballard (2000), Atkinson (1999) and Reiss (1995, 2007) have categorically challenged this approach, they did not explicitly propose new approaches of management.

There is a consensus in literature that construction projects are different in their production. Numerous studies have also clearly differentiated construction projects from other projects but none of these studies investigated the understanding and definition of a construction project to conceptualise construction project management. It is therefore important in this study to first address the understanding and definition of a construction project and the concept of construction project management managerial process, before the practical problem of planning and control can be examined and solved.

Research literature on construction management has evolved over the last few decades in terms of materials, transport systems, electronics and information technology (Sturges *et al.* 1999). The authors were examining the innovation in the construction industry at the end of the 20th century, which no doubt may have improved significantly in this 21st century. However, this is not the case as compared to planning and control techniques. Construction planning techniques are limited to the conventional techniques, although construction projects are becoming more complex and demanding.

In the 1990s, there was an academic debate in the UK construction research and industry to incorporate production models into construction (Ballard and Howell 1998, Egan 1998, Koskela 1992, Latham 1994); however, the Egan (2002) and Wolstenholme (2009) assessment after the decade has revealed that the industry's improvement is insignificant. The problems of the construction industry have been largely attributed to management problems and the fragmented nature of the industry. Specific studies such as Morris (1994), Sambasivan and Soon (2007), Ballard and Howell (2003), Sweis *et al.* (2008), and Jongeling and Olofsson (2007) attribute the problem to a lack of project planning and control. They argued that, the current PM (planning) techniques do not allow integrated management and structured analysis; there is a lack of workflow, a lack of collaboration and a lack of common understanding of process. Johansen and Wilson (2006) stress the importance of planning in construction to limit delays and cost overruns. According to Mubarak (2005), project-planning serves as a foundation for several related functions such as cost estimating, scheduling, project control, quality control, safety management and others; however, none of the methods available currently in the construction industry give all these functions. Most of the current techniques focus on scheduling only rather than planning. Sullivan *et al.* (2010) argue that poor logistic planning cost the UK construction industry over £3 billion. Kenley (2004) advocates that it is time to focus more effort on changing the way work is planned and managed in construction, whilst Johansen and Wilson (2006) concluded that unless the industry finds ways to develop some convergence in planning, there will continue to be unsuccessful project planning. In response to these concerns, this thesis develops a holistic system for project planning and management to offer improvements to current practice by the adaptation of the Integrated DEFintion Zero (IDEF0 – pronounced I-Def –Zero) model as the analytical tool.

Colquhoun and Baines, (1991) and Othman (2004) argue that IDEF0 is an important tool that is easy to apply and most importantly to understand. During the course of this study, it was established that the IDEF0 model is little known and seldom used in the UK construction industry and globally little known in the construction industry. However, it has the potential to be adopted as the analytical process tool for developing holistic planning and control (Othman, 2004 and Ang *et al.,* 1999). They advocate that IDEF0 aids in understanding the process through its visual representation of the flow of activities.

1.2.2 The Rationale of the Research

Kozak-Holland (2011) argues that the history of PM can be traced from many centuries ago. According to Morris *et al.* (2006), the current form of PM began in the late 1950s. However, it was adapted into construction industry 40 to 50 years ago (CIOB 2002). The evolution of PM has been closely related to the development of systems engineering in the US Defence and aerospace industry, and to engineering management in the process engineering industries (Morris 1994). By the late 1960s, the US Defence developed the current predominant tools in construction industry such as: Work Breakdown Structure (WBS), Program Evaluate Review Technique (PERT, similar to Critical Path Method), Network Diagram, and Gantt chart (originally developed in 1917 by Henry Gantt) as the main PM tools. Morris (1994) argues that, despite its long development, the concept and techniques of PM currently available to the general practitioner, however advanced and specific they may be, are often insufficient to the overall task of managing a project successfully. Thus, delays, cost overruns, and suboptimal performance in the construction industry are a global problem, which is due to the lack of effective PM (Atkinson 1999, Wolstenholme 2009, Koskela and Howell 2001). Dvir and Lechler (2004) established that numerous empirical studies on project management success factors suggest that planning is the major contributor to project success. Greenwood and Gledson (2012) discuss the importance of frontend planning. Equally Johansen and Wilson (2006) highlight the importance of planning from both frontend (first planning) and last planning. Despite these empirical studies identifying planning as the key issue, there is limited literature on the planning techniques (most of the literature focuses on the conventional techniques developed before the 1960s). Ballard and Howell (1998, 2004) argued that only about 50% of the tasks on weekly work plans are completed by the end of the plan week due to lack of project planning and control.

The problem of insufficient technique has been compounded by a lack of understanding and communication within a project. BSI (2010) established that a lack of communication within the UK construction industry costs the industry over £20 billion annually. This communication problem in the construction industry can be categorised in two parts that are the social and activity flow. The former (social) has been discussed by Dainty *et al.* (2006) but the common understanding of the process still remains a problem, while the latter (flow) has been advocated by other researchers, especially, lean construction researchers. Ballard and Howell (1998) claim the current management and principle of construction lack "flow". Similarly, Koskela (1992) claims traditional planning fails to support the planning of work flow of teams or material flows and may lead to suboptimal flows. He also argued that construction project management as practiced is based on the conventional theory of transformation (that is input to give an output). He concluded that the current academic research and teaching in construction engineering and management is founded on an obsolete conceptual and intellectual basis. Thus, it should be replaced with a form that encompasses Transformation, Flow and Value generation perspectives within a single TFV theory (Koskela 1992, Koskela and Howell, 2001).

In parallel, in the mid-1990s, Glenn Ballard introduced the Last Planner System® (LPS) to bridge the gap in flow in planning but from production perspective (Ballard 1994, 1998). According to Ballard, LPS is a system for production control (Ballard 1998, 2000a, 2000b). According to Ballard (2000b) and Lean Constructionists[1], LPS has been applied successfully in many projects. Henrich *et al.* (2005) claim LPS is suitable for directive-driven production rather machine driven. According to Henrich *et al.* (2005), the LPS has two main focuses: short term planning[2] (which does not have a prominent role in LPS) and development of social system on site. Kenley (2004) and Henrich *et al.* (2005) establish that LPS adds a production control component to the traditional PM system. This implied LPS is still dependent on the conventional PM tools, although they have heavily criticised these techniques to be insufficient (Ballard 1998, Koskela 1992, 2000; Ballard and Howell 1998, 2000). Johansen and Porter (2003) concluded in their study, 'an experience of introducing LPS in UK construction project', that there are cultural barriers to the implementation of LPS as well as the UK building construction, where a project is carried out by subcontractors.

According to Bertelsen *et al.* (2006), the deeper understanding of workflow in construction process is one of the main contributions of Lean Construction. Similarly, the Ballard and Co publications on the LPS suggest that, it was introduced to partly address the issue of workflow in the existing techniques. However, according to Kenley (2004), LPS emulates flow through managing control systems and activity protection but does not physically create flow in the production system. Similarly, Bertelsen *et al.* (2006) also reviewed the Lean Construction general theory and LPS as the tool for managing flow of work. Bertelsen *et al.* (2006) found that LPS does not present general tools for management of six of Koskela's seven flows[3]

[1] Discussed www.iglc.org

[2] Short term duration denotes anything less than four weeks normally weekly

[3] For more detail, please see figure 3.1 in chapter 3 of this thesis.

(discussed in chapter 3) neither does it deal with them in detail. The LPS has been claimed to be a successful tool for the Lean Construction; however, Henrich *et al.* (2005) claim a Danish study on its use did not find significant benefits. Kenley (2004) argues that Lean Construction is regulated to the current planning and scheduling methodology, although they focus on conversion. He further established that, the difficulty of applying Lean Construction arises from the problem of identifying workflow in a production system that is based around the discrete activities inherent in activity based critical path planning and execution. Bertelsen *et al.* (2006) reviewed the current construction planning and control techniques including LPS, and discussed their limitations. They ascertained for long term planning (also referred as master planning) the technique used is CPM, whilst the intermediate (look-ahead) uses CPM, LoB and Critical path. LPS is mainly used for control. Both Kenley (2004) and Bertelsen *et al.* (2006) concluded that there is a need for new understanding and better flow model suited for PM. Maylor (2003, 2010) suggests a need for a holistic approach for project management. It is therefore proposed that the current planning and control techniques are inadequate in managing construction projects.

In this response, and for better understanding, and realistic project planning and control in the construction industry, there is a need to investigate the industrial problems associated with project planning and control, and identify the construction work flow and requirements for planning and control. Therefore, this research focuses **on the development of the Total Planning and Control system, a holistic planning and control technique to enhance the current project planning to be as effective as possible to improve the flow**. The Total Planning and Control system is developed to improve and/or overcome the limitation of planning and management technique, communication barriers, lack of collaboration due to inter-disciplinary and iterative nature of construction, lack of common understanding and workflow, and improve the learning process in construction. In addition, it enhances project control by increasing value through the process by the introduction of a comparator; thus, the TPC system enhances the current construction project management practice. The importance of planning is highlighted by Ballard and Howell (1998), who indicated that when planning reliability is above 50%, it will save 30% of labour consequently reducing project cost.

In order to develop a new holistic and innovative planning and control system, there is a need for a suitable technique to represent the construction work flow, and the requirements for project planning and control. This necessitated the review of process flow models including IDEF0. By the late 1980s, the US Defence, which has been the reference point for PM, also turned to manufacturing to increase their productivity, thus introducing a programme for

Integrated Computer Aided Manufacturing (ICAM). ICAM highlighted the need for better analysis and communication techniques for the people involved in improving productivity, hence developing IDEF0.

In conclusion, the rationale of this study is summarised as follows:

1. The construction industry contributes significantly to every economy, it impacts on every person, especially in terms of where they live and work. The management of projects is necessary to having a vibrant society and economy. Conversely, it also accounts significantly for carbon emission. Thus sustainability is an essential aspect of the entire project management process and therefore its true value should be assessed as part of the planning and control process which has not been explored in existing literature Therefore, improving construction project planning and management is crucial to every economy, society, as well as the environment.

2. Project management principles from professional societies have become an important part of construction management. This is based on the assumption that a construction project and its managerial process are the same as any industry. Yet, various researchers have differentiated construction projects from other projects.

3. These professional societies focus management of projects on the TCQ model. This is no different with the management of construction projects; however, empirical studies have established that this model allow trade-offs.

4. In construction project management, numerous empirical and professional studies have established the importance of planning and control, where planning is recognised as a major contributor to project and project management success. Koskela and Howell (2002 p. 300) states that *"it is no exaggeration to claim that project management as a discipline is in crisis"*. Maylor (2003), among many researchers stresses the importance of a holistic approach to project management.

5. In spite of all these studies, planning and control techniques are limited to the conventional techniques in both literature and practice. Even though existing techniques have been criticised as insufficient, they cannot be supplanted since there is no better. The problems identified include:
   - The existing techniques focus on scheduling (mainly time and cost)
   - Lack of integrated management and structural analysis of the process
   - Lack of work flow and common understanding of the process

- Lack of information flow and distribution
- Lack of collaboration (first and last planning)

1.3 AIM, OBJECTIVES AND RESEARCH QUESTIONS

1.3.1 Aim

The aim of this research is to develop a holistic planning and control system through the incorporation of production models to enable the delivering of sustainable construction projects and enhance the current practice.

1.3.2 Research Objectives

The specific objectives of this research are to:

1. Critically review the literature on the concept of project management, planning and control, and production modelling techniques as it applies to the construction industry. In addition, review the concept and understanding of achieving sustainable construction in a project management context.
2. Empirically investigate the understanding and definition of a construction project and other projects in order to conceptualise the construction project management managerial process.
3. Empirical investigation of industrial problems associated with project management, and planning and control.
4. Identify the requirements, factors and task flow for project planning and control.
5. Adapt the methodologies identified to suit the construction process and from the first four objectives develop an innovative holistic project planning and control system called the Total Planning and Control (TPC) system.
6. Implement and evaluate the TPC system through the Case study projects.

1.3.3 Research Questions

From the research aim and objectives two main questions were formulated. The questions are as follows:

Q1 What are the industrial problems and challenges associated with project planning and control, and what are the essential drivers and flows required for successful task completion?

Q2 How can the project planning and control problems identified in Q1 be addressed in an innovative system to enhance the current practice?

1.4 OVERVIEW OF WORK DONE

This study is situated in the construction project management of building and civil engineering works. However, the concepts of PM in other fields are explored in literature as it is applied and adopted into the construction industry. The study also reviews the incorporation of a bespoke of Koskela's TFV theory of production into the development of the proposed holistic planning and control system (Koskela 1999, 2000). This theory has been widely acclaimed by lean constructionists. According to Bertelsen *et al.* (2006), the introduction of deeper understanding of flow and value is part of the main contributions of lean construction. Koskela establishes that a value is associated with satisfying the client's requirements. However, Salvatierra-Garrido and Pasquire (2011) challenge the understanding of 'value'. They argue that value should be examined from a global perspective. In broader terms, they claim value is the meeting point of production and delivery capacity, society's value perspective and stakeholders' value perspective. This study equally shares this view of value. This research is situated in the intersection of the conventional construction project management, lean construction and some adaptations from the manufacturing industry (see figure 1.1 below).

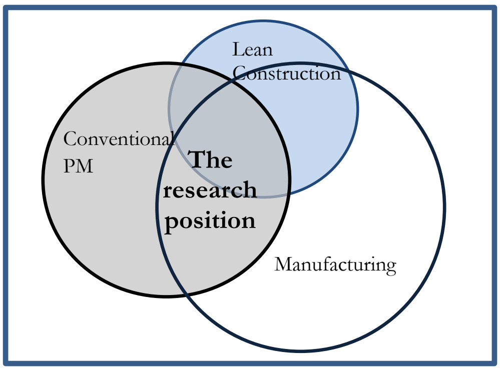

Figure 1. 1: The position of the research in the existing PM knowledge

The scope of this study covers the conceptualisation of the construction PM process, identifying the problems of the industry and challenges associated with PM especially project planning and control, the investigation of requirements and task flow for project planning and control to develop the Total Planning and Control (TPC) system and its implementation.

The literature establishes the theoretical position in construction PM as well as identifying the gap in knowledge. Figure 1.2A shows the structure of the literature review and how they are connected to each other (using patch work), while figure 1.2B shows the structure of each chapter, which adopts the funneling approach (Wellington *et al.* 2005). The illustrates that each chapter starts with an introduction of the chapter, then an overview, which discusses the pertinent issues, background and terminologies which then narrows down to the main discussion on existing literature and finally a conclusion is drawn.

The literature review spans from the beginning to the analysis and writing up of this thesis, therefore, it was not limited only to the beginning or the first part of the research. This ensures broader understanding of the subject area and being up to speed with the latest studies in the research area. Particularly, it aids in the development of the Total Planning and Control (TPC) system.

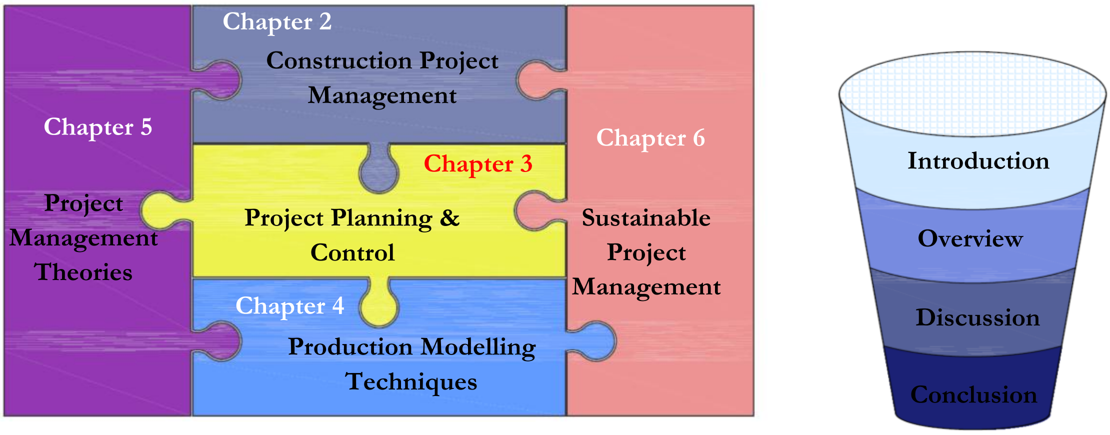

Figure 1.2A: Jigsaw connection of chapters

Figure 1.2B: Arrangement of chapters

Figure 1. 2: Structure of literature Review chapters – Research stage one

Similarly, the critical literature review enhanced the philosophical assumptions and methodology for this research. An initial structured interview with 40 participants was conducted to establish the theory and to streamline the research focus. Then, this was followed with multiple case studies and finally with semi structured interviews; in total, four case studies and 52 participants' interviews. The research process below clearly explains the stages of the study.

1.5 OVERVIEW OF METHODOLOGY

The ontological position of this research is social constructivist that deemed reality as a means of social construction with project management knowledge as individual and condition dependant. It concentrates on the subjective but critical social and textual phenomena, thus, drawing the epistemology of interpretivism. The main research strategy for this research is the qualitative approach and the methods used are case studies and interviews.

1.5.1 Methodology

When undertaking a research project, it is important to choose the correct methodology to ensure specific research objectives, questions and/or aims can be met and the findings validated, i.e. the type of knowledge to be discovered such as, descriptive, explanatory or exploratory (Naoum, 2007; Yin 1994)

Construction management[4], where this study is situated, is a fairly new discipline, which makes use of methodological pluralism drawing on influences from several philosophical as well as methodological paradigms (Fellows and Liu 1997, 2008, Knight and Ruddock 2008). Methods used have evolved from social and natural sciences, and accordingly both quantitative and qualitative data collection techniques are utilised with respective modes of inference. This has led to an abundance of recognised research methods, which have been used to contribute successfully to knowledge. Several considerations have to be taken when choosing what method(s) to use. Numerous philosophies of science and scientific paradigms quite naturally play an important role in this. However, the appropriateness of the method and the conclusions thereof cannot be assessed on a philosophical stance alone. Rather, it is the appropriateness of the research method, in conjunction with the applied research design to examine the research problems in its totality, that is key.

1.5.2 Research Strategy

Owing to the qualitative nature of this study, four strategies were considered as suggested by Hunter and Kelly (2008) i.e. action research, grounded theory, qualitative interviews and case study research. All these strategies have their advantages and disadvantages; however, choosing the appropriate strategy is not only to suit the research problem but also how well it fulfils the practical limitations that are undoubtedly set on the study e.g. time, resource constraints and access to data. The strategy adopted should be adequately applied so that important elements are not missed out or constrained, thus, suiting the problem under investigation. Interview and case study research were selected, as it is deemed to be the most applicable to this project's aims and objectives. It is also worth noting that case study and qualitative interview are complementary approaches. Therefore, this study considers qualitative interview and case study approaches

[4] Construction management here representing the entire discipline of construction and its management

Both Bryman and Bell (2011) and Fellow and Lui (1997) insist on the importance of using qualitative interview, which centres on the researcher's interest about the depth of the study as compared to the other strategies, such as survey, and is consistent with this study. Consequently, qualitative interview was deemed appropriate as this study explores industrial problems associated with planning and control to develop a holistic technique.

1.5.3 Research Process

The following are brief descriptions of the research process stages.

Stage 1: Literature review to establish the present state of knowledge and knowledge gap. Stage one is a comprehensive literature review, examining academic and technical journals, technical reports, articles, conference proceedings, theses, text books, case studies, websites, government and professional guidelines.

Stage 2: Preliminary interviews with senior representatives involved in Construction PM in academia and industry as well as university students. A semi-structured interview was used (See appendix 4 for copy). This approach aids in focusing on perspective and expert experiences (Bryman and Bell 2011). This assisted in ascertaining the current practice and more importantly, streamline the research through identification of essential areas of interest and conceptualising construction project management managerial process.

A total of forty interviews were conducted comprising fifteen academics, fifteen practitioners and ten university students in the field of construction project management. The views of professional societies, especially in the UK, such as APM, CIOB and RICS, are clearly publicised and this is covered in the literature review. Thus, it was unnecessary to interview these societies. Each interview lasted not over thirty minutes. Owing to the qualitative nature of the questions, the researcher carefully selected people to be interviewed. During the interview, the participants were asked several questions including their knowledge and understanding of some key terminologies associated with construction project management. Other questions included the factors and roles of project management, discussion on construction project as production system, and the tools and techniques for PM. This ensured a professional and perspective understanding of whether construction project is the same as any other project. In addition, it also explored the knowledge, understanding and application of other process models including SADT/IDEF0 model since it is adapted as the foundational modelling technique. The interviews were carried out to a point that the desired data saturation was achieved. The interviews were verbatim transcribed and they were analysed using the content analysis (code and themes). The key words were grouped and further analysed.

Stage 3: The case studies primarily utilised observation, documental review and both semi-structured and unstructured interviews as the main tools for data collection. The observation gave the author information knowledge and understanding of social behaviour of the cases. Documentary evidence is important as it corroborates evidence from other sources and in obtaining the basic factual information about the case (Knight and Ruddock 2008). In contrast, semi structured interview is a powerful form of formative assessment and it allows generalisation of results and conclusions from the case study. However, it should be acknowledged that this requires considerable time for pre-planning and collecting data. It took the author circa a year to complete the first three case studies. Three of the case studies were conducted within this period with the fourth case studied conducted afterwards. Having received consent from the case study companies, some documents were photocopied and photos were taken, which were later analysed and discussed.

A total of 26 qualitative interviews amongst the four case studies were conducted comprising 5 from the first, 11 from the second, 7 from the third and 3 from the fourth case study. The each interview lasted around an hour and during which the interviewees commented on planning and control processes, problems and challenges associated with project management, planning and control, how these issues could be improved and clarification of some of the issues identified during the observations and documentary review. All the interviews were audio recorded and transcribed verbatim. The conventional content analysis and bespoke grounded analysis were used, where lists of codes representing themes were identified.

Stage 4: In the process of the analysis, it was noticed that a few questions cannot be generalised because they are case-focused and thus other expert perspectives needed to be investigated to complement some of the results. As a result 15 interviews were conducted with industrial experts in respectable organisations including all the stake holders. The data collected was analysed and compared to the case studies data (discussed in chapter 11). Interviews were conducted with senior members of construction companies, consultancy firms, developers and clients to have the perspective understanding of the problems associated with construction project management (especially planning and control) and possible improvements.

Stage 5: Drawing from the initial four stages, the researcher explored and developed the initial theory and PM tool called the Total Planning and Control (TPC) systems. During the course of the analysis, the requirements, task flow and relationship for project delivery planning and control were identified. These elements were integrated by the adaptation the ICOM representation of IDEF0 as the foundation, which produced the holistic but innovative planning technique, Total Planning and Control (TPC) system. The technique is based on the case studies from small projects (subcontractors), large complex building projects and engineering projects and the experts' views in the organisations, thus arguably a representative of the industry.

Stage 6: The initial TPC system was introduced and implemented by the researcher on the case study projects to identify the practicability in its implementation and to get practical feedback for improvement where possible. An evaluation group, people with expertise, from each case study was established, which included senior managers and external senior academics with interest in the study. The primary task for this group was to offer feedback on the TPC systems for necessary improvement. Positive feedback was received and they commended the study. They gave some practical recommendations for improvement and the attitudes of the experts were positive and the TPC system was greatly appreciated.

1.6 CONTRIBUTION TO KNOWLEDGE

This study primarily contributes to construction project management knowledge by qualitatively exploring the actual operational problems in the construction industry and extending the innovation from lean constructionists and production models to develop an innovative total planning and control system that is advancing forward to make project planning and control more applicable in reality.

1.7 STRUCTURE OF THE THESIS

This thesis is structured into twelve main chapters categorised into three main stages. This first stage is the literature review (chapters 2 to 6); the second is the research design and methodology (chapter 7) and the third stage is synthesis, which includes discussion and analysis, development of TPC, findings and the conclusions (Chapters 8 to 12). The first group deals with the present state of knowledge and concepts as presented in the literature. The second stage deals with how the entire research project was carried out and the philosophy underpinning this research. The third stage is discussions on the interviews and case studies where the problems in stage one are critiqued and criticised as applied to construction planning and control. Finally, a new technique was developed and applied to enhance the current project management practice. The brief of the chapters has been presented below followed with a structure shown in figure 1.3 describing the research process, the relationships between the thesis chapters, the research objectives, the research process and activities. The model of this thesis is no different from that recommended by many scholars such as Saunders *et al.* (2009), Robson (2002), and Bryman and Bell (2011). They all agree that the structure should be in the following five stages, introduction, literature review, methodology, analysis and discussion and conclusions. This thesis adopts this five stage model.

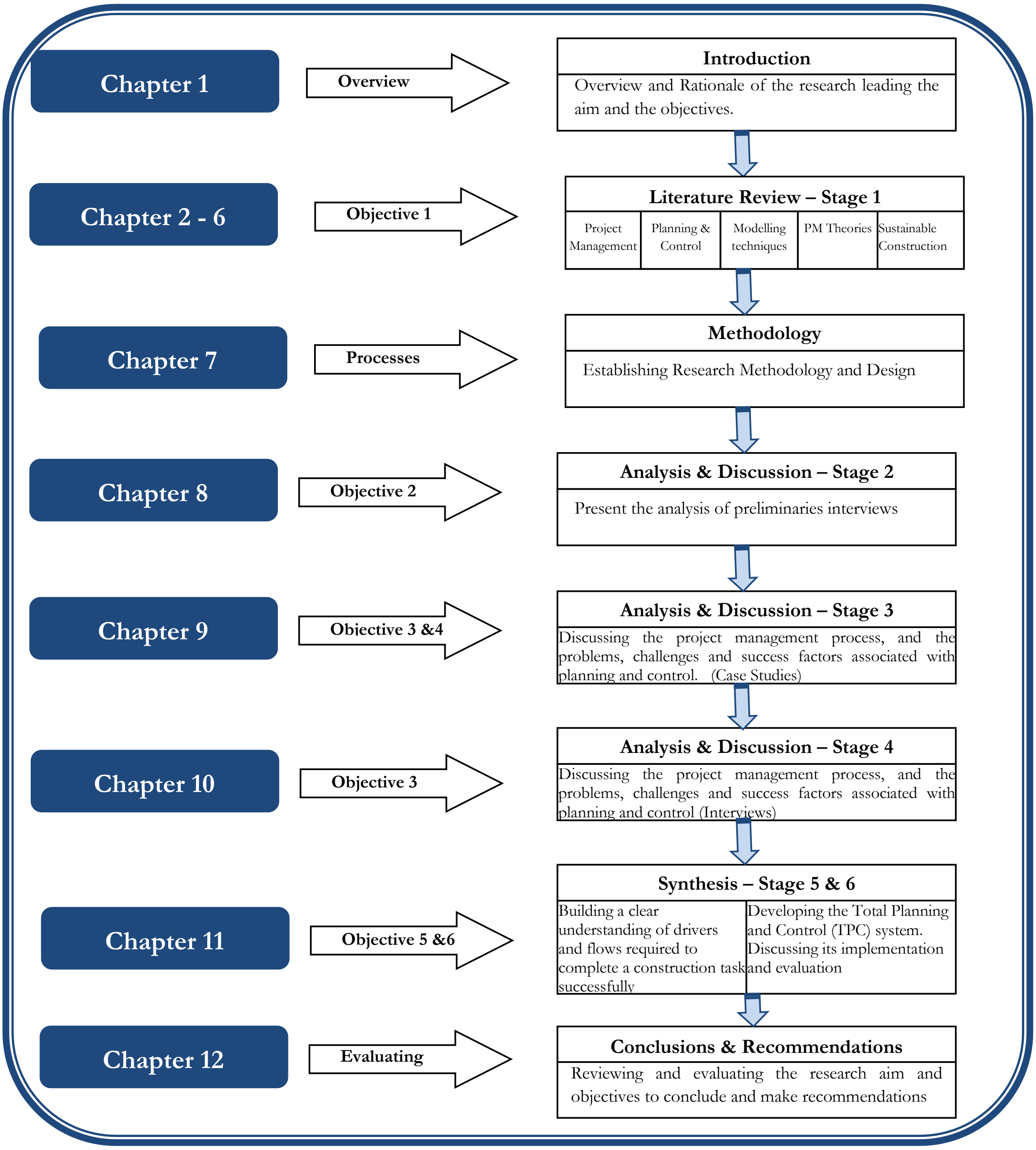

Figure 1. 3: The Thesis Structure

CHAPTER TWO: CONSTRUCTION PROJECT MANAGEMENT

2.1 INTRODUCTION

This chapter discusses the background of project management (PM) in the context of construction as the main field of this study. Firstly, this chapter discusses the overview and background of the problem being reviewed. Then the focus is turned to the understanding of three main important issues relating to construction PM. These issues are separate, yet, they complement each other, which are the understanding and definition of construction project, and construction PM; the Project Management Managerial Processes (PMMP); and the success factors and delays in construction. The definitions of projects and PM are presented, since the importance of the understanding of these terminologies and the management construction project based on TCQ are vital to the conceptualisation of construction PM and its managerial process. This sets a conceptual platform to introduce TPC which is the main aim of this study. Other uncommon definitions for project and PM within construction management literature were also reviewed. Consequently, the limitation of the existing concept and PMMP were presented together with the success factor of PM. The chapter is concluded with a summary of the review of the literature and the knowledge gaps, which resulted in the research questions.

2.1.1 Overview and Background of Project Management

Kozak-Holland (2011), and Cleland and Gareis (2006) all argue that the history of PM could be traced back to many centuries ago. Cleland and Ireland (2006) disagree with the statement that PM is the accidental profession which emerged in the early 1970s. They argue that PM as a discipline has changed over several centuries, where PM has been used to create positive change in societies. Yet, Maylor (2010) argues that up to 1950 there were no generally accepted methods or recognised processes for PM.

Cleland and Ireland (2006) claim that PM was formally as a discrete contribution arising from the management discipline in the 1950s. They argue that prior to that the focus was on cost, scheduling and technical performance. However, it lacks a recognised definition and acceptance of the management concepts and processes in an integrated manner. Morris *et al.* (2006) also argue that the current state of PM was initiated in the late 1950s and 1960s with the establishment of the professional PM societies. In the late 1960s and 1970s the societies for PM were established. Maylor (2010) refers to this initial era as the first generation of PM, where associations were established. Both Maylor (2010) and Morris (1994) argued that the 1950s to 1980s, where standards became increasingly recognised, marked the second generation of PM. Maylor (2010) claimed that the 2000s is the third generation of PM where there is widespread acceptance of PM concepts due to the publication of Bodies of Knowledge (BoK). The first[5] of the associations to be formed was the International Project Management Association (IPMA) in 1965 and Project Management Institute (PMI) in 1969 in the USA. This was followed by the Association for Project Management (APM) in 1972 in the UK, which has its origins in IPMA. These professional bodies in the attempt to standardise the PMMP published the PM BoK and APM BoK respectively (APM 2006, PMI 2004). These publications marked the beginning of the second and third generations of PM as claimed by Maylor (2010). There have been other publications from professional and governmental bodies regarding PM: these include, Engineering Advancement Association (ENAA) of Japan, Project in Controlled Environment - PRINCE 2 (the UK government standard for PM). These BoKs have significantly influenced PM in many industries including the construction industry. Burke (2003) presented a chronological review of PM.

According to Cleland and Gareis (2006), PM has become "boundary-less"—cutting across disciplines, functions, organisations, and countries. Nevertheless, numerous researchers such as Morledge *et al.* (2009), Sullivan *et al.* (2009) and Cox *et al.* (2006) have differentiated construction projects from other projects from a supply chain perspective. The question is asked: **whether a construction project is the same as any other project?** Although the understanding and definition of construction projects may not be the core issue under investigation in this research, it is vital to the conceptualisation of construction project management principles. This conceptualisation will set a platform for the main aim of this study, developing a holistic planning and control system.

Despite the standardisation of the PM principles by these associations, the problems of delays, cost overruns, and sub-optimum performance in the construction industry is a global phenomenon. Governmental organisations, academics and professional bodies from both developed and developing countries have continuously criticised the construction industry including:

[5] The first denoting the associations with the term project management not including societies such as CIOB

- the UK[6] Government: Latham (1994), Egan 1998 and Wolstenholme (2009)
- the UK professional bodies CIOB (2002) and RICS (2011)
- academics in the UK such as Sturges *et al.* (2000), Koskela (1992, 2000, 2001, 2002), and Dainty *et al.*, (2006)
- global academics including Sambasivan and Soon (2007), Assaf and Al-Hejji (2006), Love *et al.*, (2004), Xue *et al.*, (2007), Ballard (2000), and Ballard and Howell (1998, 2000, 2003).

Most reports highlighted the fragmented nature of the industry, the lack of co-ordination and communication between parties, and the informal and unstructured learning process. Latham (1994) and Egan (1998) emphasised that the industry's main problems include delay, communication and knowledge sharing between parties.

These problems have compelled many studies, including this study, to investigate how to bring improvements to the construction industry. Therefore, this chapter presents a critique of construction PM. The UK's best practice recommends the following (BRE, 2000):

- Understand the construction process by monitoring it, mapping and recording the activities
- Continually improve the process by eliminating all non-productive activities
- Brief the construction team about the importance of adopting a process approach
- Continually implement the planned changes
- Continually review the process and provide feedback to management and operatives using the checklists provided

It is therefore necessary in this chapter to critically review the understanding and definition of a construction project and PM in the context of construction. This is followed with the review of construction PM and PMMP. This chapter is concluded with the success factors of construction PM.

2.2 WHAT IS A CONSTRUCTION PROJECT?

Conventionally, the term 'project' is used for all projects including construction but the literature has indicated the difference between construction project and other projects. There has been insufficient study, if any, to close this gap of understanding and conceptualising a construction project. However, before the construction project could be understood it is prudent to understand what a project is?

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[6] Where this study is being conducted

2.2.1 What is a Project?

According to PMI, a project could be "the development of software for an improved business process, the construction of a building or bridge, the relief effort after a natural disaster, the expansion of sales into a new geographic market — all are projects[7]". APM also suggests "everything from the Olympics to organising a wedding can be considered a project".[8] The two biggest PM societies understand a project could be anything. Similarly, in the opinion of one of the interviewees (discussed in chapter 8), "a *project can be anything really, like organising a party tonight"* but the interviewee insisted that construction project is a special and specific type of a project. Therefore, the question is **what is a construction project?**

The Cambridge Dictionary defines the term project as "piece of planned work", while the Oxfords English Dictionary defines it as an "individual or collective enterprise that is carefully planned and designed to achieve particular aim" or "a proposed or planned undertaking" (Cambridge Dictionary 2008, Oxford Dictionary 2001). Both dictionaries define project by using the key word "planned or planning". Arguably, both dictionaries suggest that a project is about 'planning'. In addition, both dictionaries ascertain that the word 'project' was derived from a Latin word '*projicere',* which means '*throw forth'*; and the early senses of this word were *plan* and "*to cause to move forward".* It could be concluded that the dictionary meaning and the early sense of the word project is about **'planning'.**

However, with the establishment of PM societies and the publication of BoK together with progressive academic research in this area, the word 'project' has been defined and discussed differently. Table 2.1 gives the definitions observed in literature from both researchers and the established PM societies. Gittinger (1982) examines a project from an agricultural stance. In his definition, he describes the complexity aspect of 'project'. Steiner (1969) and Reiss (1995) argue mostly from the human resources perspective. Thus, their definitions are inclined to projects that are human resource driven. Steiner's definition describes project from a construction perspective. It is suggested that all these definitions discuss some characteristics of a particular project. Turner's definition tries to generalise the understanding of a project by amalgamating some of these characteristics (Turner 1999). Similarly, the PM BoK has also followed Turner's definition pattern. This could be perhaps because Turner, being one of the

[7] According to www.pmi.org

[8] www.apm.org.uk

editors and scholars for Project Management Journal and a renowned member of PMI, may have influenced the definition of the PM BoK. Since the attempt of Turner and PM BoK to generalise the definition, many of these definitions have followed suit except APM BoK (2006). The question is, is this generalisation necessary for a construction project? Sullivan *et al.* (2010) claim that it is impossible to copy such from other industries to construction; albeit, their emphasis was from manufacturing.

Table 2. 1: Definitions of 'Project' observed in Literature

Author(s)	Definition	Comments
APM Bok (2012)	A project is a unique, transient endeavour undertaken to achieve planned objectives	Association for Project Management (UK's largest professional body for project management)
APM Bok (2006)	A project is a temporary effort to create a unique product or services.	
APM Bok (2004)	Projects are unique, transient endeavours undertaken to achieve a desired outcome.	
PMI Bok (2004)	A project is a temporary endeavour, having a defined beginning and end undertaken to meet unique goals and objectives usually to bring about beneficial change or added value.	PMI (the world largest project management professional association)
British Standard 6079 (2000)	A unique set of coordinated activities, with definite starting and finishing point, understanding by an individual or organisation to meet specific performance objectives within defined schedule, cost and performance parameters.	The United Kingdom standards for project
CIOB (2010)	Unique process, consisting of a set of coordinated and controlled activities with start and finish dates undertaken to achieve an objective conforming to specific requirements including constraints of time, cost and resources.	Chartered Institute of Building
Project Management Association of Japan (2005)	A project refers to a value creation undertaking based on a specific mission, which is completed in a given or agreed timeframe and under constraints including resources and external circumstances	Project Management Association of Japan
PRINCE 2 (2009)	A management environment that is created for purpose of delivering one or more business products according to a specified business case and a temporary organisation that is needed to produce a unique and predefined outcome or result at a given time using predetermined resource.	Project in Controlled Environment (UK government standard for project management)-
Steiner (1969)	A project is an organization of people dedicated to a specific purpose or objective. Projects generally involve large, expensive, unique or high risk undertakings which have to be completed by certain date, for a certain amount of money, within some expected level of performance	Researcher(s) in construction management
Reiss (1995)	Project is a human activity that achieves clear objectives against a time scale.	Researcher(s)
Gittinger (1982)	Projects are the whole complex of activities in the undertaking that uses resources to gain benefits albeit he was referring to agricultural projects.	Researcher(s)
Turner (1999)	Project is an endeavour in which human, financial and material resources are organised in a novel way to undertake a unique scope of work of given specification, within constraints of cost and time so as to achieve beneficial change defined by quantitative and qualitative objectives	Researcher(s) in construction management
CMAA (2010)	Project is a total effort required in all phases from conception through design and construction to accomplish the owner's objective.	Construction Management Association of America

The effort toward defining and understanding of construction project is sparse. The attempt in this area has been the description of construction project and the assertion from some researchers. Although some researchers (as discussed above) have established the difference between a construction project and other projects, none of these studies have vigorously reviewed the definition and the understanding of a construction project.

Two main issues can be drawn from the above review: firstly, there is no 'clear' definition and understanding for a construction project. Even though, both early meanings and dictionaries suggest 'project' to be about "planning", researchers and societies attempt to generalise its understanding to fit all projects. Secondly, most of the definitions explicitly and implicitly include constraints, mainly time cost, and quality (TCQ) due to the idea of generalisation. The latter is discussed in detail later in this chapter. APM (2006), Reiss (1995) and CMAA (2010) stand out from other definitions as presented in table 2.1. These definitions draw their understanding of a project as a conceptual stance then describe its essence, in much the same way as Heidegger (1982) ascertained that the essence of a tree is not itself a tree. In the same view, the essence of a project is not itself a project. Thus to define what is a construction project is vital to its conceptualisation. The PM BoK 5th edition defines a project as "a temporary group activity designed to produce a unique product, service or result", which seems not different to that of APM (2006). Surprisingly, the APM BoK (2012) 6th edition also defines a project as "a unique, transient endeavour undertaken to achieve planned objectives" APM (2012). The APM BoK (2012) has now included the objectives, where objectives are defined as outputs, outcomes and/or benefits. In the attempt to generalise the definition these societies keep changing their definitions year after year (APM, PMI). This generalisation of the definition and principles of PM could be put down to the fact that all these associations want more members across all sectors – power relations.

2.3 CONSTRUCTION PROJECT MANAGEMENT

2.3.1 Background

The current predominant definitions and concepts of construction PM originated from the establishment of the PM societies. These societies have influenced the construction industry not only with their definitions but also with the generalisation of PM principles. In the UK, the biggest 'construction association', CIOB has published the code of PM; however, the industry depends on the PM BoK and its PMMP. Besides, there is less contention with the PMI PMMP. It is arguably generally accepted and the current CIOB code of practice adopts a similar process (CIOB 2010).

Construction PM[9] researchers have arguably accepted this managerial process since they fail to discuss these issues but rather cite them as definitions. The only studies that clearly argued against the principles in the construction PM perspective are that of Koskela and colleagues. They argued from the theoretical stance and claim the existing construction PM practice is obsolete (Koskela 1992, Howell and Koskela, 2002). Ballard (2000) also argued from the production control point of view. He claims that the existing construction management[10] based on the so-called project constraint (TCQ) is part of the construction project failure. The question is asked whether there are differences between project and PM constraints. Arguably, construction PM is a fairly new discipline as compared to other disciplines such as architecture and engineering. Researchers have concentrated much effort solely on problems and their causes rather than the fundamental issues and their practical solutions. The next section reviews the definition of construction PM, the constraints and its management.

2.3.2 What is Construction Project Management?

In order to precisely define or understand construction PM, the composite term has to be broken down and a number of associated terms have to be defined. There are three words here, which are 'construction', 'project' and 'management'. The dictionary meaning of construction is the work of *'building or making something, especially buildings, bridges'* etc. while, its verb 'to construct' is to *'build something or put together different parts of something'*. Although construction primarily focuses on building structures, currently it also includes some elements of de-construction, which include demolition and alterations (This is stressed by one interviewee).

The definition of project has been discussed earlier in this chapter, which simply means "to **plan or planning**". Management is also defined as the control and organisation of something (Cambridge Dictionary 2008). This dictionary meaning of management ascertains management as "**control and organisation**". Thus, using these words simultaneously as 'construction project management' literally denotes *"planning, control and organising the work of building, especially, buildings and civil works"*. This view is compared with other researchers' and societies' definitions. (APM, British standard for project management, CIOB 2002, Perera and Holsomback, 2005) Table 2.2 presents the comparison of the definitions.

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9 Construction PM denotes the end-to-end management of a construction project

10 Construction management is the management of the construction process usually onsite.

Table 2. 2: Definitions of Project Management observed in Literature

Author(s)	Definition
APM BoK (2006)	Project management is the planning, organisation; monitoring and control of all aspects of a project and the motivation of all involve achieving the project objectives safely and within agreed time, cost and performance criteria. The project manager is the single point of responsibility for achieving this.
PM BoK (2004)	Project management is the application of knowledge, skills and techniques to execute projects effectively and efficiently.
British standard for Project Management (BS6079)	Project management as the planning, organisation, monitoring and control of all aspect of a project and motivation of all those involved in it to achieve the project objectives on time and to the specific cost, quality and performance.
Oisen (1971)	Project management as the application of collection of tools and techniques to direct the use of diverse resources towards the accomplishment of a unique, complex, one time task within time cost and quality constraints. Each task requires a particular mix of these tools and techniques structured to fit the task environment and lifecycle of the task.
CIOB (2002)	PM is the overall planning, co-ordination and control of a project from inception to completion aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time within authorised cost and to the required quality standards.
Reiss (1995)	Project Management is a collection of loosely connected techniques, some of which are useful in bringing project to a successful conclusion.
Lock (2007	PM has to develop to plan, coordinate and control the complex and diverse activities of modern industrial, commercial and management change.
Perera and Holsomback (2005)	Project management is the function of planning, overseeing, and directing the numerous activities required to successfully achieve the requirements, goals, and objectives of the project/program.
Turner (1996 p. 6)	Referring to the project management conference held in St Petersburg, Project management was described as art and science of converting vision into reality.

Lock (2007 p. 1) suggests that PM has to develop to plan, coordinate and control the complex and diverse activities of modern industrial, commercial and management change (IT projects). He further claimed that, the purpose of PM is to forecast as many of the 'Danger fields' and problems as possible and to plan, organise and control activities so that projects are completed successfully in spite of all the risks. These definitions suggest that the PM process is **Planning, and Control and Organisation** but the over cited PMMP state otherwise. The process is 'initiation, planning, execution, control and closing', which is discussed later in this chapter. Table 2.2 presents the leading definitions observed in literature for PM. These definitions, although from slightly different sectors to construction, are useful to facilitate the understanding of PM in the context of construction.

Most of all the definitions discussed in table 2.2 incorporated terms such as objectives (APM BoK and British Standard for PM); where objectives are time, cost and performance criteria. Oisen (1971) and CIOB (2002) describe project constraints as TCQ. However, Reiss (1995) identifies '**time'** as the main constraint to a project. The question is asked as to how these so-called objectives or constraints can be confirmed or/and achieved. Arguably, by 'Evaluation' is the response to this question. (discussed in detail in chapter eight). Amrina and Yusof (2011) claim that an evaluation process has been key in the manufacturing industry for continuous improvement, but the question remains **why not in construction project management**?

2.3.3 Project Constraints

The main constraints of every project arguably include TCQ; this forms the iron triangle and is also accepted as success criteria and project constraints (Atkinson 1999, CIOB 2010). Therefore, some researchers brand the definitions without these TCQ (or its like) as "others". For example, Ismail *et al.* (2007) and Atkinson (1999) among others classified the definitions of Reiss (1995), Lock (2007) and Turner (1996) as "others". Arguably, this indicates these researchers as well as the PM research committee position that these definitions are not the generally accepted definitions. In consensus, both researchers and the societies deemed that project and PM constraints revolve around TCQ. However, Alali & Pinto (2009) suggested that the definition of PM should look beyond this so-called iron triangle. The question asked is whether project constraints are restricted to the iron triangle.

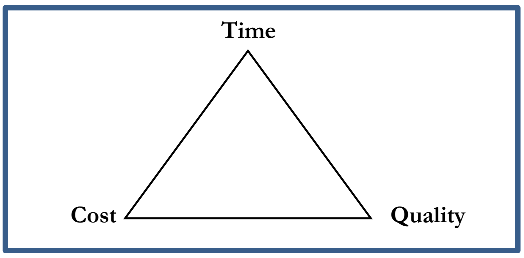


Figure 2. 1: Iron Triangle

Generally, people perceive projects to be linear, ordered and simple, thus, predictable, arguably, due to the dominance of the scientific management concept. The definition of Oisen (1971) for PM recognises the complexity of construction project as a constraint. Similarly, Gittinger (1982) considers projects as *the* ***whole complex of activities*** *in the undertaking that uses resources to gain benefits.* Bartelsen (2004) argues that a project is a 'complex and dynamic phenomenon'. In Turner's (1996) view the process of 'converting vision into reality' is complex. Understanding the complexity of project will enable the understanding of the entire project, according to Steiner (1969). Recognising a project's complexity may trigger many issues including scope, resources, procurement route, strategic management, technology, specification, mechanisms and implementation process (this is discussed in chapter 8).

Studies such as Johansen and Wilson (2006) acknowledged 'risk' as one of the project constraints including the TCQ. Equally, Steiner (1969) again stressed the constraint that seems ignored in the project constraints and that is risks. He defines a project as "…unique or high risk undertaken…" In the PMI, PM BoK Guide, a project is a temporary endeavour undertaken to create a unique product or service (PM BoK 2008). Many researchers and societies of PM share this view. It is being temporary and unique that exposes the high risks in project. Bower (1994) Williams (1995), Kutsch and Hall (2010) PMI BoK and APM BoK discuss the importance of risk and analyses it in projects, especially construction. Risks potentially prevent the project manager from meeting predefined project objectives of scope, time and cost (Kutsch and Hall 2010). However, risks and complexity are not discussed as project constraints and projects are being managed largely based on TCQ (see chapter eight for a detailed analysis).

2.3.4 Managing Projects based on TCQ

There is consensus in PM literature that TCQ are project constraints as well as client objectives. For example, Bowen *et al.* (2000) advocate that TCQ are claimed to be the core objectives of a construction client. Researchers of PM advocate that project measures of success are TCQ (Wateridge, 1995). Other researchers adopt the APM BoK's project constraints of time, cost and performance. Thus, the benchmark of success and failure factors is centred on TCQ. PMI also established scope, cost and schedule as the project constraints used to manage projects. Wateridge (1995) concluded that only two of many criteria are necessary for judging the success of projects, i.e., time and cost. Primarily, PM concentrates on time and cost, thus neglecting the relative importance of quality.

Wit (1988) illustrates the distinction between project success and PM success; notwithstanding, he ascertained that good PM is key to project success. He concludes that planning is the top priority for achieving a successful construction project, while frequently used criteria for project success were budget performance (Cost), scheduling performance (Time) and client satisfaction (Quality). Atkinson (1999) has contended this stance; he argues that, the current PM process that focuses on managing TCQ to determine the success of a project is obsolete. Similarly, Belassi and Tukel (1996) argue that many researchers concentrate on the critical failures rather than project success. Yet, literature is scant on proposing a new model for management projects and for performance assessment.

Reiss (1995, 2007) argues that managing projects based on TCQ is like juggling three balls of time, cost and quality. You can only achieve one or at most two at a particular time. He was implying that this conventional model of TCQ for PM allows trade-offs between time, cost and quality. The iron triangle and PM constraints allow trade-offs. Trade-off means achieving a constraint (say cost) at the expense of other constraints (say quality and time – using the iron triangle). Similarly, schedule maybe achieved at the expense of scope and cost (using the project management constraints). However, if any two (say time and cost) should be achieved simultaneously, it must be at the expense of the other or extra cost. Herbsman and Williams (1991) establish that there are major failings with these traditional approaches of project delivery. Atkinson (1999 p 337) questioned that, if both factors and criteria of success were deemed known, **why are projects continuously described as failing**?

Hartman and Ashrafi (2004) suggest that approximately 50% of construction projects exceed their original cost, run late or fail to meet client objectives. As discussed, TCQ is included in the major definitions of both project and project management. TCQ could be project constraints but not necessarily a management model or performance indicator. Ballard, (2000), Koskela (2000) and Howell and Koskela (2002) have also argued this view. Sweis *et al.* (2008) ascertained that there are major failings in this traditional approach to project delivery. The problem of managing construction projects is partly based on the use of the conventional TCQ model (Ballard and Howell 2003, Koskela and Howell 2002, Atkinson 1999).

2.3.5 Project Management Managerial Process (PMMP)

The Royal Institute of British Architects (RIBA) Plan of Work, which was first published in 1963 was the reference for many construction projects[11] (Gething, 2011). This plan of work has evolved in different publications and the most recent was 2007 that was amended in 2008 (RIBA 2008). The recent publication 'Green Overlay to the RIBA Outline Plan of Work' was to clarify the issues and their timing; in response to the growing imperative that sustainability is actively considered in design and construction buildings but did not amend fundamentally the plan of work (Gething, 2011). The processes are in the following sequence, preparation, design, pre-construction, construction and use (See figure 2.2). RIBA (2008) claims the plan of work organises the process of managing and designing building projects.

The plan of works developed by RIBA has evolved as generally accepted in the construction industry since Architects lead building construction. The Pre-construction stage incorporates production information, tender documentation and tender action. Similarly, CIOB advocates that pre-construction is the field of activity where projects are developed from the design to the start of construction on site (see figure 2.3). CIOB (2002) claims that the preconstruction process in its depth and complexity depends on the scale of a particular project. This implies

[11] It is also found on www.riba.org.uk

that from 'preparation to pre-construction stage' according to RIBA Plan of Work are considered to be Pre-Construction from the definition of CIOB.

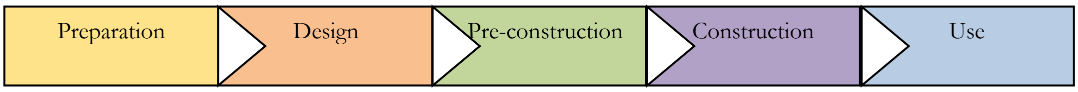


Figure 2. 2: RIBA Plan of Work

Figure 2. 3: CIOB Construction Process

Maylor (2010) also developed a model called four phases of project lifecycle termed the 4-D model, where D1 – Define it; D2 – Design it; D3 – Do it; D4 - Develop it

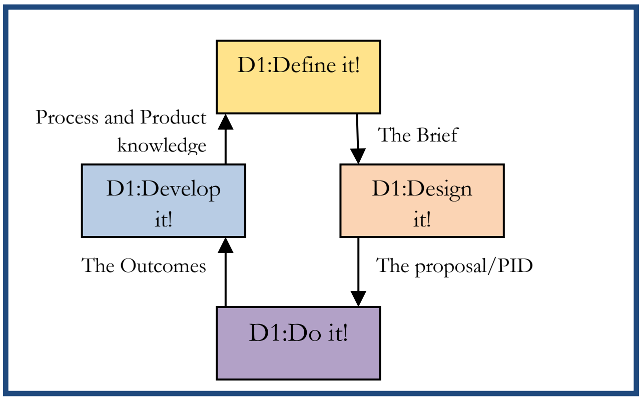


Figure 2. 4: Four phases of project lifecycle – 4D Model (source: Maylor 2010 p. 32)

The 4-D model appears to combine the pre-construction and design stage of RIBA plan of work to Design it (D2). However, the 4-D model still includes D1 - Define it! which represents the preparation stage on the RIBA Plan of Work.

One common understanding from the definitions of PM presented early in this chapter is the fact that the PM process spans from inception to completion (closing). The Building Research Establishment (BRE), one of the largest research establishments in the UK in the built environment, also published jointly with Darzenta *et al.* (2000) the representation of the construction process (see figure 2.4). Toeing the same line with CIOB, they argue that construction processes are mainly three stages (pre-construction, construction and post-construction). However, Darzenta *et al.* (2000) argue that there are five other main sub headings under the main three headings. Under pre-construction, there are conception, detailed design and construction preparation. Under Construction, there is the build, while under post construction there is operation and maintenance. It appears that the managerial process is conception, detailed design, construction preparation, build, and operation and maintenance. Comparing this to Maylor's 4D, it is suggested that D1 (Define it) and D2 (Design it) are all under pre-construction. Similarly, preparation, design and pre-construction from the RIBA plan of work are under preconstruction.

This has prompted the understanding of the "pre–construction". The word 'construction' has been discussed earlier in this chapter; thus, left with the word "pre". The word *pre* was derived from Latin meaning "before", "earlier", and "in advance of". Therefore, the word "pre" and 'construction' used simultaneously to form 'pre-construction' literally denotes 'before-the build' or 'in advance of the build'. For this reason, CIOB (2002) and Darzenta *et al.* (2000) defined pre-construction as all activities before construction. They all agree that the construction process is mainly, pre-construction, construction and post-construction stage.

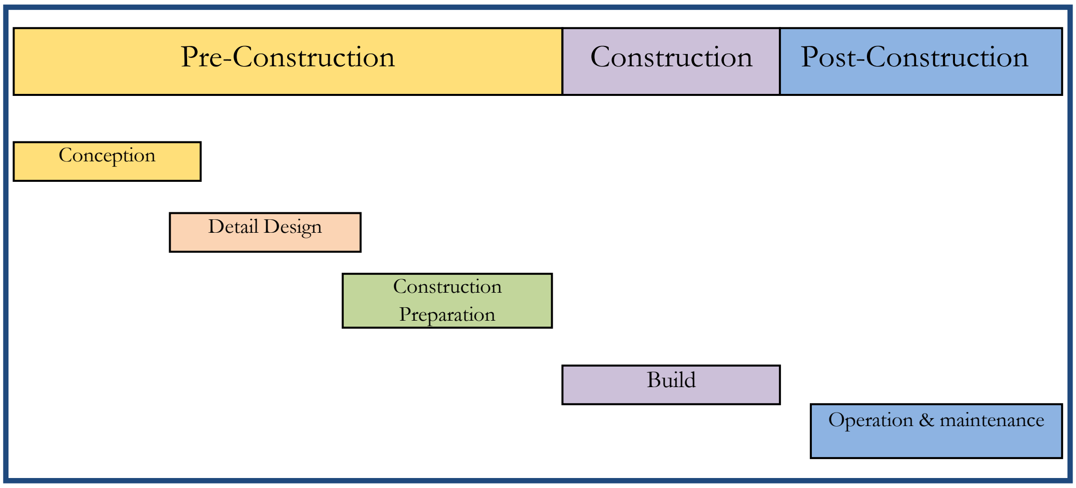


Figure 2. 5: Representation of the construction process (Adapted from BRE 2000 jointly published by Darzentas *et al.* 2000)

On the other hand, PMI, PM BoK published the PMMP (see figure 2.5). This managerial process is generally accepted in the industry due to the contributions this society has made to methodologically standardising the PM process over a few decades. PM BoK advocates that project managerial processes are as shown in figure 2.6 which is as follows, Initiating, Planning, Execution, Controlling and Closing process (PMI 2008 p. 6).

Notwithstanding the PMI influence on PM, there have been attempts by other researchers to produce an alternate understanding of the PM process. For example, Zipf (2000) emphasises the project plan being prepared and then action shifted to monitoring, reporting and action based on variance. Howell *et al.* (2000) critique this model as it is only concerned with the performance within the plan and not with the management of those activities or their relationship. They argued that importance of all these are apparently defined by scope, budget and schedule or TCQ, which is the basic problem with the existing concept.

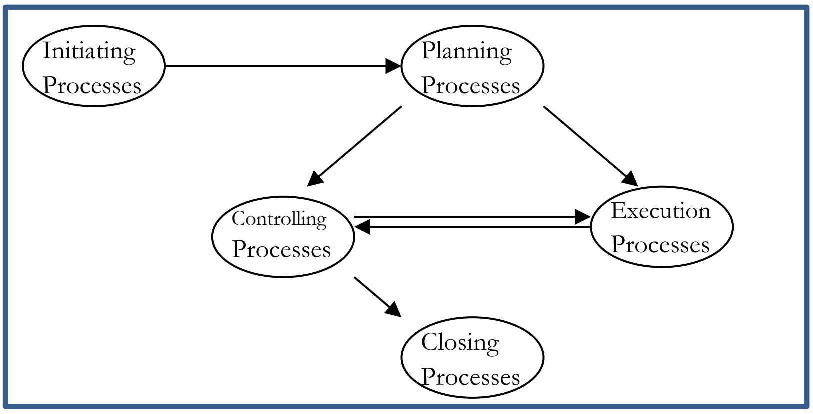


Figure 2. 6: Project Management- Managerial processes (PM BoK 2008, p. 6)

The construction industry is generally described as dynamic and multi-disciplinary in nature (Egan 1998). PM principles have become an integral tool to design and deliver these projects. This process is being managed by multi-disciplines with construction project. There are disciplines like Project Managers, Construction Design Management Co-coordinators, Designers (normally, Architects and Engineers), Contract Managers, Construction Managers, Commercial Manager, Planner, Quantity Surveyors and Estimators involved in designing and executing a construction project. In this thesis they are classified as managers. Some of these roles and duties may overlap but seem clearly separated. The most overlapped and slightly confused roles are the Project Manager, Construction Manager and sometimes Contract Manager. This is because these three roles are all involved in delivery of the project both on and off site. Johansen and Wilson (2006) affirm that they are involved in the later planning (last planning). CMAA (2010) asserts that project managers and construction managers are used interchangeably. However, they are obviously different roles. It is perhaps due to the fact that the principles of PM have not been fully incorporated into construction management as a field.

Therefore, as the core purpose of this study is to develop a holistic planning and management model, there is a need to briefly examine the difference in roles, especially between a project manager, construction managers and contracts manager, as they are part of the main anticipated users of the proposed TPC system.

2.4 SUCCESS FACTORS OF A PROJECT AND PROJECT MANAGEMENT

In the new conceptual framework for factors affecting project success by Chan *et al.* (2004) the main success factors can be categorised into five main groups. These groups are human related factors, project-related factors, project procedures, PM actions, and external environment. They argue that PM encompasses all of these five groups, for example, under project procedures, there are procurement and tendering methods; under project related factors are types of project, nature of project, and number of floors of the project, complexity of the project and the size of the project. Walker and Vines (2000) argue in their work in Australia that critical success factors for a project are management competence, team confidence, team experience and external factors. Hubbard (1990) argues that PM is key for project success. The question asked is whether PM factors are the same as project success factors.

Numerous researchers attempt to investigate the success factors for both project and project management, utilising a questionnaire and its complement quantitative strategy. However, investigating a 'real-world' problem cannot be based on statistical value but rather investigating by asking those involved, thus using qualitative strategy.

2.6 CONCLUSION

Historically, Architects and Engineers managed construction projects until a few decades ago when these PM principles were adopted. CIOB (2002) ascertained that these principles were adopted into construction circa five decades ago. Thus, it is evident from literature that the adopted PM principles have not been appropriately integrated into construction management. This has raised many issues within construction PM literature as discussed. Professional bodies have uncommon understandings of a project, while the understanding of construction project is not properly explored. There are two gaps in knowledge identified in this review, which are as follows:

1. **What is a construction project and construction PM?**: There are two main issues observed as literature attempts the standardisation of the understanding and definition of project. Firstly, there is an assumption that all projects including construction projects are the same. If this is the case, it could be said that the generalisation of the concepts of project has somehow affected the construction project and its management in particular due to its nature and complexity. This is being posed because, for example, Koskela and Howell (2001) argue for explaining construction as a production process, whilst Bestelsen (2004) also propose that construction should be seen in a complexity perspective. In as much as Koskela and Howell (2001), and Bestelsen (2004) share similar views that construction is a production, both of them have different views on the construction project. This illustrates the nature of the construction project, which arguably makes construction

projects somehow different from other project. Secondly, the literature has just been scant on the understanding and definition of construction project management. This could be due to the fact that the construction project management discipline is fairly new as compared to other disciplines such as engineering and architecture.

2. **Conceptualisation:** It is obvious from the literature that managing construction project based on TCQ is insufficient as well as there are deficiencies in the assumptions for project constraints and the construction PM managerial process.

As a result, the following questions are derived from this chapter for further investigation, which contributes to the definition, conceptualisation of construction PM and its management model. What do practitioners and academics believe:

1. is a construction project and construction PM?
2. are constituent roles or parts of construction PM? - (CPMMP)
3. are the main differences in roles and responsibilities for contract manager, project manager and construction manager?
4. to be project success factors and project management success factors?

CHAPTER THREE: PROJECT PLANNING AND CONTROL

3.1 INTRODUCTION

Project planning and control is the main focus of this chapter in the context of construction. This chapter reviews the existing literature, concepts and techniques within the construction industry, identifies the knowledge gaps and introduces the need for a holistic system to enhance current practice. The chapter commences with an overview, then a review of project planning and control which discusses the existing requirements and techniques. Planning and control software are also reviewed.

Furthermore, delays and the success factors of planning and control are presented. Delay is discussed because time is one of the key factors to any project. Reiss (1995) advocates that time is the main focus of project planning. The chapter concludes the summary of the review as well as the knowledge gaps.

3.2 OVERVIEW OF PLANNING AND CONTROL

The word "planning" is derived from the noun "plan". The Oxford dictionary defines plan as "detailed proposal of doing or achieving something". According to the US Army Corps of Engineers (2013), planning in terms of civil works (construction) offers a structured, rational approach to solving problem(s). Project Planning has been defined as the "process of choosing the one method and order of work to be adopted for a project from all the various ways and sequences in which it could be done" (Antill and Woodhead 1990, p. 8). It was ascertained that everything begins with planning; for example, planning is the start of the 'pipeline' that addresses water resource needs. In construction management literature, Hayes-Roth and Hayes-Roth's (1979) definition for planning is widely accepted and they stress the close relationship between planning and control. They defined planning as the "predetermination of a course of action aimed at achieving some goal. It is the first stage of a two-stage problem solving process. We refer to these stages as planning and control" (Hayes-Roth and Hayes-Roth, 1979 pp. 275-276). This definition is adopted by planning studies such as Birrell (1980), Laufer and Tucker (1987), Johansen and Porter (2003) and Ballard (2000). Ballard (2000 p. 2-8) argues that controlling time involves planning, scheduling and monitoring. He further claims planning decides what is to be accomplished and in what sequence; scheduling determines task duration and time; and monitoring checks the progress of the task against the schedule and forecasts when work will be completed. This again indicates the strong connection between project planning and control. Griffith *et al.* (2000) assert that planning and control are considered a vital prerequisite in construction projects. Shenhar *et al.*, (2001) recognise project planning as an integral part of an organisation's strategic thinking and strategic management; while Laufer and Tucker (1987) claim that planning facilitates project control.

Jongeling (2006) refers to project planning as the planning and control of construction activities, including the choice of construction methods, the definition of tasks, the estimation of required resources and the identification and coordination of any interactions among different tasks and use of common resources. He further argues that project planning includes all activities required in the total construction process from the conceptual development stage through design to hand-over to the client. Although Laufer and Tucker (1987) established that the definition of planning is still a subject of lively debate, they agree with Ackoff's (1970) definition of planning as a decision-making process performed in advance of action which endeavours to design a desired future and effective ways of bringing it about. Emery (1969) described planning as a top-down, systematic, complete and hierarchical process. Mubarak (2005) claims that planning serves as a basis for numerous related functions such as: cost estimating, scheduling, project control, quality control, and safety management. Laufer and Tucker (1987) advocate that planning literature addresses three main audiences: corporate management, client project management and construction company project management.

Agyekum-Mensah *et al.* (2012a) claim the term planning and scheduling are often interchangeable; however, scheduling is one part of planning. They argue that whereas planning seeks to answer the 5Ws & H (what, when, where, whom, why and how) questions, schedule answers 'what and when'. This view is also shared by Laufer and Tucker (1987), Mubarak (2010), Clough *et al.* (2000), who emphasise that planning should answer these questions: what should be done (activities), how should the activities be performed (method), who should perform each activity and with what means (resources) and when should activities be performed (sequence and timing). Mubarak (2005) suggests that a schedule is simply the itinerary in much broader terms, while Clough *et al.* (2000) describe schedule as calendar dates for start and finish of an activity. Laufer and Tucker (1987) claim there is a fundamental confusion between planning and scheduling. Although Jongeling (2006) agrees that planning is a broader term than scheduling, in his PhD thesis, he uses both terms to represent the same idea. Mason (1984) discusses several inconsistencies in the use of planning and schedule in construction literature. Antill and Woodhead (1990) define scheduling as the determination of the timing of the operations comprising the project and their assembling to give an overall completion time. Ballard (2000) explains that planning decides what is to be accomplished and in what sequence, while scheduling determines task duration and time.

Arditi (1985) ranked planning at the top of the list on potential for headquarters productivity of construction companies, whilst Ackoff (1970) emphasises that it is probably the most important activity in an organisation. Johansen (1995) discusses the importance of planning from both 'soft and hard' planning, whilst Johansen and Wilson (2006) highlight the 'first plan' perspective and Ballard (2000) the 'last plan' stance. Raymond and Bergeron (2008) argue that improvement in effectiveness and efficiency in managerial tasks is observed as a result of better planning. According to Dvir and Lechler (2004), numerous studies have concluded that a key factor for project success is planning. Laufer and Tucker (1987) argue that planning is vital to the role of a project manager, yet, there are increasing concerns over the failure of construction planning to achieve its goals. They established that there are major flaws in the current planning techniques which include:

- Focus – they argue that scheduling is overemphasised, while methods planning is neglected.
- Role – it is identified that control overshadows action planning.
- Process – the decision making process receives almost all the attention, while the necessary steps prior to following it are ignored.

There are numerous concerns in construction management literature that the current techniques available to the general practitioner are insufficient in planning and managing construction projects (Morris, 1994; Koskela, 1992; Koskela and Howell 2002; Sweis *et al.* 2008; Ballard, 2000, Ballard and Howell 2001, 2003; Birrell, 1980; Kenley 2004; Naaman 1974; Hartman and Ashrafi 2004).

Hartman and Ashrafi (2004) argue that despite the good coverage of planning in PM literature (books, journals, and conference proceedings) a significant number of projects still fail. Laufer and Tucker (1987) advocate that the conventional techniques cannot be supplanted since a better technique is unavailable. Ballard and Howell (1998) also indicate that when planning reliability is above 50%, it will save of 30% labour, consequently reducing project cost. In the same respect, Kenley (2004) advocates that it is the time to focus more effort on changing the way work is planned and managed in construction.

3.3 CONSTRUCTION PROJECT PLANNING AND CONTROL

Project planning has been discussed extensively in PM literature but discussion of construction project planning techniques is limited. Construction project planning techniques were heavily discussed in the literature in the last three decades in the 20th century. However, it is sparsely discussed in this 21st century, although numerous studies have indicated that the current techniques are insufficient. Studies in the 21st century on project planning reiterate the application of the conventional methods rather than proposing new methods (including Rad and Anantatmula 2005, Cooke and William 2009, Melton 2008, Mubarak 2005, 2010, Griffith *et al.* 2000, Clough *et al.* 2000, Lock 2000, Hinze 2012 and Patrick 2004 who have published on project planning). Griffith *et al.* (2000 p. 12) articulate the importance of project planning in the construction industry as they argue that "to plan a project as early as possible is paramount to success". Similarly, Clough *et al.* (2000 p. 56) suggest that "planning is the devising of a workable scheme of operations which, when put into action, will accomplish an established objective".

Zwikael *et al.* (2005) argue that projects in different countries may be managed in different ways; notwithstanding, the project planning techniques used are similar in many countries, if not the same. They established that the planning tools in Israel and Japan are similar. Similarly, research has indicated that the planning techniques in construction are the same globally (Antill and Woodhead 1990, Mubarak 2005, and Dvir and Lechler 2004). These techniques include WBS, Gantt chart, CPM,PERT, and LoB which are referred to in this thesis as conventional techniques.

Mubarak (2005 p. 3) agrees that project planning serves as a foundation for several related functions such as cost estimating, scheduling, project control, quality control, safety management and others. However, he argues that none of the methods available now in the industry gives all these functions. Hartman and Ashrafi (2004) establish that poor planning is one of the major causes of project failure. Jongeling and Olofsson (2007) claim that only 15-20% of the time of Sweden construction workers is spent on direct work due to lack of planning. They claim that approximately 45% of time is spent on indirect work, which includes preparations, instructions and getting materials, and 35% on redoing work and errors within the Sweden construction industry.

Morris (1994), Arditi *et al.*, (2001) and Kenley (2004) claim the evolution of PM and its planning techniques have been closely associated with the development of systems engineering in the US Defence and aerospace industry. The Department of US Defence, before the late 1960s, developed and promoted tools such as: Work Breakdown Structure (WBS), Network Diagram, Critical Path Method (CPM) (similar to Programme Evaluation Review Technique, PERT), Line of Balance (LoB) and Gantt chart (originally developed in

1917 by Henry Gantt) as the main PM techniques (referred to in this thesis as the conventional techniques) (Mubarak 2005).

3.3.1 Existing Requirements for Planning

As current construction planning is predominantly based on these conventional techniques, the following are the three main process requirements for scheduling. There are three main processes or requirements for conventional planning: (1) WBS, (2) Task Duration, and (3) Logical Sequence

3.3.1.1 Work Breakdown Structure

WBS was developed together with PERT by US Defence. The initial concept of WBS was to decompose work into a product-oriented family tree. Mubarak (2005) suggests that WBS is defined as a task-oriented, detailed breakdown of activities that organises, defines, and graphically displays the total work to be accomplished to achieve the final objectives of a project. Before a Gantt chart or CPM is used, the project must be broken down into smaller elements, that is, in general terms WBS. Mubarak (2005) argues that there is no absolute correct or incorrect way to break down a project but the breaking down is mainly due to the scheduler or the planner. However, in practice, the scheduler or the planner is normally not part of the construction of the project on site. Thus, there is no continuity of the schedule development. In construction, WBS has been more task-oriented as the definition suggests but the question asked is: should it be deliverable-oriented as construction focuses on subcontractors achieving deliverables. Practically, under the deliverables are the tasks. Ballard (2000) argues that the objective of WBS should not be based on budgeting and monitoring only but should include the understanding of flow (discussed in detail later in this chapter).

3.3.1.2 Task Duration

Estimating for activity duration can vary, but Mubarak (2005 p. 44) and Clough *et al.* (2000 p. 79) suggest the generally accepted formula for estimating activity duration as:

$$\boxed{\text{Duration} = \frac{\text{Total Quantity}}{\text{Crew productivity}}}$$

Figure 3. 1: Conventional Calculating of Task Duration

For example, 12,000m^3 of excavation and a crew average productivity of 600m^3 per day implies the duration = 12,000/600 =20 days. This formula does not make mention of the activity constraints, and the availability of mechanisms (plant, equipment and labour with the required skills). Further, it is assumed that crew productivity is constant, thus the variable is 'the total quantity'. This assumption is contradictory to the practical construction project productivity. Duration that is dependent on crew productivity only, arguably, is a flaw. The duration of a task is dependent on the task constraints, availability of the required skills and mechanisms to execute the task (details presented in chapters 9 and 11). In addition, a study by Yung and Agyekum-Mensah (2012) on productivity establishes that 15.2% of productive time is lost only on smoke breaks on construction sites, which is normally not factored into the productivity assumptions. This indicates that productivity on a construction site is constrained by many other factors which are rarely discussed in the literature. Therefore, it challenges the scientific formula for duration.

3.3.1.3 Logical Relationships

There are variants of the network techniques, known variously as critical path scheduling, critical path analysis and PERT. The fundamental idea of the network is to represent graphically the sequential relationship between the activities that are to be performed in the project. In the conventional techniques, generally the variants of the network diagram, the relationship exists mainly between two activities where the start of one activity depends on the finish of the other activity. In broader terms, it is developed based on 'input and output' relationship. For example, in figure 3.2A, task T only has two arrows (which is input and output). Again, activity A should be finished before B starts, likewise, B before C. In figure 3.2B, activity B starts at the same time as A (which is a parallel activity) but C starts only after activity A is completed. This means the relationship is just between the two activities which is contradictory to practical construction project. Figure C is an error under the CPM. This error terminates the calculations of any CPM program (Mubarak 2005).

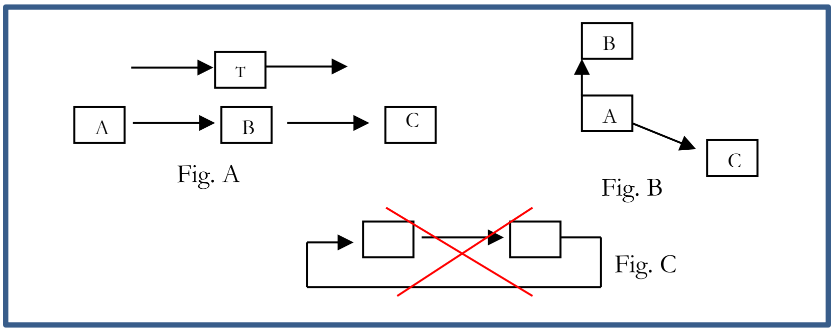


Figure 3. 2: Logical Representation of Activities

The 'network' shows relationships among activities but typically it is only between two activities. It may be argued that this technique is beneficial for estimating the completion date of a project. A lag (duration) could add to extend or reduce the starting time of next activities depending on the logic relationship such as finish-start (figure A), start-start (figure B)or finish-finish.

3.3.2 Existing Requirements for Project Control

Conventionally, project control is the process of regulating the 'plan' (the baseline or first plan) from deviation (normally, over spending and schedule slippage) during the construction stage. Mubarak (2010) ascertained that the most important use of a plan is for project control, thus there is a very close relation between project planning and project control. Mubarak (2005 p. 147) summarised the project control process into four main steps. These are:

1. Monitoring work progress (where monitoring simply mean observation)
2. Comparing it with the baseline schedule and budget (what it was supposed to be)
3. Finding any deviations, determining where and how much, and analysing them to discover the causes
4. Taking corrective action whenever and wherever necessary to bring the project back on schedule and within budget

Traditional project control mainly focuses on time and to some extent on cost which is consistent with the conventional project planning techniques. Burke (2003 p. 211) argues that "if the project is off course, then control in the form of corrective action must be applied". In this view, Ballard (2000) suggests that this approach to control is inadequate because it does not deal with the management of the construction, thus he introduces the LPS, which adopts a production control system. LPS focuses on the social aspect and adopting the push and pull concept of manufacturing system to improve workflow. LPS examines what 'should' be done to complete a project, what 'can' be done and deciding for a given time frame what 'will' be done" as key for control. Details on LPS and the conventional techniques are discussed below.

3.3.3 Planning and Control Techniques

In this section, the existing planning and controlling techniques are reviewed. The section is categorised into three groups. These comprise narrative planning, conventional techniques and the contemporary techniques. Trauner (2009) classifies the common schedule techniques as narrative schedule, bar or Gantt chart, linear schedules and CPM.

3.3.3.1 Narrative Planning

Narrative schedule is normally used by small and sometimes medium size organisations. It is used for small project with few activities, where the plan and sequence of the work are narrative (Trauner, 2009). It is not suitable for projects with many activities and complex projects. Over the years, the most dominant techniques for construction planning have been the conventional techniques.

3.3.3.2 Conventional Techniques

Gantt chart was originally referred to as bar chart but was later named after the developer, Henry L Gantt. Popescu and Charoenngam (1995), and Mubarak (2005) describe Gantt chart as "a graphical representation of project activities shown in a time scaled bar line with no links shown between activities". The popularity of the use of Gantt chart in the construction industry stems from its simplicity, easy usability and that it does not necessarily require technical knowledge and ability to graphically represent project activities on a time scale (Mubarak 2005). Cooke and Williams (2009) advocate that Gantt chart was originally the main project management scheduling tool but it does not show dependency. Therefore, it does not clearly indicate which operation directly relates to the successful completion of a project. Equally, Mubarak (2005) argues that Gantt chart is limited by lack of logical representation. Its logic is a subjective decision of the planner. It is also limited by the size and the complexity of projects. Researchers have argued that the limitations of using Gantt charts resulted in the adoption of a more sophisticated technique in the 1950 and 1960s, CPM andPERT (Cooke and Williams, 2009; Mubarak, 2005; Popescu and Charoenngam, 1995). Gantt and CPM complement each other. CPM and PERT are categorised into the conventional network diagram as discussed earlier. There are basically two main types of network diagram that are, activity diagram method (activity on arrow) and Node diagram method (activity on node) (reference to figure 4.3a and 4.3b). The activity on node was later developed to precedence diagram, then as CPM and PERT.

The CPM technique was developed in a response to the problems in planning and the control of projects in the USA in the late 1950s (Burke 2003). The US Navy were concerned with the control of the Polaris Missile program, whilst the E.I DuPont de Nemours Company were faced with constructing a major chemical plant. Therefore, the PERT and CPM were developed simultaneously by the US Navy and the E.I du Pont de Nemours Company respectively. The latter was originally developed as technique called the Project Planning and Scheduling (Antill and Woodhead 1990), which was later advanced to CPM. Since its development it has been one of the fundamental techniques in planning and managing construction projects. The concept of CPM is mainly based on time and cost estimates. A key part of PERT and CPM is to determine and calculate the critical path (activities that must be performed in order for the project to finish on time). PERT is a variation of CPM that take slightly more sceptical view of duration estimates for tasks. Again, PERT adopts a probabilities approach as compared to CPM. Another variation to PERT developed in last decade is the Critical Chain also known as theory of constraint, which is also based in probabilistic estimates of task duration.

Antill and Woodhead (1990) claim CPM is a powerful tool for managing all types of projects. They claim the use of CPM in the USA construction industry in the mid-1980s and early 1990s led to a decrease of 20% in project times as compared to similar projects not using CPM. Antil and Woodhead (1990) argue that the use of CPM enables the most economical planning of all operations to meet desirable completion dates. They stress CPM replaces the trial and error judgment of managers based on their experience to choose operation times and team size. In addition, CPM is an open-ended process that permits different degrees of involvement by management to suit their different requirements and objectives.

In the review of Laufer and Tucker (1987) on construction project planning, they argue that planning in the construction industry focuses on time planning and to a lesser extent on resource allocation. However, there is very little attention paid to the key issue of how the work will be executed. In that response, Antill and Woodhead (1990) argue that if time was of no consequence, each activity could be performed in a manner that will give a lower cost. In the study of Clough *et al.* (2000 pp. 55-75), chapter 4 was entitled "project planning" but the authors start the chapter with "construction time control is a difficult, time-consuming, and arduous management function". They further assert that monitoring is comparing time allowed against job progress. This emphasises that the conventional planning techniques focus mainly on "time"[12].

The conventional techniques including CPM have been criticised as ineffective by construction management researchers. According to Laufer and Tucker (1987), only 15% of CPM/PERT users in large construction firms deem these techniques as very successful, 43% use it effectively and in small construction firms only 10% attempt to use it. Birrel (1980) argues that academics have failed to ask questions about the practicability of CPM for construction. He claims CPM is incompatible with the construction process. He argued that the concept of CPM was created in the military/industrial settings where US Defence put less weighting on cost and efficient use of resources as compared to construction where subcontractors are concerned with efficient use of resources. Lutz and Hijazi (1993) claim there are two main disadvantages of using CPM and PERT in the construction industry. One

[12] This is not to oppose that time is important in planning.

is the emphasis on finding an optimal solution based on the shortest project duration, which involves minimising resources or cost. The other is the limited emphasis placed on input modelling. Mason (1984), and Laufer and Tucker (1987) have discussed specific limitations with CPM. Abeyasinghe *et al.* (2001) and Greenwood and Gledson (2012) presented the limitations of CPM in resources scheduling. Laufer and Tucker (1987, p. 255) identify some specific weaknesses with using CPM. These include the following:

- The CPM model refers mainly to technological constraints while the limitations of resources are barely considered. It does not ensure full continuity for the construction crew, which is the backbone of operation planning in construction.
- Even for technological relationships the model does not always provide satisfactory solutions. CPM is suitable for 'sequential' operations, which characterise an erection type of work. It is not suitable for 'bulk' operations, which is typical of an installation type of work where detailed sequencing of activities is often irrelevant or unimportant.
- When technological relationships are well defined and the model may be theoretically satisfactory, Laufer and Tucker find that in many instances CPM is difficult to apply in practice.

Birrell (1980) discussed extensively the limitations of CPM in his study, *Construction Planning – beyond critical path (CPM).* In response, Schlick (1981) claims the title and the content of this publication, which suggests that CPM in construction is a failure and the diagonal path of work squads and queuing theory being the answer to construction planning is misleading. He argues that there is no construction planning that will work for all types of projects. This is because CPM is compatible for certain types of construction projects; whilst the diagonal path and queuing theory is also limited to repetitive type of work such as a high rise building.

Antill and Woodhead (1990), who are advocators of CPM, acknowledged that the overlapping activities as normally indicated on a Gantt chart are impossible with normal CPM. They however claim that the current CPM computer packages allow the use of conditional and overlapping relationships to be prescribed. Austin *et al.* (2002) acknowledge the successful application of CPM in the construction industry; however, they claim it is wholly inappropriate in planning the design process due to the iterative nature of the construction design process. Commonly, CPM has been criticised for ineffective cost control and inefficient utilisation of resources, which is more important to a contractor. Cooke and Williams (2009) argue that another reason for not using CPM is the introduction of linked Gantt chart (bar chart) in more sophisticated PM software. They however argue that linked

Gantt chart can be confusing and difficult to interpret in complex projects, meaning complex interrelations cannot be clearly shown.

In a study conducted by Laufer and Tucker (1987), reviewing construction project planning, concluded that, so long as better methods are unavailable, CPM cannot be supplanted but its continuous use is conditioned by awareness of its limitation, which would serve as an incentive for the allocation to information gathering and diffusion.

Lutz and Hijazi (1993) discuss the network scheduling techniques used in the construction industry, namely CPM, PERT, decision critical path method (DCPM) and the graphical evaluation and review technique (GERT). CPM and PERT, which are closely similar, have been discussed earlier in this chapter. DCPM is a deterministic method similar to CPM which presents a decision node into the network to offer a decision alternative based on resource constraints. According to Taylor III and Keown (1980), GERT was originally developed by A. A. B. Pritsker. Naaman (1974) presented GERT and he argued that GERT was developed because of the deficiencies in the existing techniques (CPM, PERT and DCPM). He indicated that GERT is an amalgamation of the concept of DCPM, Linear Flow Graphs and stochastic network (PERT). Lutz and Hijazi (1993) simply recognise that GERT is the combination of DCPM and PERT. Naaman (1974) acknowledges that GERT was developed for some specialised sectors. Although Naaman (1974) clearly pointed out one of the significant advantages of GERT for its handling of multiplicative (probability) and additive (time and cost) elements simultaneously by the use of transforms, he quickly added that GERT is still restricted in the types of network it can evaluate. Naaman (1974) emphasises that the GERT technique does not lead to the full distraction of time for equivalent branches between input and output. Taylor III and Keown (1980) claim Q-GERT was later developed as an extension to GERT to include queue nodes but its reference in literature is rare. Naaman (1974) also established that it is not used in the construction industry (see table 3.1 for comparison).

Another planning conventional tool available to the construction industry which is worth mentioning is the linear flow graphs or line of balance (LoB) technique. Kenley and Seppanen (2010) advocate that scheduling techniques can be categorised in activity-based and location based; where the activity-based is techniques discussed previously such as CPM and PERT. Seppanen and Kenly (2005) explain that Location based approach such as flowline (also known as LoB) is defined as a location based activity management driven by the principle of continuous use of work resources. The line of balance concept comprises a graphical plot representing cumulative production versus time (Lutz and Hijazi 1993). Arditi and Albulak

(1986) refer to the LoB technique as a "linear scheduling method" or "location-based schedule" since it is used for repetitive projects. In the study of Lutz and Hijazi (1993), they establish that LoB consists of a family of graphical and/or analytical linear scheduling techniques including, space schedule method (TSSM), vertical production method (VPM), velocity diagrams, linear scheduling method (LSM) and line of balance scheduling. Arditi and Albulak (1986) argue that the origin of LoB is not clear; however, Arditi *et al.*, (2001) and Lutz and Hijazi (1993) suggest that this technique was developed by the US Navy in the early 1950s during the Second World War for programming and controlling repetitive and non-repetitive projects. In fact, Lutz and Hijazi (1993) claim that it stems from the Goodyear company in the 1940s but it was developed by the US Navy. Arditi *et al.*, (2001) argue that the LoB technique was not fully developed and implemented by the US construction industry due to the immense popularity of network techniques including CPM/PERT. Regardless, it has been applied to repetitive construction projects (Arditi and Albulak 1986), resource scheduling and highway pavement construction (Arditi *et al.*, 2001). Lutz and Hijazi (1993) discuss its use especially in European contractors for repetitive works. The main benefit of LoB is that it provides production rates and duration information in the form of an easily interpreted graphics format. A LoB plot for linear construction can be easily constructed. However, typically it is suitable for repetitive work as compared to non-repetitive work. One of the drawbacks of LoB assumes rates are linear (that is, constant rate of production of time). The contention is that the underlying theory of LoB is that the production rate of an activity is uniform. This is contradictory to general construction activities. Henrich *et al.* (2005) also present the limitations of LoB in planning and managing complex and non- repetitive projects.

Table 3.1 provides a comparison of the methods adopted from Naaman (1974). Although Naaman's study seems a bit old, it is the relevant study that has compared the methods. In addition, these methods have not changed in essence. Table 3.1 shows that most of the techniques, if not all, are based on time and cost and are mainly based on CPM/PERT.

Following a detailed review and analysis by Laufer and Tucker (1987), recommendations were made for the effectivity of construction project planning. They recommend that methods should be changed (e.g. gathering and diffusion of information), policies should be modified (e.g. the role of planning and control), assumptions should be adjusted (e.g. attitude to uncertainty) and the overall philosophy of project management should be re-examined. It is recognised that not much work has been done on the first three recommendations. However, their recommendations, the latter in particular, have influenced the works of Koskela and Ballard[13] on Lean Construction. Johansen (1995) presented the concept of introducing soft planning ; however, in a paper that he co-authored, Johansen and Greenwood (1999), they compared hard, soft and lean planning and concluded that soft planning is largely part of lean planning, thus The Last Planner System® (LPS).

Table 3. 1: Comparison of Networking Methods *(*Source: Naaman, 1974, p. 360*)*

Methods	Diagramming	Network Characteristics	Time characteristics	Activity constraints	Major application	remarks
CPM	Activities: On arrows (time scale possible on arrow). On nodes	Additive: Time Cost	Fixed or deterministic duration	All activities must be completed for project completion	Known projects where duration can be estimated accurately	Levelling of resources available time/cost trade-off possible
PERT	Activities: On arrows On nodes	Additive: Time Cost	Probabilistic activity duration (unimodal Beta function for all activities)	All activities must be completed for project completion	Research and development. Completion times are random variable.	PERT/cost available
DCPM	Activities: On nodes (distinction between decision and activity node)	Additive: Time Cost	Fixed or deterministic duration	Only a set of alternatives must be completed to complete the project	Project involving decision among many alternatives where duration times are known	Decision node represented by triangle. Integer programming solution Heuristic solution
Linear flow graphs	Activities: On nodes	Single multiplicative parameter (efficiency)	Deterministic (solution possible through use of transforms)	All nodes must be realised to give input/output relations	Project involving Reliability Feedbacks Repetitions Electrical engineering	Efficient analytical solution and sensitivity analysis through Mason's reduction
GERT	Activities: On arrows Conditioned by realisation of emanating node	Multiplicative and multi additive through MGF or transform (MGF is Moment generation function)	Probabilistic (any practical distribution of known MGF	Realisation of network implies realisation of set of alternatives only.	Stochastic networks Feedbacks Repetitions Uncertainties Research and development Decisions	GERT implements alternative decisions, handles uncertainties, uses flow graph techniques, synthesises previous methods.

3.3.3.3 Contemporary Techniques

Koskela (1992) conducted a radical investigation of construction problems from a theoretical stance. He concludes that the theory for construction PM as practice is obsolete. Therefore, Koskela and Howell (2001) assert that it should be replaced with a form that encompasses Transformation, Flow and Value generation perspectives within a single TFV theory (the theory is discussed in detail later in this thesis). They also argue that traditional planning techniques fail to support the work flow of teams or material flows leading to suboptimal flows. Koskela later identified seven flows of preconditions for the execution of construction task as shown in figure 3.3 below. Ever since the assertion and introduction of the seven flows, it has generally been accepted and most cited especially amongst lean constructionists.

[13] Glenn Ballard was acknowledged by the authors (Laufer and Tucker, 1987) for his suggestions.

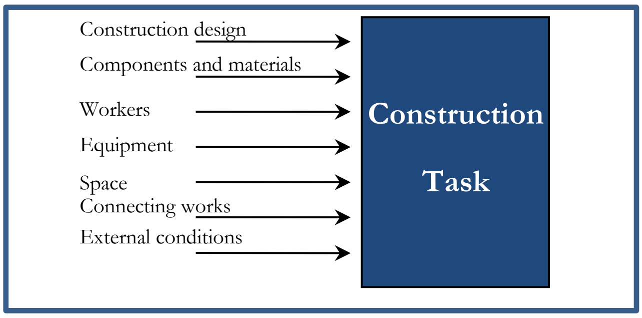


Figure 3. 3: Representation of Koskela's Seven Flows (Source: Koskela 2000)

Ballard and Howell (1998, 2003) also argue that less than 60% of weekly planned work is realised at the end of the week, which is also attributed to lack of planning. Both Ballard (2000) and Koskela (2000) argue that the conventional planning techniques fail to support workflow since these techniques are based on conventional theory. The Last Planner System® (LPS) was introduced by Ballard (1998) to address this problem of workflow in planning and control. Ballard (2000 pp. 3-2) indicates that LPS is a philosophy, rules and procedures and set of tools that facilitate the implementation of those procedures. Ballard (2000) claims LPS is for production control. Henrich *et al.* (2005) emphasise that the LPS has two main focuses, which are, short term planning and the development of a social system on site and adds a production control component to the traditional planning system. LPS is based on the limited application of methods such as CPM. Kenley (2004) argues that CPM, PERT and WBS are the mainstream planning tools due to the availability of relatively cheap and extremely powerful schedule software. Laitinen (1999) argues that the solution to problems in planning goes beyond the use of IT tools alone. Another technique used within the LPS is the "Pull scheduling" which is based on working from a target completion date backwards. This causes tasks to be defined and sequenced so that their completion date realised (Ballard and Howell 2003). Kenley (2004) argues this approach is based on the conventional planning techniques dominated by ideal logic networks. The LPS has been claimed to be a successful tool with many implementations reported in the IGLC body of knowledge[14]. However, a Danish study on its use did not find significant benefits (Henrich *et al.* 2005). They however acknowledged that LPS is suitable for directive-driven production rather than machine driven (as in manufacturing). The success of LPS has been advocated largely by lean constructionists in the proceedings of IGLC but that is not to undermine the contribution of LPS methodology to

[14] www.iglc.net

production control. Jorgensen and Emmit (2008) argue that LPS has not featured strongly in peer-reviewed journals, rather its dominance is in IGLC proceedings. The authors claim that this could result in a dominance of positive bias to IGLC papers. This is because there is little evidence of critical debate, and there is the tendency to be self-referential.

LPS is accepted as one of the main planning and control techniques for Lean Construction. LPS and Lean Construction (LC) are used normally interchangeably. This is normal because LC Institute originated from a partnership between Glenn Ballard and Gregory Howell in August 1997, and later other founding members were incorporated (Ballard 2000 p 1-7). Ballard and Howell have made a lot of contributions to the construction industry in general and lean construction in particular including the development of LPS. Notwithstanding, a study conducted by Eriksson (2010) on a LC pilot project claims that although LPS is stage 3 of the LC implementation, it is not used at all for process focus in production planning and control; rather milestone is used to a large extent. Similarly, Johansen and Porter (2003) established LPS is faced with cultural barriers in the UK. The conclusion of Johansen and Walter (2007) in their review of lean concept in German construction was consistent with similar studies conducted by Common *et al.* (2000) in the UK and Johansen *et al.* (2002) in the Netherlands that the concept of Lean construction is little known and it is seldom implemented. Johansen and Walter (2007) citing Ott (2005, member of LCI, Germany) claim the technological progress in these countries hinders the introduction of lean construction since it is socially driven. Kenley (2004) suggests that there is a need for expanding the suite of applicable tools to empower lean construction.

Kenley (2004) claims lean construction proposes a change in the traditional approach to construction PM and demands a new approach to project planning but still depends on the conventional techniques of scheduling. It was further claimed that little effort has been put forward by researchers in solving the problem of physically creating flow. Existing techniques such as LPS emulate flow through management control systems, which has resulted in the well-developed but proprietary LPS technique. Kenley (2004) suggests that there are difficulties in identifying workflow in a production system based around the discrete activities inherent in activity based critical path planning and execution. He stressed that LPS emulates flows through managing control systems and activity protection but does not physically create flow in the production system.

Arguably, a critical review of LPS by some lean constructionist prompted the study of Bertelsen *et al.* (2006). Therefore, Bertelsen *et al.* (2006)[15] also review the LC general theory and LPS as the tool for managing flow of work. They advocate that LPS implicitly takes into account the seven flows proposed by Koskela (see figure 3.1). Again, it neither presents general tools for the management of the remaining six flows nor is the nature dealt with in detail. LPS assumes the planning is "selecting from what 'should' be done to complete a project, what 'can' be done and deciding for a given time frame what 'will' be done" (Henrich *et al.* 2005). Accordingly, LPS focuses more on social system, but where the company is very hierarchical or there are language problems, then the corresponding part of LPS is limited. A project manager who applied LPS suggested "it would be great if somehow the weekly plans were linked to the master schedule" (Choo and Tommelein 2001). This was because a subcontractor did not deliver as promised, thus affecting the completion date of the entire project. Bertelsen *et al.* (2006) reviewed the current construction planning and control techniques including LPS, and discussed their limitations. They established that there is need for new understanding and a better flow model to suit construction project management. Similarly, Kenley (2004) suggests that it is the time to focus more effort on changing the way work is planned and managed in construction. Maylor (2010) suggests a holistic approach for effective management.

Table 3. 2: Comparing Lean Planning Techniques

Decision Level	**Strategy**	**Tactics**	**Control**
Time Horizon	Long term (year)	Intermediate (Month)	Short term (week)
Planning	Master	Look-ahead	Weekly
Method Interfaces	**CPM**	**LoB** **Critical Path**	**LPS**

There are a few other techniques proposed for construction management, albeit not necessarily planning and control. One of these techniques developed in the past few decades in the UK is the Analytical Design Technique (ADePT). The research for the development of this technique, ADePT, was a collaboration of Loughborough University and AMEC all in the UK (Austin *et al.* 2000). Austin *et al.* (2002) established that the ADePT methodology was developed in response to the need to provide a powerful, but simple means of understanding the interdependencies between tasks in the design process. They claim that this was necessary because the traditional techniques such as the CPM are wholly inappropriate due to the

[15] The authors are core and founding members of LC

iterative nature of the building design process. However, ADePT includes an element of Gantt chart. This technique focuses on the information flow within the design planning process. Austin *et al.* (2002) argue that ADePT is to "challenge designers to place greater emphasis on understanding and analysing the process of design". ADePT focuses mainly on the design stage, while planning is largely carried out in the construction stage as well. Beside this, the reality is that, in practice, ADePT is seldom known and references in literature are rare.

In much the same way, Jongeling (2006) proposed a process model for workflow management. His approach is a combination of the LC concept and virtual design and construction. The schedule of the workflow in also based on a location-based schedule, which has been discussed earlier. It could be concluded that construction project planning lacks techniques and now all attention has turned to software.

3.3.4 Planning and Control Software

The endeavours to develop a new workable planning technique for construction projects are scarce, due to the relative popular use of software. At the moment, all the conventional techniques have been incorporated into scheduling, normally referred to as project management software. In the PhD research of Choo (2003), he reviewed the main existing planning software which include Microsoft project (currently 2010) and Primavera (P6). Other software cited in the UK construction industry includes Asta Power Project and Project Commander. All these software and others that have not been mentioned adopt the concept of Gantt chart, CPM and WBS. They have included the idea of linked bar chart. There are two main purposes for these introduction: first, it improvises logic into the normal bar chart and, second, it connects the Gantt chart to the network diagram to give the critical path. The reality is stressed by Cooke and Williams (2009) as they argue that linked Gantt charts can be confusing and difficult to interpret in complex projects.

The conventional techniques are still the mainstream planning tools for all the software. Therefore, their limitations remain unchanged as discussed previously. Arguably, the unavailability of an appropriate planning technique may also be due to the availability of fairly cheap and extremely dominant schedule software adopting these conventional techniques. Using software has speed as an advantage, however, the solution to problems in planning goes far beyond the use of software alone. The lack of effectiveness has resulted in delays as the common factor within the construction industry globally.

3.4 DELAYS IN CONSTRUCTION

Sambasivan and Soon (2007) describe the delays in construction projects as a universal problem. This has led to many empirical studies on delays in both developed and developing economies as shown in table 3.3. Conclusions from many studies cite the fragmented nature of construction projects, lack of communication, management and financial problems as principal causes. In the attempt to understand the industrial problems in construction, delay and its causes are being reviewed. Project delay is being reviewed because the investigation and understanding of time overruns is not only associated with planning and control but it triggers the many problems within any project, such as cost, quality and management issues (Sambasivan and Soon 2007).

Trauner (2009), and Conlin and Retik (1997) classify delays into two main types that are excusable and non-excusable. By and large, the excusable type is delays that are understandable by the parties, while non-excusable is the opposing type. They claim that there are two types of excusable delay, which comprise compensable and non-compensable. Many researchers have different definitions for "delay"; however, in this thesis delay is the inability to meet the scheduled time.

Delay is recognised in the construction industry as a global problem which is attributed to many factors. Table 3.3 presents the major delays observed in literature.

Table 3. 3: Delays observed in Literature (Source: Agyekum-Mensah *et al.* 2012a)

Authors	Delay observed	Country of study
Conlin & Retik (1997)	Overrun on 52% of projects	UK
Zwikael *et al.* (2005)	Overrun on 5% of projects	Japan
	Overrun on 30% of projects	Israel
Assaf *et al.*, (2006)	30% completed on schedule (70% overrun)	Saudi Arabia
Ballard & Howell (1998, 2003)	Between 35 – 60% of weekly work regularly completed as planned	UK, USA
Odeh & Battaineh (2002)	Roads – actual to planned 160.5%	Jordan
	Building – actual to planned 120.3%	
Al-Momani (2000)	Public Project 81.5%	
Frimpong *et al.* (2003)	Groundwater construction 75%	Ghana
Aibinu & Jagboro (2002)	Building project 92.64%	Nigeria
Odeyinka and Yusif (1997)	Overrun 75% (every 7 out of 10)	
Mansfield *et al.* (1994)	Overrun as high as 342%	

3.4.1 Causes of Construction Delay

Construction project delays can be attributed to many reasons and could be initiated by any of the stakeholders on projects (Conlin and Retik 1997). Atkinson (1999) claims that construction projects are continuously described as failing. Sweis *et al.*, (2008) insist that despite the advanced technology and project management techniques available to the practitioners, construction projects experience delays. Hamzah *et al.*, (2011) conclude that the improvement of delay is not only limited to the consideration of technical factors, but also to issues of project management.

Hubbard (1990), among other researchers, claims the problem of delays is due to lack of effective project management. He argues that this is because project management is significant to project success. Equally, Sweis *et al.* (2008) ascertain that there are major failings in the traditional approaches to project delivery.

Sambasivan and Soon (2007) conclude that improper planning is the most likely cause of delay followed by poor site management. According to Sweis *et al.*, (2008), responses from both consultants and owners ranked poor planning as the main cause of delay. According to Conlin and Retik (1997), construction schedules, regardless of type, play a vital part in managing the construction process. They claim schedule is vital in identifying, preparing, analysing or refuting delay claims because they provide a specific medium for comparing and measuring time and meaning. Furthermore, they claim that the construction schedule is significant when it is applied to measure delays.

Despite all the advances in project management theory and practice, Hartman and Ashrafi (2004) claim construction project success is still below 40%. Researchers have stressed that lack of planning does not only lead to delays, it also leads to other major problems including cost overruns, suboptimal performance, poor logistics, and communication. Egan (2002) advocates that to reduce the problems, construction planning should be undertaken by an integrated team.

The problem of insufficient techniques has been compounded by a lack of understanding and communication within a project. BSI (2010) recognises that lack of communication within the UK construction industry costs the industry over £20 billion annually. This communication problem in the construction industry can be categorised in two parts that are the social and activity flow. The former (social) has been discussed by Dainty *et al.* (2006) but the common understanding of the process still remains a problem. Griffith *et al.* (2000) argue that planning is a perfect communication medium to demonstrate analytical thinking and the suggested sequence of tasks.

Sullivan *et al.* (2010) argue that poor logistics cost the UK construction industry over £3 billion. They highlighted the report on Improving Construction Logistics (Strategic Forum for Construction, 2005). According to the Strategic Forum for Construction (2005), the causes for the additional cost include operatives waiting for materials and skilled craftsmen being used for unskilled jobs. Effective planning becomes really indispensable when projects become complex (Griffith, Stephenson and Watson 2000). This argument led to another problem of resource management, and cost overruns. Jongeling and Olofsson (2007) claim that only 15-20% of the time of a Swedish construction worker is spent on direct work due to lack of planning. The importance of planning is also highlighted by Ballard and Howell (1998), who indicated that when planning reliability is above 50%, this will save 30% of labour, consequently reducing project cost.

Baldwin and Manthei (1971) conducted one of the early studies to clearly present the causes of delays in construction in the USA. This was followed by the study of Arditi *et al.* (1985), and Sullivan and Harris (1986) in Turkey and the UK respectively. Thereafter, numerous researchers have examined the causes of delays in various countries in construction as shown in table 3.4. Among the studies, Hamzah *et al.,* (2011), Sweis *et al.* (2008) and Fallahnejad (2013) produced critical reviews on the causes of delays observed in literature. Hamzah *et al.* (2011), and Sambasivan and Soon (2007) concluded their critical review on causes of delays by identifying the main causes; these include, poor planning, poor site management, financial issues, delay of material delivery and management problems. Sweis *et al.* (2008) believe that these main causes can be grouped into three categories, which are input factors (concerned with labour, material and equipment), internal environment (contractor, owner and consultants) and exogenous factors (weather and government regulations). They identified poor planning as the main initiator of delays from both owners and consultants. Although many studies have indicated delay is a universal problem within the construction industry, the UK literature is sparse on the causes of delay.

Survey is the dominant approach used for investigating causes of delays (table 3.4), perhaps, because of the dominance of the quantitative (survey) research in construction management as a field of study. Using survey in this case only allows the existing factors in literature to revolve; thus, there is no new understanding of the problem. Researchers have stressed that to understand the 'real-world' problem of why something occurs e.g., the causes of delays, it is important to ask those involved in the projects. (Robson 2011, and Seymour *et al.* 1998).

Table 3. 4: Studies on Causes of Delays in Construction

Author(s)	Country of Study	Method used
Mansfield *et al.* (1994)	Nigeria,	Survey
Assaf and Al-Hejji (2006)	Saudi Arabia	Survey
Al-Momani (2000)	Jordan	Survey
Frimpong *et al.* (2003)	Ghana	Survey
Stumpf (2000)	General	Literature review
Sweis *et al.* (2008)	Jordan Middle East	Survey
Hamzah *et al* (2011)	General	Literature review
Sambasivan and Soon (2007)	Malaysia	Survey
Odeh and Battaineh (2002)	Jordan	Survey
Fallahnejad (2013)	Iran	Survey
Lo *et al.* (2006)	Hong Kong	Survey
Han *et al.* (2009)	Korea	Survey
Enshassi *et al.* (2009)	Gaza Strip	Survey
Abd El-Razak *et al.* (2008)	Egypt	Survey (piloted Semi Structured)
Fugar & Agyekwah-Buah (2010)	Ghana	Survey

3.5 SUCCESS FACTORS IN PLANNING AND CONTROL

Belassi and Tukel (1996 p. 141) stated that "only a few studies in the project management literature concentrate on critical factors that affect project success or failure". They believe that much of the research in PM literature focuses on lists of critical factors, where each list varies in its scope and purpose. The success factors identified in all these studies are generic lists. Wit (1998) examined success factors for both project and PM, and he identified planning as the main success factor for both project and project management. However, the literature is limited on the success factors for planning and control. The few studies of success factors in planning include Jenster (1987), where the author introduces an information-based approach to strategy development and control.

3.6 CONCLUSION

Project planning is a core part of PM and it serves as the basis for many functions, such as cost estimating, communication, project control, quality control safety management, logistics management. Mubarak (2005) argues that none of the methods available in the construction industry gives all these functions. Currently, planning in the construction industry focuses on time (scheduling) and to a lesser extent on resources allocation.

The review indicates that the construction industry is influenced by the US Department of Defence, who developed many of the conventional techniques and made many more techniques popular. Table 3.1 above gives a comparison of the methods, which shows that most of techniques, if not all, are based on time and cost as the additive and mainly based on CPM/PERT. This includes the contemporary technique, LPS, although the conventional techniques have contributed their quota to project planning and control in the construction industry. Currently, it is insufficient for planning and controlling the construction project. Most of the planning is based on the trial and error judgment of managers based on their experience to choose operation times and team size. In addition, the existing techniques do not allow 'flow' of tasks.

This illustrates that the planning technique is limited to CPM. It is therefore evident that the flaws that Laufer and Tucker (1987) identified almost three decades ago are part of the major setbacks to the construction project planning. They concluded that planning methods should be changed (e.g. gathering and diffusion of information), policies should be modified (e.g. the role of planning and control), assumptions should be adjusted (e.g. attitude to uncertainty) and the overall philosophy of project management should be re-examined.

Numerous studies have established that planning is the core success factor in both project and PM. However, in the UK (where this study is conducted) especially, there is limited literature on both causes of delays and the success factors for planning. In summary the two gaps in knowledge identified in this chapter are as follows:

1. There is the need to explore the industrial problems associated with planning and control, which include the success factors.
2. There is the need for a holistic technique as recommended by scholars to supplant the existing techniques to enhance current practice. This technique should:
    - address many of the limitations identified in the planning and management of construction projects
    - overcome communication barriers within planning and managing a project
    - promote collaboration due to the inter-disciplinary nature of the industry
    - overcome lack of understanding and workflow
    - overcome limitation of evaluation, thus promoting learning and improving skills
    - Serve as the foundation for related functions, such as cost estimating, resource management, quality control, project control, risks management and logistics management.

CHAPTER FOUR: PRODUCTION AND MODELLING TECHNIQUES

4.1 INTRODUCTION

This chapter is a critique of two issues, firstly, construction as production and, secondly, production modelling techniques as applied to construction. This chapter examines production from the manufacturing industry to understand the term, as production is more widely associated with manufacturing than construction. This led to the definition for project production for this thesis. Later, the chapter focuses on construction as project production to understand to what extent production models can be adopted. The understanding of this leads to the review of the second issue, i.e. the modelling techniques.

Planning techniques are being represented by models, where model denotes the 'simplified description of a system or process' and more generally a 'representation of reality'. The main modelling techniques predominantly used in manufacturing are reviewed together with the conventional modelling techniques in the construction industry. This led to the consideration of IDEF0 model as the appropriate modelling technique for this study. Therefore, a detail commentary on IDEF0 was presented, which include its previous applications and limitations.

4.2 PRODUCTION MODELS

This research is not intended to compare the manufacturing industry to the construction industry, but rather to understand the concept of production from manufacturing and other industries in relation to construction. This is to aid in the consideration of concepts that predominantly emanate from manufacturing into construction industry in order to enhance construction PM.

4.2.1 What is Production?

The term 'production' has been used literally to mean 'manufacturing'. Unsurprisingly, synonyms for the word 'production' include manufacture, assembly, making, and fabrication (Oxford Dictionary 2001). Vonderembse and White (1991 p. 3) also suggest that in manufacturing specific term referring to the 'production of goods', where product is normally referred to as 'services or goods'. They explain that in production, operations are the processes by which input (people, capital and material) are translated to produce output (goods and services) see figure 4.1.

Figure 4. 1: Production Operations (Source: Vonderembse and White, 1991 p. 3)

Ballard (2000) claims production has been denoted mostly to mass market, movably from place of manufacture to place of use. From his construction perspective, he describes production as designing and making artefacts. He believes this description will help the understanding of construction as production (this will be discussed later in this chapter).

In the early 1920s, Thomas Warner Mitchell published a journal article "What is Production" in his quest to understand production. He argues that the purpose of production is to furnish goods with which to satisfy our (social) want. Although, he considers many wants to have their origins from needs, he suggests that each specific want is capable of complete satisfaction during any given short period (Mitchell, 1920 p. 64). He draws from the argument: *"concrete material things called 'commodities', articles of 'wealth', 'economic goods' or simple 'goods' do not exist or come into existence spontaneously as needed or desired. They do not spring into existence automatically in response to want. They are produced".*

The materials for these wants exist somewhere in disassembled form which must be assembled into the combinations that are capable of satisfying these wants (Mitchell, 1920 p. 65). Examples cited include converting wood into chair and table; and the steel and bone into penknife. Mitchell (1920) claims that traditionally production is mostly associated with farmers and manufacturing but not railroad (the broader sense, construction). This view is equally shared by lean constructionists, such as: Koskela, Ballard and Howell (Koskela 1992, 1999, 2002; Ballard 2000; Ballard and Howell 2000; Koskela and Howell 2002).

Most manufacturing is associated with volume of production, thus volume is vital to the understanding of production and process selection decisions. The two extremes are the high volume and low volume. The high volume is where the same product with higher production and demand, while, that low-volume is with lower demand for the product as illustrated in figure 4.2 below. The low-volume tends to be expensive due to the one-of-kind production. Alternatively, the high volume is normally referred to as mass production. Many literature exist on production management from the concept of **mass production** (famously, Fredrick Taylor) and in the 1960s, the concept of lean production (Toyota, Tachii Ohno and Shigeo Shingo), Vonderembse and White (1991, 2003). Anecdotally, people implied to mass production as less quality; however, Vonderembse and White (2003) argue that mass production does not necessarily mean inferior quality. They cited an example of mass production of Roll Royce does not make it inferior.

Vonderembse and White (1991) categorised production into groups from high-volume to low volume. They grouped high-volume production process as line flow process (normally referred to as, mass production or repetitive production). One of these types is the continuous flow and the other is assembly line. The other types of production processes, which is in between high-volume to low-volume, are batch, manufacturing cells (also called cellular manufacturing) and flexible manufacturing systems, and job shop (see figure 4.2). The manufacturing cells and flexible manufacturing systems are process options that offer the potential to produce low-cost product to meet varying customer requirement. Batch is a word used to describe a production process that does not have sufficient volume for a single product to fully use the facility. The low-volume production is project production, which include construction project. In this thesis, defining production is *the operations of making to meet a specific want.*

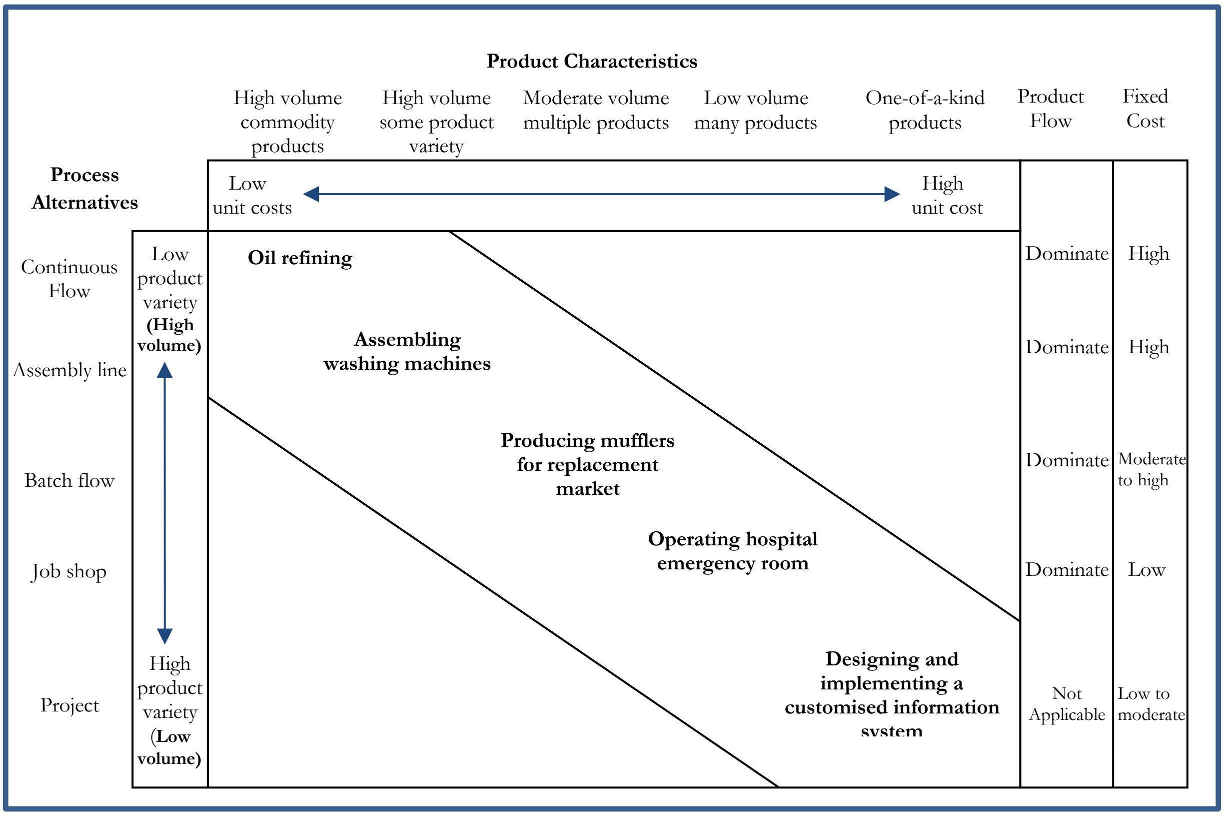


Figure 4. 2: Relating manufacturing process and product characteristics (Source: Vonderembse and White, 1991 p. 262, 266)

4.2.2 Construction as Production

Construction has been branded as unique; however, in as much as Koskela agrees with this statement, he advocates that steps, such as standardisation (standardising the component), using modularisation and prefabrication and using permanent crews (Koskela 1992, 2000) could perfectly fit in most of the types of production. Equally, Ballard and Howell (1998) describe construction as a combination of fabrication and assembly. Yes, this may be feasible in development of residential buildings by a particular developer, but the question is: **can most of the construction projects be standardised to meet the want?** as per the description of production. Ballard and Howell (1998 p 6) concluded that construction is "design and assembly of objects fixed-in-place, and consequently possesses, more or less, the characteristics of site production, and temporary teams".

Construction is classified from figure 4.2 as project production. Project (construction) production is characterised with a low-volume production, high product variety (one-of-a-kind), fixed at a position, low to moderate in terms of fixed cost, varied utilisation of equipment and product flow is not meaningful to projects production. This view has been supported in the studies of lean constructionists, such as Koskela (1992, 1999, and 2000) Ballard and Howell (1998) and Ballard (1998, 2000). Koskela (1992) include characteristics of being temporary multi-organisational. Subsequently, based on this notion Koskela developed the TFV theory (discussed in detail in chapter 5 on this thesis).

Mitchell (1920) classified production into four main activities, these include form (converting input to output, see figure 4.1), place (the location), time and possession (end user) utilities. In construction terms, the form is the transformation process, the place is the location for the project and the space availability for executing the tasks; time is the duration to carry out each task (altogether gives the completion time), and possession is the consideration of client requirements during the process. This is similar to many production theorists, where a product has fixed cost[16], except project production. This is contrary to traditional construction production, where cost is a variable, thus it is a required to factor cost into construction as production. In addition, most of the other productions are carried out under constant constraints and mostly control environment. In reality, this is not the case with construction production. Construction project production has varied constraints for each task and under uncontrolled environment[17] (site based project). Thus, it is important to consider constraints

[16] i.e. production cost + overheads + profits = cost of product. Cost increment is usually determined by the manufacturer than the customer opposing to construction project.

[17] Even modular building need to be assembled on site and the environment is different as well as the constraints.

for a task within the production. The duration taken for a task in particular process within the manufacturing production can be scientifically calculated (i.e. total/unit). This calculated duration remains constant under that environment, regardless of the location of the production. Contrary to a construction production, which its location and the individual tasks have effect on the duration.

Howell (1999 p. 4) argues that the construction industry has rejected many ideas from manufacturing owing to the idea that construction is different. From the above discussion, it could be concluded, although construction is a type production system, it has many different characteristics and process as compared to other production systems. In this stance, project production is defined in this thesis as *the operations of making or building to meet a specific need/want within an explicit boundary*.

4.2.3 Planning and Control in Production

Mitchell (1920 p. 67) claims productive capacity is limited. He argues that it is limited because productive resources, available materials, available energy, and available directing intelligence are limited. Arguably, during this time of his study, the assumption was that there was limited amount of work to be done but there was no demand for labour. Therefore, he advocated that production encompasses one other vital component, which is intelligent planning and directing. He stressed that planning and directing is an indispensable function in connection with each process (Mitchell 1920 p 67-69). He argues that in production, managers are more concerned with the productive but not the so-called unproductive labour, such as: the inspectors, the foremen, the clerks, and workers who are not directly involved in the products. However, he argues that, planning and directing, and instructing and cleaning are necessary to efficient production. It was suggested that it would be better to borrow the accounting term indirect labour to replace unproductive labour because without them there would be 'less product or no product'

Mitchell further elaborated on the essence of effective planning and directing in production. He suggests that this will lead to the effective use of materials and efficient use of energy in production. He claims that 75% of work done is wasted effort (does not contribute to the desired result by the team). It was therefore advocated that time is a vital part of production and it can be used effectively or ineffectively depending on how well the activities are planned and controlled. He concluded that organisation, planning and control, the intelligence factors are necessary for effective use of available space, available man and machine time as well as of available energy and materials.

4.2.4 Construction Production Concepts and Models

Li *et al.*, (2008) claim the manufacturing industry has made many significant improvements in both productivity and management efficiency over the last century. Comparing this to the construction industry, the improvement is far behind the manufacturing industry; thus, for many decades, the manufacturing industry has been a reference point and the source of innovation to the construction industry. Koskela (1992) and Egan (1998) recommended that construction should learn from the manufacturing sector and create a more innovative culture. Since then, researchers have been looking at manufacturing industry as a reference point to improve the construction industry; a good example is the idea of industrialisation (system building) which comes directly from manufacturing. Computer integration and automation also have their origins in manufacturing where their implementation is well ahead compared to construction. Processes, such as Supply Chain management, Partnering, Just-in-time, Project Management, and Value Engineering, were adopted from manufacturing industry into construction industry (Koskela, 1992, 2000). Researchers have also examined management and production concepts, such as Total Quality Management (TQM), Supply Chain Management, and Lean Production (Li *et al.* 2008). Koskela contributed to the establishment of Lean Construction who adopt from the concept of lean Production, whilst Latham (1994) also initiated the adoption of partnering (procurement strategy) from manufacturing sector.

The more intrinsic gaining grounds in the construction industry at the moment is the concept of lean construction (LC), which turns to challenge the existing concept of construction (Koskela 1992). Over the last two decade, the concept has been developed by International Group for Lean construction (IGLC), studies include, Koskela (1999, 2000, 2002); Howell (1999); Ballard and Howell (1994, 1998, 2000); Li *et al.* (2008), Koskela and Howell (2002). Howell (1999 p. 4) advocates that managing construction project under LC is different from the conventional practice because LC:

1. Has a clear set of objectives for the delivery process
2. Is aimed at maximising performance for customer at the project level
3. Designs concurrently product and process
4. Applies production control throughout the life of a project.

The idea behind the lean construction is to minimise waste of materials, time and effort (Howell 1999; Koskela and Howell 2002). Following the tradition of minimising waste, improving communication, reducing cost, and generating value through the process, the construction industry again fell on the manufacturing industry. In much the same time in early 1990s Hammer introduced the concept of Business Process Reengineering (BPR).

Hammer and Champy (1993 p. 2) defines reengineering as "the fundamental rethink and radical redesign of business processes to generate dramatic improvements in measures of performance such as cost, quality service and speed". They concluded that reengineering results in dramatic and sustainable improvement in performance. The idea have been echoed by many researchers including, Kim and Jang (2000). They also emphasise that, the idea of BPR is to provide means for optimising and enhancing business processes both in the product area and in administration.

Kim and Jang (2002) claim BPR seeks to perform a breakthrough strategic understanding of the process, redesigning, and value-added process, this result in sustainable improvement. Hammer and Champy (1993 p. 1 , 2) explaining the philosophy behind re-engineering stated that, re-engineering has disregarded all assumptions and traditions of the way business has always been done and instead developed a new process-centred business organisation that achieves a quantum leap forward in performance. BPR utilises components of several other tools and concepts such as System Engineering, IDEF (Integration DEFinition), Activity-Based Costing (ABC), Brainstorming workshops (BW), function economic analysis (FEA), process benchmarking (PB), customer satisfaction measurement, cross functional team building in addition to TQM of the quality movement (Kim and Jang 2002).

Besides these production concepts discussed above, there have been several protocols developed into the construction industry by researchers. The most popular and widely cited are the Royal Institute of British Architect (RIBA) plan of work, which was originally published in 1963, and British Property Federation (BPF) model (Kagioglou *et al.* 2000, RIBA 1997, Nelson *et al.* 1999). During the last decade other models, such as the Last Planner (Ballard 2000) based on lean production philosophy. GDCPP (Generic Design and Construction Process Protocol) based on its funded title construction as manufacturing process (Kagioglou *et al.* 2000; Roy *et al.* 2003) developed a reengineering construction process in the speculative house sector. Arguably, the problems within the construction are way above standardising the construction process in view of improvement. Koskela (1992) and Kagioglou *et al.*, (2000) all do agree that construction must learn from manufacturing industry, they believe caution must be taken in doing so, since, the level of maturity of both processes and practices are quite different. In addition, the structure and organisations of the industries are different.

4.3 MODELLING TECHNIQUES

The critique of process and other modelling techniques is necessitated by the need to suitably analyse and represent the work (task) flow for construction projects and the requirement for planning in order to develop a holistic planning and control (TPC) system. Two of the conventional modelling techniques in construction industry are reviewed as well as three others predominantly used in manufacturing but with good reputation in construction. Both Sanvido *et al.* (1990) and Othman (2004) agree that selecting modelling techniques are normally based on a set of criteria, which include but not limited to:

- The ability to sufficiently represent the intended functions.
- Ability to illustrate the interrelationships,
- Simple to understand and usability
- It applicability and robustness
- It credibility in that field and other fields
- Ability to adapt

4.3.1 Conventional Model Techniques

The conventional models in the construction industry are mainly process flowchart and Gantt chart. These two techniques are based on the production principles of input to give an output as illustrated in figure 4.1.

4.3.1.1 Process Flow Chart

IBM (1969 p. 1) describes flowchart as a "diagram that shows the operations performed in an information system and the sequence in which the operation are performed". Mayer (1976) reviewing 'reasoning' claims flowcharts are suitable to represent complex structure of information, where operations and sequence are represented using normally geometrics (symbols). Owing to non-standardisation in the meaning and use of specific symbols there are misunderstandings in it use, although there are some recommendations by IBM. Flowcharts are usually used for information processing.

In construction an example of flow chart is the network diagram, which was later developed into CPM (discussed in chapter 3). There mainly two types of network diagram. They are the arrow network and node network. Mubarak (2010) stressed that the popularity of the arrow network was in the 1960s and 1970s. This was then overshadowed by precedence diagram, which is an advance form node network.

Figure 4.3 illustrates the type of conventional process flow model in the construction industry. Figure 4.3a presents the arrow network; figure 4.3b describes node network and figure 4.3c illustrates a typical process flow chart.

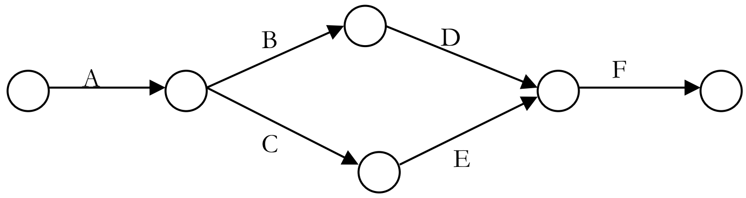
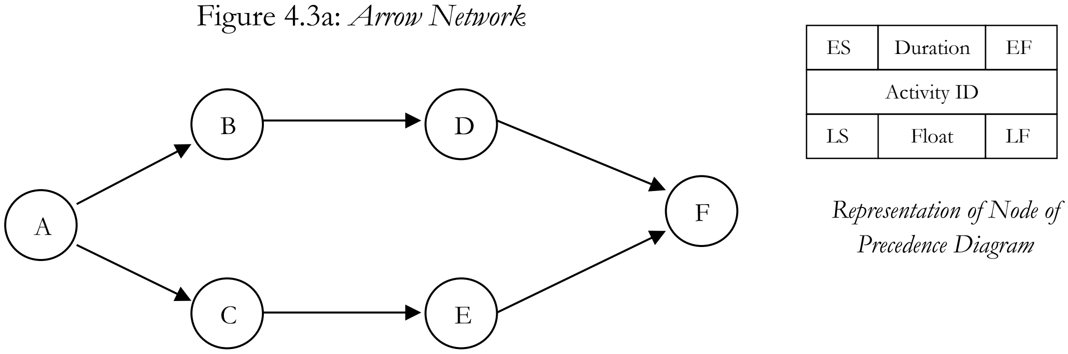


Figure 4.3a: *Arrow Network*



Representation of Node of Precedence Diagram

Figure 4.3b: *Node Network*

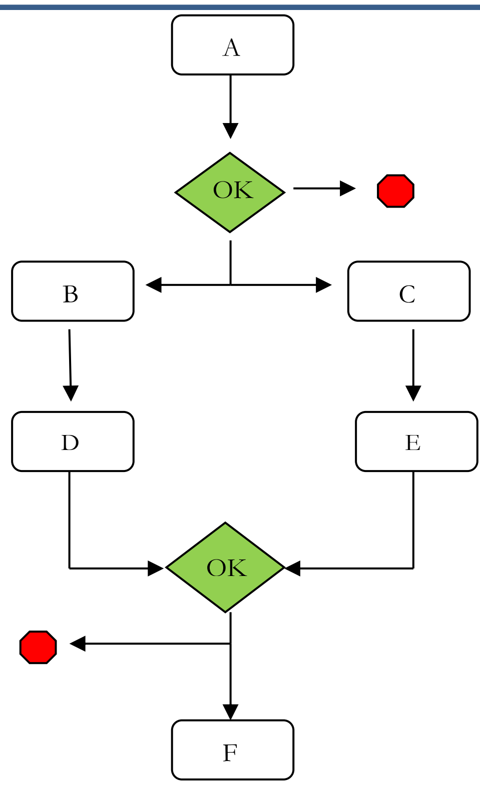


Figure 4.3c: *Process Flowchart*

Figure 4. 3: Representation of Types of Process Flowchart in Construction

The example in figures 4.3a, 4.3b and 4.3c are all describing activities A, B, C, D, E and F. Where, activity B and C precede A, D precedes B, E precedes C and F precedes D and F. (This is a simple illustration, taking Activities to represent actual construction activities).

Figure 4.3a the activity was on the arrow, whiles figure 4.3b the activity is in the node. Although in figure 4.3c the activity is in the node, there are some new symbols, such as 'OK' and 'Stop' symbols. These new symbols are for decision making; meaning if activity A is finished but it is not "OK" (accepted) both activities B and C cannot. In an occasion that activity A is not "OK" the project must stop. This is similar to activity D and E must be 'OK' before F can start. Comparing this to that of figure 4.3a and 4.3b, the necessity of completing of activity D and E before F can start is assumed but it is not explicitly shown.

As discussed in chapter three of this thesis, in all these techniques there is sequential relationship between activities (i.e. between two activities). Therefore, cannot represent the construction process and task in detail. In addition, the process flowchart (figure 4.3c) is currently unpopular in the construction industry due to the demand and complexity of construction processes.

4.3.1.2 Bar Chart (Gantt Chart)

Bar chart is another conventional technique in construction for process modelling. Mubarak (2005 p. 10) describes bar chart as "a vehicle for representing many pieces of project information". The concept of bar chart has evolved from simply showing the start and end of each activity to 'link bar chart' that also shows some resource and budget (using software). Figure 4.4 below represents a simple bar chart using the same sequence as that in figure 4.3 this technique has been discussed in detail in chapter three of this thesis.

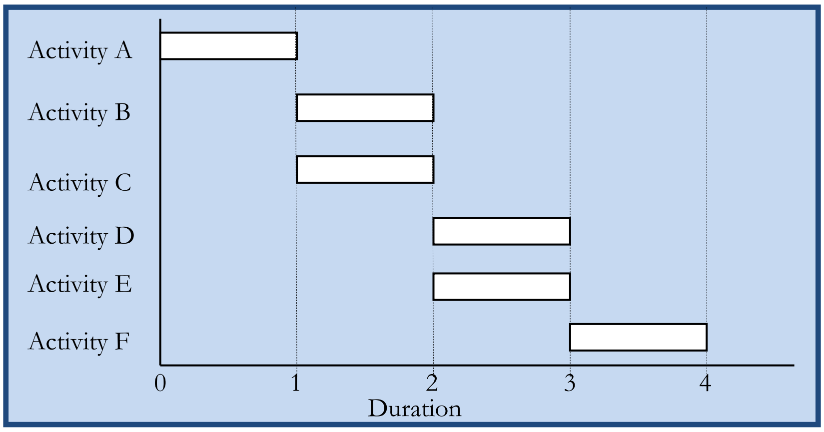


Figure 4. 4: Simple illustration of Bar chart (Gantt chart)

Figure 4.5 also illustrates a linked bar chart using Microsoft 2010. This shows the links between the activities as compared to figure 4.4 above. However, the relationship exists only between only two activities, which put it under the same category as process flow chart.

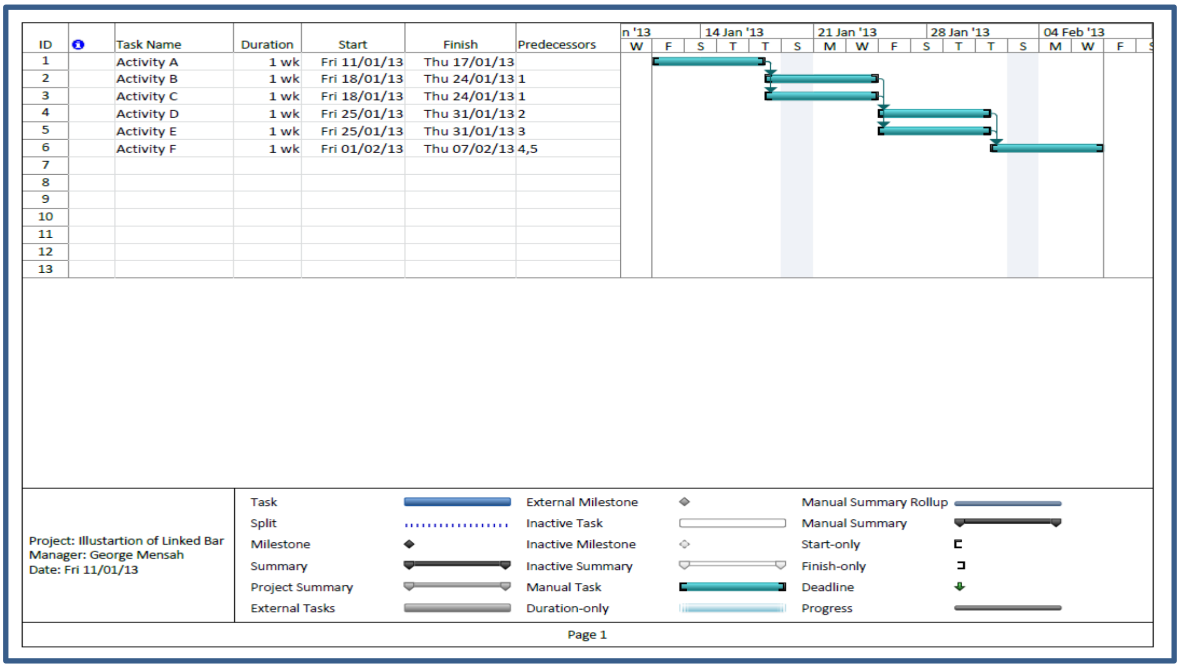


Figure 4. 5: Bar chart (Gantt chart) using Microsoft 2010

4.3.2 Contemporary Modelling Techniques

There are three main modelling techniques reviewed under this section, which are predominantly used in the manufacturing industry. These techniques are considered on the popularity and applications in the modelling as well as the applicability to transfer into the construction industry.

4.3.2.1 Hierarchy Plus – Input – Process – Output (HIPO)

According to Stay (1976), HIPO was initially developed as documentation tool. It uses diagrams to describe input, output and functions of a system and it is a system used in the top-down systems. HIPO consist of two main sections; one is the hierarchy chart, which shows how each function is divided into sub functions. This is similar to the WBS used in construction. The second is the input to process to output chart that expresses function in the hierarchy in terms of its input and output. Figure 4.6 below shows a typical example of HIPO. According to Stay (1976), and also stressed by Othman (2004), this technique lacks the capacity to display detailed information about the system.

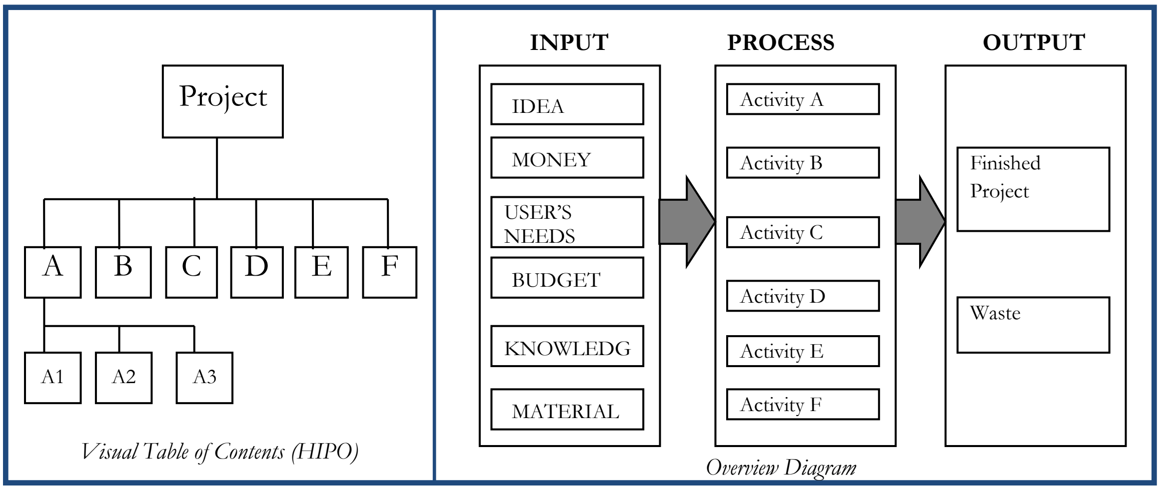


Figure 4. 6: Illustration of HIPO Model Diagram

4.3.2.2 Unified Modelling Language (UML)

Kim *et al.* (2003 p. 35) refer to UML as "a modelling language that can be used to generate computer-executable models that encode key aspects of software engineering project". It provides a set of modelling notation designed to support various domain specialism and life phases involved in the engineering system. According to Othman (2004), it is based on integrating most prominent object-oriented languages. Figure 4.7 shows an example of UML activity model for order process. UML is usually used in software engineering system. Chin *et al.* (2006) argue that UML is not a good simulation tool. According to Noran (2000), UML is in the infancy stage in business process modelling. Similarly, it is hardly cited in construction literature and industry (Othman 2004).

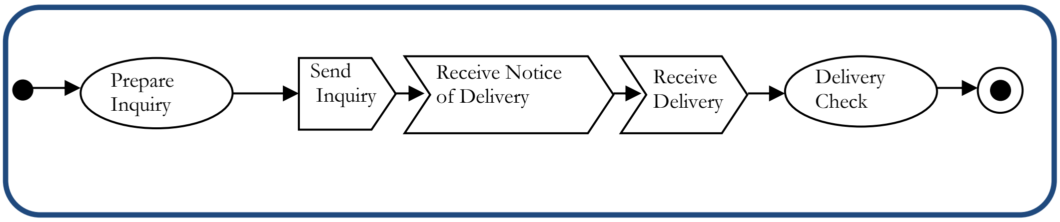


Figure 4. 7: UML Activity diagram (Order Process) (source: Noran 2000 p. 11)

4.3.2.3 Structured Analysis Design Techniques (SADT)

A SADT methodology consists of both techniques for performing system analysis and design, and a process for applying these techniques in requirements definition and system development. Both features significantly increase the productivity and effectiveness of people involved in system projects (Ross and Schoman, 1977). The two main representations of SADT are the graphical techniques and the definition of personnel roles. SADT activity model was later developed to IDEF0 model. The notation is simple, just boxes and arrows, where the boxes represent parts of whole in a precise manner, and the arrows represent interfaces between parts. This is illustrated in figure 4.8. Each box always has four arrows at the sides, that is, Input (I) Control (C), Output (O) and Mechanism (M), normally referred as ICOMs (Jongeling and Olofsson 2007), which are generally referred as ICOMs.

IDEF0 is a widely used technique for modelling. In 1993, the National Institute of Standard and Technology released IDEF0 as a standard for Function Modelling in Federation Information Process Standard (FIPS), (IDEF0 1993). Othman (2004) stressed that IDEF0 has become *de facto* in building process modelling. IDEF0 has also been discussed as a common mean of communication and it has also been applied to modelling of the construction process (Karhu *et al.*, 1997, Laitinen 1999, Karhu 2001, Karstila 2003, Othman 2004). IDEF0 allows the user to depict a view of the process or the activity (see figure 4.8).

- Inputs are resources consumed or transformed (refined) by the process
- Controls are the things guiding the process: policies, guidelines, standards, laws
- Outputs are the things created through the process
- Mechanisms are the resources required to accomplish the process such as People, tools, automation or manual requirements

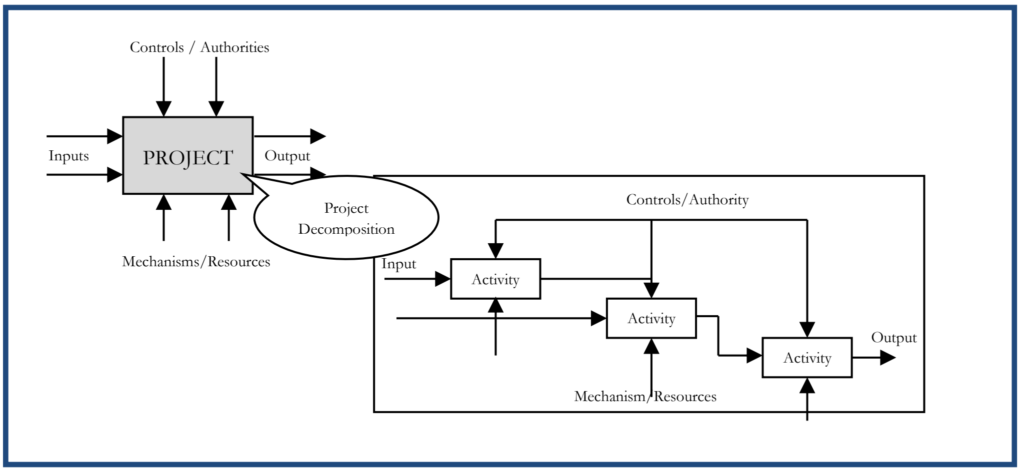


Figure 4. 8: IDEF0/SADT Notation

4.3.3 Consideration of a Modelling Technique

All the techniques discussed above (both conventional and contemporary techniques) have the ability to be used to represent a holistic planning and control data to be collected. However, IDEF0 model was considered and chosen as the appropriate analytical and modelling tool for this study because of the following:

- IDEF0 is general and applicable to any situation because it is unlike mathematical or logical methodologies or even programmes. IDEF0 methodology does not solve problems but provides tools that allow people to understand, express, manipulate and check problem elements.

- It facilitate the development of a holistic model due to the elaborated information required to perform a function or activity such as ICOM (Othman 2004)
- The use of graphical portrayal is a powerful means of representing the deliverables and how they connect or link with each other.
- It is well tested and proven through many years of use in many industries and it is easy to learn and user-friendly.
- The fundamental problem, which led to the development of IDEF0 as, stated below is no different from the current problems associated with construction projects. "*The assertion that a problem unstated is a problem unsolved" seems to have escaped many builders…All too often, design and implementation begins before the real needs and system function are fully known. The results are skyrocketing costs, missed schedule, waste and duplication, disgruntled users and endless series of patches and repairs euphemistically called "system maintenance*" – (Ross and Schoman 1977)
- It is superior to many other functional modelling methodologies in terms of simple graphics, conciseness, rigor and precision, consistent methodology, level of abstraction and separation of organisation from function (Ang *et al.* 1999)
- The US Defence, the original reference point for conventional project management techniques, when they sought to increase their productivity they developed IDEF0. Yet, the construction industry has failed to explore its adaptability, although there are few studies in construction management.

4.4 INTEGRATED DEFINITION ZERO (IDEF0) MODEL

This section discusses the representation and further critique of selected modelling and analytical technique, the IDEF0 model.

4.4.1 Background of IDEF0

Douglas T. Ross and colleagues originally developed IDEF0 in the 1970s. Douglas was the chairman of SoftTech and head of Computer Applications Group at Massachusetts Institute of Technology (MIT). Due to his background in Mathematics, Electrical Engineering and Computer Science, his interest was in the software development process, including methodology, theory, and tool development (Ross 1985). He is also renowned for the introduction of the Computer Aided Design (CAD), which was further developed and largely used in the construction industry (Ross and Ward 1968).

In the late 1980s, the US Air-force introduced a programme for Integrated Computer Aided Manufacturing (ICAM). The ICAM programme identified the need for better analysis and communication techniques for people involved in improving productivity. ICAM sought to increase manufacturing productivity through systematic application of computer technology. Accordingly, a series of techniques known as IDEF techniques were developed including IDEF0, which was adapted from SADT (IDEF0 1993 Whiteman, *et al.* 1997; Brown, 2002; Rajala *et al.* 1997). Each of these different IDEF techniques is useful for describing a particular perspective of an activity or process.

There are basically 15 different IDEF techniques (1 to 14 including IDEF1x) discussed in literature. These are illustrated in table 4.1 below. The commonly used are IDEF0 to IDEF3, from 6 to 14 are under development.

Table 4. 1: Types of IDEF Techniques in Literature

<table>
<tr><th>Model</th><th>Description</th><th>Definition</th></tr>
<tr><td>IDEF0</td><td>Functional and Activity model</td><td>used to produce structured representation of the functions, activities or processes within the modelled system or subject area</td></tr>
<tr><td>IDEF1</td><td>Information modelling</td><td>used to produce an “information model”. An information model represents the structure and semantics of information within the modelled system or subject area</td></tr>
<tr><td>IDEF1x</td><td>Data Modelling</td><td>Similar to that of IDEF1</td></tr>
<tr><td>IDEF2</td><td>Dynamic modelling method for simulation</td><td>used to produce a “dynamics model”. A dynamics model represents the time-varying behavioural characteristics of the modelled system or subject</td></tr>
<tr><td>IDEF3</td><td>Process description capture</td><td rowspan="12">Model 6 to 14 of the IDEF family have not been developed in depth. (Noran, 2000)</td></tr>
<tr><td>IDEF4</td><td>Object oriented design</td></tr>
<tr><td>IDEF5</td><td>Ontology capture</td></tr>
<tr><td>IDEF6</td><td>Design Rationale Capture</td></tr>
<tr><td>IDEF7</td><td></td></tr>
<tr><td>IDEF8</td><td>User Interface Modelling</td></tr>
<tr><td>IDEF9</td><td>Scenario-Driven is deign</td></tr>
<tr><td>IDEF10</td><td>Implementation Architecture Modelling</td></tr>
<tr><td>IDEF11</td><td>Information Artefact Modelling</td></tr>
<tr><td>IDEF12</td><td>Organisation Modelling</td></tr>
<tr><td>IDEF13</td><td>Three Schema Mapping Design</td></tr>
<tr><td>IDEF14</td><td>Network Design</td></tr>
<tr><td>NOTE</td><td colspan="2">14 have not been developed further</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">Further readings: Healy et. al 1997; Liu et al. 2009; Brown 2002; Noran, 2000 ; IDEF, 1997; IDEF01993</td></tr>
</table>

This research concentrates on the concept, methodology and application of IDEF0 model. Noran (2000 p. 16) claims that IDEF0 methodology was initially intended for use in systems engineering. Therefore, there is the importance to understand IDEF0 in details as presented in the next section.

4.4.2 What is IDEF0?

IDEF0 originated from the concept of Structural Analysis (SA) for Requirement Definition (RD). RD is to carefully assess, *why* a system is need, *what* system, *how* a system is to be constructed. Thus RD deals with three subjects: Context analysis (why), Function specification (what) and Design constraints (How). Through this RD led to the development of the SADT.

According to Rajala *et al.* (1997), IDEF0 modelling is an engineering technique for performing and managing needs analysis, process analysis, benefits analysis, requirements definition, functional analysis, system design, maintenance and baselines for continuous improvement. Brown (2002) also describes IDEF0 as a modelling technique based on combined graphics and text that are presented in organised and systematic way to gain understanding, support analysis, provide logic for potential changes, and specify requirements or support system level design and integrated activities. According to Liu *et al.* (2009) citing Khoo *et al.* (1998), IDEF0 is a method used to produce a function model, which is a complex manufacturing or production, function relationship hierarchically. It was further asserted that, IDEF0 definition systems is a set of activities that takes certain input and use some mechanism, subject to certain controls, transform those inputs into outputs. They concluded by citing Hernandez-Matias *et al.* (2006) that, IDEF0 is a function model that could be used to model relationships among various activities. In broader terms, this study describes IDEF0 as a set of directives for understanding and representing complex production system.

According to Othman (2004), IDEF0 model is easy to understand because they show processes in the same way that individuals naturally think about them. Again, IDEF0 model decompose processes into sub-processes and product flows, in much the same way that professionals think of tasks that have been set at workable levels, and will also think in terms of product deliverable.

Noran (2000) claims that one of the very essential concepts in IDEF0 model is the abstraction from time. He stressed that, "IDEF0 diagram show activation of activities, not flow (sequence)". Again he by stating that ICOMs are able to show the activity activation constraints, but neither what signals the process completion, nor the conditions for the process to actually start.

4.4.3 Main Concepts and Conceptual diffusion of IDEF0 Model

An IDEF0 model is composed of a hierarchical series of diagrams that gradually display increasing levels of detail describing functions and their interfaces within the context of a system (see figure 4.8). In order to express real-life manufacturing operations, boxes may be interpreted as operating with other boxes with interface arrows providing "constraints" as to when and how operations are triggered and controlled (El-Desouki and Hosny, 2005). The IDEF0 concept is designed to enhance communication:

- Diagrams based upon simple box and arrow graphics.
- English text to specify box (function) and arrow (data or objects) meanings.
- Gradual exposition of detail, featuring a hierarchy with major functions at the top and successive levels of sub-functions revealing well-bounded detail breakout.
- A node index for details within the hierarchic structure of diagrams.
- Limitation of detail on each successive diagram to not more than six sub-functions for ease of reader comprehension.
- Diagrams supported with text and glossary to increase the preciseness of the graphic representation.

According to IDEF0 (1993), IDEF0 has the following characteristics:

- It is comprehensive and expressive, capable of graphically representing a wide variety of business, manufacturing and other types of enterprise operations to any level of detail.
- It is a coherent and simple language, providing for rigorous and precise expression and promoting consistency of usage and interpretation.
- It enhances communication between systems analysts, developers and users through ease of learning and its emphasis on hierarchical exposition of detail.
- It is well tested and proven, through many years of use in Air Force and other government projects and by private industry.
- It can be generated by a variety of computer graphics tools; numerous commercial products specifically support development and analysis of IDEF0 diagrams.
- In addition to definition of the IDEF0 language, the IDEF0 methodology also prescribes procedures and techniques for developing and interpreting models, including ones for data gathering, diagram construction, review cycles and documentation.

4.4.3.1 Diffusion of IDEF0

IDEF0 model has it origin in the US Defence, specifically US Air force. IDEF0 was initially developed for designing and implementing engineering systems, then used largely used for computer-aided manufacturing. IDEF0 is the main technique used in BPR for redesigning processes to obtain sustained improvements in the output of manufacturing (Liu *et al.* 2009). In addition, IDEF0 was defined as an activity-based modelling technique for modelling the activities and information flows in a manufacturing or production system. In 1993, IDEF0 was accepted as Federal Information Processing Standard (FIPS) in the USA. IDEF0 has been widely used in many other industries, especially in the aerospace, information technology and manufacturing sectors. Notwithstanding, it has also been used in other unconventional manufacturing sections, which include medical research, construction and engineering industry. Table 4.2 shows the diffusion of IDEF0 model in industries that is observed in literature. Many other researchers used the concept of IDEF0 but refer to it as ICOM mode, examples include, Vonderembse and White (1991, 2003) and Maylor (2010). In fact, it is stressed by Othman (2004), IDEF0 has become the *de facto* of process modelling.

Table 4. 2: Representation of diffusion of IDEF0 model in industrials

AUTHOR(S)	DESCRIPTION OF USE OF IDEF0	COUNTRY AND INDUSTRY
US Defence		
Ross and Schoman (1977)	Comprehensive discussion, uses and application of SADT	USA, Computer Applications System
Ross (1985)	Discussed applications and extensions of SADT	USA, General review and discussion, Database engineering
IDEF0 (1993) other cite as FPIS (1993)	Comprehensive manual of IDEF0 (The standard manual). This manual is based on ICAM publication in 1981.	USA, Software Standard, Modelling Techniques
Preston and Wettach (1984)	Quality assurance models	USA, Aerospace (Airframe industry)
Marca and McGowan (1988 p. 335-354)	Description of Training system	USA, Army
Computer Integrated Manufacturing		
Colquhoun *et al.* (2007) originally published 1988	Discussed the use of IDEF0 to link Design and Manufacturing in a CIM environment	UK , CIM, Manufacturing
Colquhoun and Baines (2001) originally published in 1991	Discusses the uses of IDEF0. The use of IDEF0 as process planning in manufacturing	UK (General review) Computer Integrated Manufacturing
Gingele *et al.* (2002)	Use IDEF0 as standard for modelling Operation business processes. IDEF0 is proof to be the appropriate method for business process re-engineering	UK, Computer, Manufacturing
Manufacturing		
Guinet (1990)	IDEF0 used for Foundry production systems	USA, Manufacturing

Kusiak *et al.* (1993)	Discusses IDEF0 and IDEF3 as the comprehensive tool to reengineering design and manufacturing process	USA, Manufacturing
Presley and Liles (1995)	Discusses the use of IDEF0 for Design and Specification of methodologies	USA, Manufacturing
Greswell *et al.* 1995	A study into formulation and implementation of improvement initiatives and the link to manufacturing strategy at a major UK manufacturing company. IDEF0 was used and discussed with 7 management and planning tools which originated from the Japanese Society for Quality Circles Techniques Development	UK, Manufacturing
Khoo *et al.* (1998)	IDEF0 was adapted to perform manufacturing diagnosis. Discussed the use and previous application of IDEF0	Singapore, Manufacturing
O'Donnell and Duffy (2002)	Use IDEF0 to analysis the performance at the project or program level	UK, Manufacturing
Kim and Jang (2002)	Discusses IDEF0 and uses it to modelling in Design performance analysis in BPR. (designing the product of television manufacturing company)	South Korea, Manufacturing
Ijomah and Childe (2007)	Discuss IDEF0 among other manufacturing models but IDEF0 was found to be the ideal method	UK, Manufacturing
Liu *et al.* (2009)	An object-oriented approached based on IDEF0	China, Manufacturing
Tsironis *et al.* (2009)	Discuss, evaluate and suggest improvement to IDEF0 modelling language.	Greece, Manufacturing
Rozali R., *et al.* (2010)	Propose the use of IDEF0 to system modelling. It used IDEF0 for describing functional requirements of a system.	Malaysia, Manufacturing
Al-Turki and Faris (2010)	Use IDEF0 to analyse and modelling manufacture process, case study on car door manufacturing plant	Malaysia, Manufacturing
Selected Other Industrials		
Sanvido *et al.* (1990)	IDEF0 is used to describe idealised owner's functions and their relationship with the construction process.	USA, Construction
Lindquist (1992),	Use to methodology describe and improve cheque-processing operations	USA, Bank
Pesek (1993)	Methodology to describe cash management and wholesale lockbox systems	USA, Bank
Congram and Epelman (1995)	Detail discussion of SADT and it successful applications. IDEF0 was used to describe services process.	USA, Service Management
Ohboshi *et al.* (1998)	Used IDEF0 to study medical emergency workflow.	Japan, Medical
Chin *et al.* (2006),	Used IDEF0 for a study on mould-making processes	Hong Kong, Mould-Making

4.4.4 Previous Application of IDEF0 model

IDEF0 is a widely used technique for the structured analysis and design of systems. It is used in improving the productivity and communications in computer integrated manufacturing systems. IDEF0 has been applied successfully in hundreds of projects involving thousands of people in diverse industries as aerospace, telecommunications, and software development (Congram and Epelman 1995). Colquhoun *et al.*, (1993), Congram and Epelman (1995), Kim and Jang (2002), Presley and Liles (1995), and IDEF0 (1993) provide a comprehensive discussion on the use of IDEF0 in developing manufacturing-oriented models and its success. It has been discussed widely as a tool for BPR. Presley and Lies (1995) discuss applications of IDEF0 for design and specification of methodologies. The BPR modelling approaches reviewed by Gingele *et al.*, (2002) conclude that only IDEF completely supports the criteria. Similarly, Cheng-Leong *et al.*'s (1999) development of manufacturing enterprise systems identifies some weakness in the traditional model approaches and advocates the use of IDEF techniques. Greswell *et al.*, (1995) used IDEF0 to formulate and implement an improvement initiative in a major UK manufacturing company. Chin *et al.*, (2006) used IDEF0 together with the colour Petri nets model to mould-making processes. Jongeling and Olofsson (2007) used IDEF0 model to describe their process to develop a model for workflow using 4D. Ohboshi *et al.*, (1998) used IDEF0 to understand the medical emergency workflow. They concluded that the IDEF0 model holds promise as a method having the capacity of reproducing and designing systems like a Hospital Information System. IDEF0 has also been used in construction, albeit not as much as in manufacturing.

4.5.4.1 Application of IDEF0 in Construction Literature

Sanvido *et al.* (1990) are one of the preliminary studies to apply IDEF0 in the construction industry. Table 4.3 shows some major application of IDEF0 in the construction literature. Sanvido *et al.* (1990) used to describe idealised owner's functions and their relationship with the construction process and owing to the success of their study other researchers follow suit. IDEF0 has also been discussed as a common means of communication and it has also been applied to modelling of the construction process in Finland (Karhu *et al.*, 1997, Laitinen 1999, Karhu 2001, Karstila 2003). Austin *et al.*, (2002) adopted IDEF0 to represent the process in the development ADePT. Generic Design and Construction Process Protocol (GDCPP) considered the use of IDEF0 for the 'as is' process because of the successful use of the model to represent processes (especially for Sanvido's Integrated Building Process Model) (Kagioglou *et al.*, 2000). Although it was claimed that the partners of the study preferred to concentrate on the general principles of the process rather than the details of the activities involved. Congram and Epelman (1995) established that IDEF0 methodology is flexible and it is recommended for adaptation for services. O'Donnell and Duffy (2002) adopted IDEF0 model as the tool for measuring and analysing design performance in engineering and construction design. They agree that, although IDEF0 does not explicitly represent the element of performance, it focuses on knowledge in design.

Table 4. 3: Review on the application of IDEF0 in Construction Literature

Author(s)	Application	Country of the study
Sanvido *et al.* (1990)	IDEF0 is used to describe idealised owner's functions and their relationship with the construction process.	USA
Messner and Savido (1994)	Used IDEF0 to analyse the structure for decision making in construction organisations	USA
Bjork (1997)	Use to model and analyse construction information	Finland
Karhu *et al.* (1997)	improved co-ordination and performance of the building using IDEF to analyse and model the overall construction processes systematically	Finland
Laitinen (1999)	Information data management in B&D Construction company. He concluded that he found proof of the usefulness of IDEF0 model in construction industry	Finland
Ballard (2000)	suggested modification to the LPS by suggesting activity definition model, which he adapted from IDEF technique	UK, PhD
Kagioglou *et al.* (2000)	Initial consideration to use IDEF0 for the development of GDCPP due to its successful representation of processes	UK
Karhu (2000)	Used IDEF0 to aid in developing GEPM (Generic Process Modelling Method) Other method used was Scheduling and simple flow method – construction process.	Finland
Koskela (2000)	Used IDEF0 to represent and analyse the concept of value generation	Finland, PhD
Karhu (2001)	Reviewed process modelling and use IDEF0 for construction process model. She argues that IDEF0 is closely associated with process.	Finland
O'Donnell and Duffy (2002)	Measure the design performance in engineering and construction design adopted IDEF0 model as the tool for measuring and analysing design performance	UK, (Designing performance of product)
Austin *et al.* 2000, 2002	Use adopted IDEF0 to represent the process in the development Analytical Design Planning Technique (ADePT).	UK
Karhu (2003)	Used for a view based construction process modelling	Finland
El-Desouki and Honsy (2005)	Workflow automation (Information technology) through Value Analysis. Use IDEF0 to analyse the Value Analysis process. This resulted in 50% to 80% improvement in operation efficiency and process improvement	Egypt
Finne (2006)	Used for Construction Value chain. The role of middlemen, or infomediaries in delivering value for their customer was explored.	Finland
Jongeling and Olofsson (2007)	IDEF0 is used to describe their proposed model of location-based scheduling and 4D CAD. This is a response in managing workflow.	Sweden
Maylor (2010)	Represent project as conversion process using IDEF0; however, referred to as ICOM model	UK, Book

4.4.5 Limitations of using IDEF0

According to Chin *et al.* (2006), IDEF0 modelling gives clear description about input information, output information, resources, and constraints of process concerned in a hierarchical and systematic way, thus it was employed in his research in the mould-making. They argue that IDEF0 methodology is based on informational notation, and it is static and qualitative, which lacks mathematical rigor in their application to mould making. Nonetheless, they acknowledged that IDEF0 improves quality and productivity, thus the competitiveness of the products in the industry. Healy *et al.* (1997) stated that static models are used to understand enterprise or system.

Both Razali *et al.* (2010) and Tsironis *et al.* (2009) argue that parallel processes are not visible to an IDEF0 model and often people misinterpreted the arrows and lines as representing a sequence of activities, which is contrary to initial concept of IDEF0. They all agree that IDEF0 is excellent at showing function requirements.

4.4.6 Adaptation of IDEF0 for Planning Modelling Technique

IDEF0 has been discussed extensively and used in many industries, albeit not as much in the construction industry. The review indicates that none of studies have explored or adapted IDEF0 as modelling for project planning technique. This could be due to its inability to represent parallel activities and the 'output arrows' not meant to represent sequence of activities. Nonetheless, the basic problem that drove the development of SADT (IDEF0) as stated below is no different from the problems associated with construction projects.

"The assertions that "a problem unstated is a problem unsolved" seem to have escaped many builders…All too often, design and implementation begins before the real needs and system function are fully known. The results are skyrocketing costs, missed scheduled, waste and duplication, disgruntled users and endless series of patches and repairs euphemistically called "system maintenance" – (Ross and Schoman 1977)

The hypothesis is if "planning should answer these questions, *what* should be done (activities), *how* should activities be performed (method), *who* should perform each activity and with *what* means (resources) and *when* should activities be performed, and IDEF0 was developed to answers *why, what* and *how* questions", then IDEF0 is considered as the appropriate modelling technique to develop a holistic project planning and control technique. Ross and Schoman (1977) suggest that IDEF0 is for planning, managing, and assessing engineering systems. Again, Colquhoun and Baines (1991) found IDEF0 to be a powerful tool that offers a number of features, which makes it easy to apply, and most importantly to understand.

4.5 CONCLUSION

The core of this chapter focuses on construction as a particular type of production system and the appropriate modelling technique to be adapted for this study. The importance of this review is to understand construction as production which aids in subsequent adaptation from manufacturing and this is good because manufacturing has been a reference point for the construction industry. The review indicates that although construction is a type of production system, it has many different characteristics and processes as compared to other production systems. Consecutively, this study suggests construction project production is *the operations of building to meet a specific need/want within explicit boundaries.*

The review indicates that planning and control are essential parts of production system; this makes production modelling techniques an essential part of planning. The review establishes that learning from manufacturing must be done with caution, due to the level of maturity of both processes, the practices are quite different, the production type, and the structure and organisations of the industries which are different. This necessitated the review of both conventional and contemporary modelling techniques applicable to construction. IDEF0 was considered appropriate for this study, its detailed review demonstrates that it is widely used for function modelling in many industries; albeit not as much as in construction. It has also been used in the Finland and USA construction industries for modelling construction project, and understanding communication. IDEF0 has not been explored in terms of planning, perhaps, because of its limitation of representing parallel activities or due to its arrows not used to represent sequence of activities. Notwithstanding, it has the potential to be explored as the basis to developed a holistic planning and control technique particularly for the construction industry.

The questions to be further examined as a result of this review are

- What is the understanding of practitioners about construction as a production
- What is the knowledge and understanding of the UK practitioners on IDEF0

CHAPTER FIVE: PROJECT MANAGEMENT THEORY

5.1 INTRODUCTION

This chapter reviews the theories that underpin PM implicitly and explicitly. In construction PM, there is no single theory agreed by both researchers and practitioners as the prescribed theory. Even among practitioners, the concept of theory does not sit comfortably. Some use the word 'theory' to suggest that, although the idea may be good, its application maybe debatable. In more sensible terms, theoretical is not necessarily practical. Notwithstanding, this non-consensus of theories, scientific management, Koskela's TFV theory and complexity theory were reviewed as they implicitly and explicitly underlay the practice. Wells (2007 p. 9) stated that there is "no theory without practice and no practice without theory…".

These theories are reviewed because (1) the conventional project management and its planning techniques are based on scientific management theory, (2) Construction projects have generally been described as complex and that the understanding of complexity theory and how it relates to construction project is important, and (3) Koskela argues that the underlying theory for PM is obsolete, thus introducing a single TFV theory, which has currently been cited especially by lean constructionists[18].

Therefore, this chapter first presents the concept of scientific management as being the foundation of many construction planning techniques. This is followed with a discussion of complexity theory. The introduction of this concept challenged the scientific management theory, thus, a presentation is given on their differences. The TFV theory that was introduced in the 1990s is also discussed as it claimed the existing theory was obsolete. This chapter is concluded with a commentary on this study's assumptions.

5.2 SCIENTIFIC MANAGEMENT THEORY

Scientific Management theory was developed by Fredrick Winslow Taylor (1865-1915). Scientific management is also referred to as "task management" by Taylor (p. 30). Thompson (2003) claims that perhaps one important part of scientific management concept is the task idea of planning.

[18] www.iglc.org

Before Taylor's introduction of the scientific management theory, there were no performance standards and labour output standards. As a result, he introduces time and motion study to determine time, cost and quality (TCQ) of work. This has since been the performance indicator, success criteria and management model in contemporary PM practice (this is discussed in chapter 2 of this thesis). Taylor suggests that for maximum output of workers and machines the following principles of scientific management should be followed.

Incentive: Giving the employee what he/she most wants, i.e., money, and vice versa giving the employer what he/she most wants, i.e., lower labour cost of production. (p. 10). Taylor asserts that employers usually want more work with less cost, which he thinks is impossible. Rather, more work, more money and vice versa. He agrees that in the case of complicated manufacturing settings, the employees wage could also be determined by their competitors.

Training: Management[19] should train the employees so that they can do the highest class of work they can do based on their abilities. That is the training should enable the employees to work at a faster pace with maximum efficiency (p. 12).

Responsibility: For stability in the work process, there should be equal distribution of work among the workers and the management. This allows managers to concentrate on the management, while the worker also focuses on the task. Taylor believes that this brings personal teamwork between the workers and management, which he calls 'task management'. He believes that this will also enhance productivity as well as profits.

Planning: Taylor suggests management should lead planning because management have the scientific data, therefore allowing the workers to do their tasks. The planning should be conducted by breaking down the work and the labour. Activity should precede the other activities. He stressed that planning should be done at least a day in advance and it should be communicated in writing. The planning should cover what should be done, how it should be done and the time allowed for it to be done. The task should be executed by the required trade. The condition he emphasises is that, if the trade and the management do the task right within the time required, both will take an incentive. He cautioned that management should ensure that workers' health is not in danger when assigning them a task.

[19] Management include superintendents and foremen who Taylor refers to as first class trades.

5.2.1 Scientific Management, and Planning and Control

The scientific management theory is a dominant force behind the conventional planning and control techniques (discussed in chapter 3). This theory led to several methods and studies, predominantly, work study (motion study[20], time and method study, and work measurement), work scheduling (Gantt chart) and CPM/PERT. Scientific management assumptions are to measure, observe and experiment comparison, incentives, and standardising both methods and conditions. Darwin (1996 p. 24) argues that, although scientific management is not wrong, it is limited. Again, critics argue that scientific management is rooted in the Newtonian type of management concept in a broader sense, where Newtonian management believes that the process of manufacturing is a linear process (Darwin 1996, Geyer 2003 and DeCarlo 2004). They argue that scientific management theory assumes process to be a linear one; however, not all processes are orderly, reducible, predictable and determinism as per the Newtonian system (Geyer 2003 p. 4). This was not to condemn the theory, but rather to introduce a discovery that not all processes are linear. Accordingly, a new theory emerged, i.e. complexity theory, which is discussed below.

5.3 COMPLEXITY THEORY

Contrary to the linear process and stability in Newtonian, chaos and uncertainty are the standards of complexity theory. Complexity is more concerned about parts, relationships and the environment. Complexity is non-linear phenomenon and one of the first people to study non-linear, complex, systems is Edward Lorenz. In 1961, Lorenz developed a computer programme for modelling weather system (Gayer 2003 p. 6). Since then, there have been many similar concepts arising from other disciplines including, the pure sciences (biology, physics and chemistry), mathematics, computer and social sciences (Mitleton-Kelly 1997, Mitleton-Kelly 2000, Gayer 2003, and Peltoniemi and Vuori 2004). These studies focus more on the social sciences prospective. Baccarini (1996 p. 201) establishes that complexity plays a major role in PM as he argues that complexity:

- Helps in establishing planning, coordination and control requirements
- Hinders the clear identification of goals and objectives of the project
- Is an essential criteria for selecting a suitable project organisational form

[20] Developed by Frank and Lillian Gilbreth (Husband and wife)

- Influences the selection of project inputs, for example, the expertise and experience requirements of management personnel.
- Used as a selecting criteria for suitable project procurement strategy.
- Affect TCQ requirement of a project and complexity is directly proportionate to time and cost.

In the review of complexity, Mitleton-Kelly (2000) established that there is no single theory for complexity, but many of these theories emerged from various sciences of complexity. Therefore, complexity in the context of social sciences is limited as compared to its contribution in natural sciences (Peltoniemi and Vuori 2004). Complexity has also been discussed in construction literature (Bertelsen, 2003, Bertelsen and Koskela 2005, Baccarini 1996, Ireland 2007, and Bertelsen *et al.* 2007). The question asked is what is complexity? The next section discusses the understanding of complexity as a theory.

5.3.1 What is Complexity?

The word 'complex' originated from a Latin word *'complexus'* meaning "group of related element". The Oxford dictionary defined complex as "consisting of many different and connecting parts". This means the term complexity is mainly concerned with relationship of elements or parts. In terms of this study and PM, it is more concerned with the relationship between activities, which opposes the perceived linear relationship.

There is no accepted definition for complexity because it is relatively new (Bertelsen 2003). Bertelsen (2003) asserts that the widely publicised definition includes the 'edge of chaos'. Yet, Baccarini (1996 p. 202) defines complexity in terms of project as "consisting of many varied interrelated parts and can be operationalized in terms of differentiation and interdependency". Mitleton-Kelly (2000 p. 25) argues that complexity is associated with inter-connectivity of elements within a system. She claims that complexity "arises from the inter-relationship, inter-action and inter-connectivity of elements within a system and between a system and its environment".

Therefore, in PM context, complexity is the inter-relationship of activities, inter-action of actors and the inter-connectivity to the real-word of the project and its environment.

5.3.2 Complexity in Construction production

Baccarini (1996 p. 201), who is one of the pioneers to explicitly discusses the concept of complexity in construction management literature, describes construction as complex after the

Second World War; therefore necessitated the adoption of complexity theory. In addition, construction projects have been described as complex and dynamic by numerous researchers in the field. Chan *et al.* (2004 p. 153) argue that this is due to increasing uncertainties in technology, budgets and development of process. Baccarini (1996) argues that understanding complexity is vital, because PM literature and societies fail to explicitly state the type of complexity within a project. Construction is characterised by temporary team, relational activities and different environmental condition.

5.3.2.1 Temporary team

Most construction projects are undertaken by several people from different disciplines made up of different actors (stake holders), thus social actors (people) are one of the main drivers to every construction projects. These people are normally temporarily assembled for a particular project, which makes inter-action of these people very vital to expose communication barriers from complexity stands. Dainty (2008) elaborates on the problem of communication within the construction industry. Similarly, BSI (2010) established that, lack of communication within the UK construction industry costs the industry over £20 billion annually. Therefore, from complexity stance, the relationship between the actors is a non-linear process.

5.3.2.2 Relational Activities

The activities that exist in construction are more relational than linear. The relationship between activities in techniques, such as CPM and Gantt chart are normally between two activities, i.e. input and output relationship (discussed in chapter 3 of this thesis). From complexity stance, the inter-relationship between activities is not only linear or orderly but some relationships are non-linear. Bertelsen (2003) argues that construction is normally seen as linear and simple; however, he believes that it is a complex phenomenon. He claims the schedule presents an idealised linear project of what should take place. Egan (1998, 2002) describes construction as fragmented, thus from complexity stance there is a need of relationship between activities.

5.3.2.3 Differential Environmental condition

The differential environmental condition is notwithstanding one of the important part of complexity concept that has been neglected in literature. Although few studies in construction PM have discussed some types of complexity in construction, none of them have discussed the complex environmental condition. For example, Ireland (2007) divided the complexity of a project into technical and management complexity, which focuses on the team and processes, including technology (discussed above). Bertelsen (2003) focuses on the process, i.e. the relationships between the activities discussed above.

Baccarini (1996) suggests that complexity must be applicable to environment as well as organisation, technology, information decision making and system. He, however, discusses only organisational and technological complexity, and its integration. Construction projects are exposed to different environment such, as weather and local social environment. From both natural science and social science perspective of complexity, the stress of system environment was equally important (Peltoniemi and Vuori 2004, Gayer 2003, and Mitleton-Kelly 2000).

Construction is contrary to that of traditional manufacturing, where productions is done in a controlled or refined environment and value is standardised regardless of the local social actors. Gayer (2003 p. 15) argues this assumption is flawed, because humanity and its environment are not necessarily linear or ordered. In complexity stance, the environment must be considered in understanding a project.

5.3.3 Complexity, and Project Planning and Control

There is a misunderstanding that complexity is seen as a chaos concept, thus written project planning may not be necessary under complexity (DeCarlo 2004). DeCarlo (2004) introduces what he called eXtreme PM (also termed agile), in which he advocates the use of Just-In-Time planning. In his approach, he specified that "the manager shoot the gun and attempt to redirect the bullet" (DeCarlo 2004 p. 7). The managing procedure of this approach is leading and dictated by only the leader. Not surprising, the author's argument was driven from IT project, thus could be concluded that it might not be the case in construction project settings. Mitleton-Kelly (2000 p. 27) argues that although chaos and complexity are used interchangeably, they are different, especially in their application to social systems. She argues that although they are identical, chaos is founded on iterative principles.

Geyer (2003 p. 15) argues that complexity is not to condemn the existing concept of planning but to bridge the gap between the natural sciences (scientific management theory) and the social sciences (the importance of humans in planning and control). He argues that the importance of complexity theory is that both physical and social realities are made up of wide range of interacting order, complex and disorder phenomena. He concluded (in p. 17) that it is the bridge of the natural and human sciences without favouring one above the other.

Bertelsen and Koskela (2005 p. 69) in the attempt to improve planning and control, introduce four strategies. These strategies are (1) build in buffers (slack) for absorbing the impact of complexity. (2) reducing the complexity from an operational point of view, i.e. using the same team for more than one project. (3) codify the procedures to be used and train in performing these procedures under stress, i.e. increasing the techniques capabilities to deal with complex situation; and (4) improve the system's own capability to act on the given tasks without orders from management, i.e. increasing reliability in the individual agents and distribution control.

Bertelsen *et al.* (2007) suggest the management of construction process under complexity is to improve the flows. Similarly, Ireland (2007 p. 3) concludes that complexity is used in project only when it is necessary and he advises not to use it frequently. He states that:

"some elements of complexity may be addressed through risk management; however, it is helpful to established [sic] the degree of complexity that must be addressed during the implementation of any project. Higher complex projects require special consideration during the planning to anticipate the approach taken and the possible results if something is not done. Whereas risk management addresses failure and consequence, complexity focuses more on the degree of difficulty to implement a project"

Baccarini (1996), Ireland (2007), and Bertelsen and Koskela (2005) agree that complexity aids in better project planning and control, and thus addressing complexity is essential to planning and control projects. This means that planning techniques should incorporate complexity and also aids in identifying the complex related functions.

The introduction and acceptance of complexity in other sense has brought pluralism of implicit theories in construction PM, thus Koskela in the 1990s introduced a parallel concept, TFV, which is discussed below.

5.4 TRANSFORMATION, FLOW AND VALUE (TFV) THEORY

In developing TFV theory, construction PM falls into manufacturing industry, mainly Lean Production (Toyota). The TFV theory was partly introduced in the 1990s by Koskela and later fully developed as a single theory (Howell and Koskela 2000). They asserted that the current PM theories are flawed. Their underpinning statement is:

"Project management as taught by professional societies and applied in the current practice must be reformed because it is inadequate today and its performance will continue to decline… project management is failing because of flawed assumptions and idealized theory" Howell and Koskela (2000 p. 1)

Howell and Koskela (2000) assert that the deficiencies in assumptions of the current PM theories are summarised as follows:

- Uncertainty as to scope and method is low
- Relationship between activities is seen as simple and sequential.
- Activity boundaries are rigid
- It is believed that control against standards for activities will ensure outcomes, and outcomes can be improved by improving individual activities.
- Production management is not viewed as a project management concern.

5.4.1 TFV Context

In 1992, Koskela first proposed a twofold theory, the transformation and flow theory, where the emphasis was placed on the flow view (Koskela 1992). In 1999, he followed it with a publication, "managing of production in construction: a theoretical view". In this publication, he describes transformation view "as a transformation of input into output" and flow as "a flow of material, composed of transformation, inspection, moving and waiting" (see table 5.1). He suggests the name for practical application of transformation and flow view as task and flow management respectively. This is arguably a combination of scientific management (task) and complexity (flow), which are discussed above. In Koskela's view, task and flow should be considered simultaneously. This led to the introduction of the seven flows, the preconditions for construction task, (see figure 3.3 discussed earlier). Koskela argues that there are seven flows of input to generate the task result. He explained external conditions are mainly weather related (i.e. extreme temperature, rain, snow, and wind). Koskela later included the perspective of value creation, which was synthesised to Transformation, Flow and Value creation (TFV) theory (Koskela 2000). He describes value as creating of a process, which defines and meets customer's requirement.

Researchers such as Kenley (2004) argue that this concept is neither new nor was it inverted by lean constructionist, Koskela. He claims this was just to bring old theories to bear. Koskela (1992, 2000, and 2002) acknowledges this fact. Indeed, in his co-publication "the underlying theory of project management" they emphasise that the thrust was not to present a new theory, rather, novel theories found to be more powerful than the existing implicit underlying theories (Koskela and Howell 2002 p. 303). Notwithstanding these arguments on the contrary, Koskela and colleagues are acknowledged for explicitly proposing a single theory for PM, which they claim brings deeper understanding of construction project. In addition, this concept still remains unchallenged; perhaps this is due to the facts that it makes existing implicit theory explicit as well as amalgamating both theories discussed above. Indeed, it draws from both scientific management and complexity theory, which bridges the gap.

Table 5.1 presents Koskela's views on transformation and flow as he claims to adopt from manufacturing, especially from the lean production.

Table 5. 1: Transformation and Flow views of Production (Koskela 1999)

	Transformation View	**Flow view**
Conceptualisation of production	As a transformation of input into output	As a flow of a material, composed of transformation, inspection, moving and waiting
Main principles	Hierarchical decomposition; control and optimising of decomposed activities.	Elimination of waste (non-transformation activities); time reduction; variability reduction
Methods and practices	Work breakdown structure, MRP, Organisation Responsibility Chart	Continuous flow, pull production control, continuous improvement
Practical contribution	Taking care of what has to be done	Taking care what is unnecessary is done as little as possible
Suggested name for practical application of the view	Task management	Flow management

5.4.2 Transformation View

The transformation view is the first of the concept analysed and proposed by Koskela (1992, 2000). Koskela (2000) agrees that the transformation view is not new as it has been dominant in recent centuries in operation management and even implicit in construction industry. He claims transformation view stems from economics and has it conceptual foundation on scientific management. In terms of project management, it is described as scope management, where, scope is defined through the WBS. He argues that the current project management is purely based on transformation and its principles of hierarchical breakdown.

Koskela argues that in as much as transformation view is useful, it only addresses "an adequate, or sufficient, amount of work to be done". This view only addresses the activities needed for a project. He however argues that transformation view is not particularly useful in determining how not to use resources unnecessarily, thus the concept of flow is needed to complement the transformation view.

5.4.3 Flow View

The second of the concept proposed was that of flow. In Koskela view, the main objective of flow concept is to eliminate waste (non-value added) such as reducing variability. Koskela (1992, 2000) stated that the Gilbreths originated the flow view as scientific management concept in 1922. Yet, Henry Ford first translated it into practice from 1913, then later in the 1940s adapted by Toyota (lean production). Koskela (2000) initially presented three types of flows, these consist, Materials, Location and Assembly (workstations). In this conceptualisation, Koskela was comparing construction project to car manufacturing (Toyota). Notwithstanding, he later proposed the seven flows for construction task. Berstelsen *et al.* (2006 p. 35) categorise these work flows into two main types that encompass of both physical and immaterial flows. The physical flows involve materials and equipment and that of the immaterial flows comprise of information, crew, space and external conditions. They however contended that despite the success of using these seven flows, the argument remains that "it is not based on structured analysis of the nature of the process and its flows".

Horman and Kenley (1997) also argue that since the 1950s, construction companies have managed and protected their workflow reliability as they considered workflow as 'common sense'. In similar response, Berstelsen *et al.* (2006) claim the concept of flow from lean perspective is misinterpreted and dissemination by non-lean constructionists (IGLC). Jorgensen and Emmitt (2008) also argues that, it is time that lean construction concept should feature in other peer review journals to establish a level of credibility. Berstelsen *et al.* (2006) argument was that, most studies on work flow, even within lean constructionist, focus on logical sequence of the task, few studies have examined the flow of materials and components but literature on other flows such as crew, information and equipment, is sparse. Kenley (2004) argues that the acceptance of workflow has also been hindered by the lack of technique.

5.4.4 Value Creation

The third concept discussed and proposed is the concept of value. According to Koskela, value is created from the client point of view, which focuses on matching all the client requirements in the best possible way. However, in reality, does the construction client really know what they want from the onset of the project? According to Koskela (2000), the practical contribution of value generation view is "taking care of the client that requirements are met in the best possible manner". Table 5.2 shows Koskela's later work on value concept.

Table 5. 2: Value Generation view of TFV (Koskela 2000)

	Conceptualisation of production	**Main Principles**	**Methods and practices**	**Practical contribution**
Value Generation View	As a process where value for the customer is created through fulfilment of his requirements	Elimination of value loss (achieved value in relation to best possible value)	Methods for requirement capture, Quality Function Deployment	Taking care that customer requirements are met in the best possible manner

Both Howell and Koskela (2002), and Salvation-Garrido and Pasquire (2011) argue that the current value is described in terms of scope, cost and schedule (alternatively TCQ) and it is determined by the client at the inception of the project. Ballard (2000) suggests that value is created in iterative dialogue between ends and means. Again, Ballard and Howell (1998 p 5) considered "value is generated through a process of negotiation between customer ends and means. The role of the designer is to make explicit to the customers the consequences of their desires". However, in as much as Howell and Koskela (2002) agree with Ballard and Howell (1998), the former suggest that the need for stability is balanced against the reality that the world around project and its technology are subject to change.

It could be suggested that the concept of value can be divided into two, that is the perceived value and the delivery (production) value; where the 'perceived value' is the client determination of value (this is normally expressed through TCQ) and the 'delivery value' is determined through the process of delivery or production. Similar view has been also emphasised by Emmitt *et al.* (2005), they suggest that these can be categorised into external (perceived-customer) and internal (delivery – production) value.

In the study of Salvation-Garrido and Pasquire (2011), they critically reviewed the theory of value, albeit mainly from lean construction perspective. They claim in lean thinking, value is connected with waste. As they cite the argument of Bertelsen and Koskela (2004 p. 6) advocating that the "concept of value is the most difficult to approach in the new way of managing construction project". Salvation-Garrido and Pasquire (2011, p 9) also concluded that currently, and even, among lean constructionists, the concept of value is still confusing. Therefore, they identified that the impact on society is missing from literature as the current practices aim at satisfying only the end-users and/or client requirements. In addition, they argue that value concept from lean constructionists has focus on customer satisfaction at on-site production (Salvation-Garrido and Pasquire, 2011p 15). They proposed that value should be the meeting point of "production and delivery capacity, stakeholders' value perspective and social value perspective". They concluded that researchers and practitioners should embrace global understanding on concept of value. They believe that the environmental and society are the main goals for construction industry but technological tools and public policies (political) add value to society in global sense.

Synonyms of the word 'value' include assessment, usefulness, and worth. In project management terms and putting these synonyms into perspectives of both Koskela's, and Salvation-Garrido and Pasquire's, then value of a product or project should be assessed that it is worthy and useful once delivered. Therefore, value in this thesis is considered as perceived (client), delivery (production) and social-environment (local society and environment) views.

5.4.5 TFV and Planning and Control

LPS is the acclaimed technique to support the TFV theory. Koskela (1999) argues that a tighter task management contributes to flow reliability. He then asserts that method of LPS combines central elements of task management and flow management for production control in construction (Koskela 1999). However, in a later study of Koskela (co-authored) after a decade, they suggest that LPS does not represent six flows as suggested and it does not even manage them as discussed in chapter 3 (Bertelsen *et al.* 2006). This has prompted a call from researchers, especially from IGLC for a technique to address the main concerns (Berstelsen *et al.* 2006, Kenley 2004).

In terms of planning and control, TFV's requirement in broad terms, is to include flow and management of value to the scientific management concept. The purpose is to ensure the deficiencies identified, which led to the introduction of TFV (as discussed above), are met.

5.5 CONCLUSION

The three theories discussed above, despite being separate, they are connected. The scientific management is the foundation, where complexity was introduced by contending its linear and orderly process. TFV is an amalgamation of these two to bridge the gap.

Scientific Management advocates that planning should be led by management and they should do so in writing, thus introducing WBS and linear connection between activities (as in CPM discussed in chapter 3). Complexity challenged the idea of 'all process being linear', thus considers inter-connectivity between activities. Complexity bridges the gap between the natural sciences and social sciences. Complexity is inevitably an important issue in PM as it helps in identifying the planning and control requirements.

Scientific management focuses on task management, while complexity focuses on inter-connectivity (flow). TFV is a combination of both by extracting value as a standalone concept for manufacturing. Currently, most studies on planning and control concentrate linear sequence of activities and limited techniques, and few, if any at all, on workflow. There is currently an urgent call by both researchers and academics for a novel holistic technique. Therefore, this study adopts a bespoke version of TFV, (a combination of both theories as discussed), where value is considered as perceived (client), delivery (production) and social-environment (local society and environment) with a management model to develop a holistic planning and control technique. Value, in this sense, is sustainable value, thus the next chapter reviews sustainability and how it fits into PM as well as the proposed technique.

CHAPTER SIX: SUSTAINABLE CONSTRUCTION

6.1 INTRODUCTION

This chapter reviews and discusses sustainability in the context of project management. This is to ensure that the subject of sustainability is well thought-out in the understanding of project management and in the development of the new holistic technique. Also, it ensures that value is considered from a global perspective rather than only customer requirements. There is a need to review sustainability and sustainable construction, and to consider its future involvement in the project management field.

The chapter begins with the review of understandings and definitions of the term sustainability. This was then narrowed to sustainable construction where the study is situated, examining the existing concepts of achieving sustainable construction. Sustainable construction was then discussed against project management. This led to opening the gap in knowledge and proposing a new model.

Sustainability has become an important issue in recent decades. This is because of the increase in global environmental deterioration. Population increase and endeavours for economic growth mean that sustainability is one of the most important issues currently facing the world. The construction industry has been criticised as one of the main culprits in the not achieving sustainability agenda. For example, despite the construction industry's economic contributions of 10 % to the UK's GDP, the industry equally contributes to about 48% of UK's CO_2 emissions. In the same way, the construction industry is socially driven and initiated for social reasons. Industrial practitioners and researchers are exploring ways of achieving sustainability in construction projects. Researchers have concentrated on materials, and designs on technical issues: such as materials, building components, construction technologies and energy related design; however, neglecting the managing of the projects. Yet, most of the emissions occur in the actual construction stage. Again, the construction industry contributes significantly to general waste during the actual construction stage. For example, Kibert (2002) established that the annual waste created by the USA from construction demolition waste is a little over 50% of municipal solid waste.

Therefore, any effective management measures to achieve sustainability are worthwhile and should be considered as part of the growing sustainability agenda.

6.2 BACKGROUND OF SUSTAINABILITY

In Philosophical Investigations, Wittgenstein (1953) defined "meaning" by the way language is used. A word may have different meanings according to how it is used in a language game. He argued that words may be empty of meaning, or may have some meaning, or may be full of meaning. Thus, to define a word it is prudent to understand its history and its context because the definition of a word is vital to its understanding.

According to Adams (2006), the idea of sustainability is relatively recent and can be traced back to a conference held 30 years ago. Adams (2006) argues that, the concept of sustainability emerged from the UN conference on the Human Environment – (Stockholm, 1972), where poverty of the developing countries was a key issue. The Swedish government at that time was concerned about the amount of pollution from other European countries that had damaged their lakes. In attendance in that meeting was the Indian Prime Minister, Indira Gandhi, who made a profound statement that perhaps changed the understanding of other attendees. She said, "poverty is the worst pollution" (Adams 2006; Dresner 2002). This led to the establishment of United Nations Environment Programme (UNEP) based in Nairobi, Kenya (Dresner 2002 p. 28). Their first meeting formulated the term eco development as a way of verbally reconciling the desire for development and environmental protection. The often cited concept of sustainability emerged in 1974 from a report of an Ecumenical study conference on Science and Technology for human development (WCC, 1974). This was convened in response to developing countries' objections to concerns about the environment whilst human beings in other parts of the world suffer from poverty and deprivation (Dresner 2002 p. 1). Both conferences had poverty as a common platform for sustainability. In 1980, the term sustainable development was gradually developed through the world Conservation Strategy (Adams 2006, Dresner 2002).

The term "sustainability", which literally means ability to sustain, is currently a major concern that seems to have an imprecise interpretation by many scholars and practitioners. Generally, sustainability is perceived to be ecology. The word "Eco" means "environmentally friendly or sensitive". Ecology is a scientific study of the relationship of living organisms with each other and their surroundings, while sustainability is derived from the Latin word *sustinere* – meaning to hold (Oxford Dictionary 2001). There are many synonyms or meanings for the word "sustain" which includes: 'maintain or keep', 'bear', 'support' or 'endure/suffer' (Oxford Dictionary 2001). These meanings establish a clear difference between the words, although they could complement each other. It seems the main aim of the debate about sustainability was what may be termed sustinere-eco, which literally means to hold the environment or maintain the environment; more sensibly, it is maintaining the earth as well as maintaining the human race. Maintaining the environment (earth) was the initial purpose of the Stockholm 1972 meeting but their concerns about poverty of developing countries polluting the environment became as pertinent as their initial purpose, which is maintaining the human race.

6.3 WHAT IS SUSTAINABILITY?

The common understanding of the term sustainability is difficult to achieve. This is because of the isolated discussion of the definition of sustainability in existing literature, which is a fundamental problem. In this section, the general understanding and definitions of sustainability is discussed.

In 1987, the term sustainability and sustainable development came to prominence through the publication of Our Common Future also known as the Brundtland report by United Nations' World Commission on Environment and Development (Adams 2006; Dresner, 2002). The report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). This was adopted and progressively accepted in 1992 by national governments with wider engagement from business leaders and governmental organisations through the United Nations Conference on Environment and Development. However, the definition has various interpretations from scholars and practitioners in many fields. From the perspective of some environmentalists, sustainable development is an oxymoron, as development seems to entail environment degradation. Serageldin and Grootaert (2000) argue that "a sawmill is worthless without a forest" From their perspective, the economy is a subsystem of human society, which in itself is a subsystem of the biosphere and a gain in one sector is a loss from another. According to O'Riordan (1988), some environmentalists claim that sustainable development is a contraction and the term is used as a cover for continuing to destroy the natural world. Some economists argue that sustainable development is too cautious about the future, potentially leading to sacrifices of economic growth for the sake of excessive concern about depletion of natural resources (Dresner 2002). Arguably, this opened up the debate to scholars and practitioners in respective fields. In economic terms some economists treat consumption of the Earth's capital as if it were income. David Pearce and colleagues defined sustainability as "non-declining capital" where the earth is referred to as natural capital (Dresner, 2002 p. 76). Caring for the Earth also defines sustainable development as "a development that improves the quality of human life, while living within the carrying capacity of supporting eco-systems" (Hill and Bowen, 1997). Although, Adams (2006, p.. 2) claimed that the definition of Brundtland report was vague; he believed that it cleverly captured two fundamental issues: environmental degradation and economic growth. He argued that the concept of sustainability is holistic and imprecise. This idea brings people together but does not necessarily help them to agree on goals, thus sustainable development arguably ends up meaning nothing. Similarly, Michael Jacobs also claims that sustainable development is a "contestable concept" (Dresner, 2002 p. 66). However, those in favour of the debate and of the Brundtland report argue that disagreement does not show that it is meaningless.

The divergence of views discussed above illustrates the complexity of the subject and also proves that sustainability is ambiguously defined. So therefore, this study concludes that there is no common understanding of the term sustainability. However, there is a separate and overlapping theme of maintaining the earth and human race as well as improving the economy.

Notwithstanding, the diversity of ideas, disagreement and argument of the topic of sustainability, sustainability has been used more in the sense of human sustainability on the planet since the 1980s. Sustainability has gradually been extended to many sectors including, the construction industry. Perhaps, this led to the development of the term sustainable construction.

6.4 SUSTAINABLE CONSTRUCTION

The term sustainable construction was originally proposed to describe the responsibility of the construction industry in attaining 'sustainability' (Hill and Bowen 1997). Thus in November 1994, the first International conference on sustainable construction was held in Tampa, Florida, USA. The purpose of the conference was to assess progress in the new discipline that might be called sustainable construction or green construction. The conference defined sustainable construction as the creation a healthy built environment based on resource-efficient and ecologically based principles (Kibert 1994). Since then, the industry has had different interpretations and this has initiated a number of problems related to how sustainability can be achieved.

According to IUCN (1991) and Thompson (2002), sustainable activity is activity that can continue forever. This definition echoed more doubts in the construction industry because a construction project is deemed out of context with this definition of sustainable activity.

6.4.1 Existing concepts of sustainable construction

The sustainable development agenda has been evolving worldwide for over two decades. Sustainable construction addresses the role of sustainability within the built environment (Kibert 2008). Sustainable construction comprehensively addresses the ecological, social, and economic factors of a construction project (Kibert 2008). It has been generally accepted that core mainstream sustainability thinking has become an idea in three dimensions: environmental, social and economic sustainability. These have been represented with pillars, concentric circles and overlapping circles as illustrated in figure 6.1 by Adams (2006) and cited by many scholars.

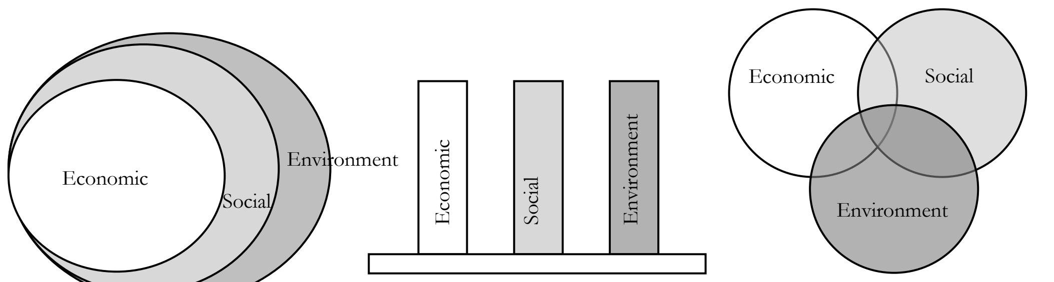


Figure a: Concentric circles Figure b: Pillars Figure c: Overlapping

Figure 6. 1: Three dimension of sustainability (source: Agyekum-Mensah *et al.* 2012)

The construction industry, like any other industry, still depends on the primary components identified in the conventional model (Economic, Social and Environmental) to achieve sustainability (Murray *et al.*, 2006; Bullen and Love, 2011; Murray and Cotgrave, 2011). Presley and Meade (2010) among other researchers refer to this as the "triple –bottom line" (that is, economic, social and environmental). This is a simple way of categorising sustainability into these three primary components. Hill and Bowen (1997) claim that the principles under which construction will be more sustainable are divided into four main "pillars". These pillars are: social, economic, biophysical and technical. The authors explained that the biophysical pillar is used to include the atmosphere, land, underground resources, the marine environment, flora, fauna and the built environment; while, the technical pillar was chosen to represent the performance and quality of a building structure. Thompson (2002) used the "triple bottom line" to develop an overlapping model with three value areas being ecology (environmental values), delight (aesthetic values) and community (the social values). Adams (2006) claimed that the conventional model of the understanding of sustainable development is flawed because it implies trades-offs can always be made between environmental, social and economic dimensions of sustainability. These trades-offs draw the argument to technological influence in the industries and the economic ability to pay. Perhaps this encouraged or influenced the UK Government's decision to rule out regulation on retrofitting as part of the Green Deal (RICS 2011). Retrofitting is where new technology or features are added to older systems to improve efficiency, increase output and reduce carbon emissions. In the built environment, this will help in improving the energy efficiency of existing buildings including factories, universities and domestic properties.

Heidegger (1982) defines technology as the means to an end. Technology or the product of technology as Heidegger explains is a factor in sustainability. However, it is marginalised in the discussion of sustainability (Dresner 2002, p. 146 citing Fukuyama). It was further ascertained, from Fukuyama's argument that, it is impossible to abandon technology and live in some Rousseauian idyll. Those who do that will be abandoning the means to defend themselves against those who do not. This justification was argued by Heidegger's view concerning technology, where technology was differentiated from its essence. Heidegger ascertained that the essence of technology is not itself technological as the essence of a tree is not itself a tree. In a broader sense, technology is a human activity and a means to an end, thus, one may conclude that this activity and its products profoundly influence every area of human life; while, others may think technology is entirely beneficial to mankind or more prudently it brings both benefits and harms. Although technology is a human activity, it may be beyond the control of individuals, perhaps the human race; this is where it is also linked to sustainability. However, current debates of sustainability do not explore Heidegger's view. The essence of technology, in a Heideggerian sense, is the supreme danger because it prevents us (human beings) from having a proper understanding of our own being and a contributor to the lack of achieving sustainable development. Kemp (1994) argues that technology is widely considered as attractive to reduce environment sustainability but questioned whether alone is sufficient to achieve an environmental sustainability. He established that more fundamental changes in technology are needed to achieve environmental sustainability. This study therefore argues that technology is one of the important factors in the discussion of achieving sustainability. Therefore, one cannot ignore the contribution of technology as one of the core factors in achieving sustainable development.

Similarly, the view of achieving sustainability in the construction industry has evolved over the years. The preliminary focus was on how to deal with the issue of inadequate resources - especially energy. This was followed with a shift towards how to reduce the impact on the natural environment, which includes the establishment of BREEAM (Building Research Establishment Assessment Method) in the UK. BREEAM examines the building impact on the environment from the design perspective, which forms part of project management (Uher 1999). In the United States of America (USA), the U.S Green Building Council is committed to high performance green buildings (Kibert 2008). In recent years, emphasis has been placed on technical issues: such as: materials, building components, construction technologies and energy related design concepts termed "Ecobuild" and "Green Build". The term Green Build, Eco-Building and high performance building and sustainable construction are often used interchangeably in sustainability concepts (Presley and Meade, 2010 and Kibert, 2008).

6.5 PROJECT MANAGEMENT IN SUSTAINABLE CONSTRUCTION

Project Management is the overarching procedure that delivers construction projects that start from pre-construction (well before construction) and continues through construction to post construction. In much broader terms, the project management process spans from inception to disposal, which encompasses the whole life cycle of a project.

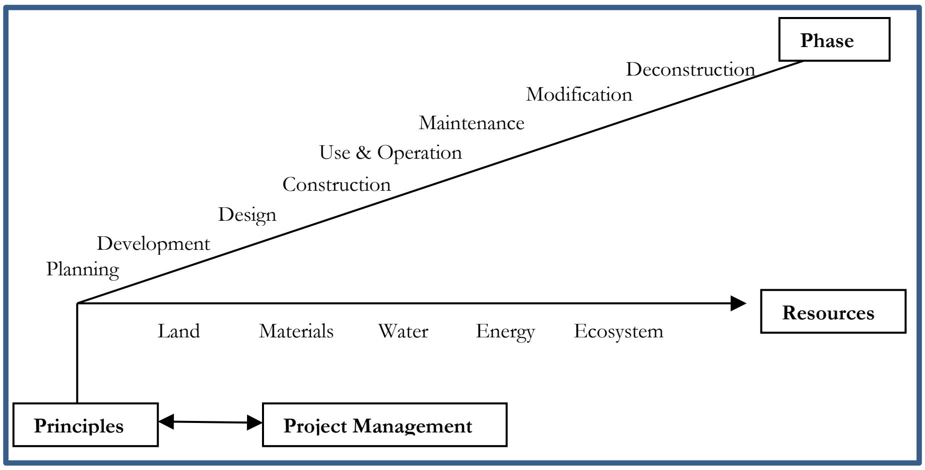


Figure 6. 2: Framework for Sustainable Construction (Source: Agyekum-Mensah *et al.* 2012)

The above model (figure 6.2) was originally developed in 1994 at the International Conference for Sustainable Construction and later adapted in Kibert's (2008) book, Sustainable Construction. The phases are shown on the inclined line of the figure illustrating the construction process while the horizontal line represents the resources. The management of these phases and resources is termed project management. This model explicitly illustrates the project management principles needed to achieve sustainable construction, albeit Kibert (2008) did not refer to the model as a project management process but used the term principles.

Equally, sustainable construction covers the entire project cycle of a project, as proposed by the framework for sustainable construction in figure 6.2.

The current sustainable construction agenda concentrates on individual processes such as: design, energy consumption and materials in achieving sustainability. However, all of these aspects are part of the project management process. They are not isolated aspects of project management process; hence achieving sustainability is dependent on the entire project process. Sustainable development must begin with inception through delivery to lifecycle use and finally disposal. Waste disposal is also one of the integral parts of project management, for example, waste from the construction industry is enormous but seems to be marginalised. According to Kibert (2002), annual waste created by USA from construction demolition waste was 145MMT, which was compared to a municipal solid waste stream of 280MMT. This implies that construction industry contributes about one third of the total USA waste. Kibert, (2002) (citing Hasegawa, 2001) argues that the average life of a building in the UK is about 62years whilst that of USA is 32 years, which is a contributor to the excessive waste incurred from demolition in the USA. This raises questions about the current approach to sustainable construction that is based on material, energy and design. On the flip side, it is illustrating the essence of effective project management.

It is an established fact that the construction industry is reliant on effective project management to deliver projects. The project management process spans from inception to disposal (demolition and clearing away) of a project, which encompasses the whole life cycle, planning (inception, design, procurement, delivery and strategic planning), control and monitoring (execution controlling and planning controlling) and evaluation (purpose use, project evaluation, demolition and disposal). The initial problem of how to achieve sustainability within the industry was compounded by the term sustainable construction being used to describe a process which starts well before construction per se (in the planning and design stages), through construction, and continues after construction (Hill and Bowen 1997) and finally to disposal. As such, the only process, which covers these processes end-to-end, is project management. However, it has been marginalised in attaining sustainability in the construction industry. The current debate focuses only on some of the processes in the entire project management process.

The industry has embraced the core mainstream of sustainability as a relationship or balancing act between social, economic and environmental factors. (Refer to figure 6.1). However, the industry is still faced with the problems of sustainability as compared to other industries (Ofori 1998). Kibert (2008) argues that green building delivery systems manufacturing products are evaluated for their life cycle impact including energy and emissions. Likewise, HMSO (2005) argue that, the current sustainability model is unsustainable. There is therefore a need for a new holistic model for sustainable construction or development.

6.6 CONCLUSION

Despite the construction industry's economic contributions, the industry equally contributes to circa half of the CO_2 emissions. Thus sustainability has become the prevalent problem facing the industry. Practitioners and researchers in their attempts to explore ways of achieving sustainability in construction projects have concentrated on materials, and designs on technical issues: such as materials, building components, construction technologies and energy related design; however, neglecting the importance of managing the projects. Yet, most of the emissions occur in the actual construction stage.

The concept of sustainability has been argued to end up meaning nothing and the triple bottom line of economic, social and environmental factors have been flawed to allow trade-offs. Technology, which plays a key role in the sustainable debate, has been ignored and project management has also been marginalised. Currently sustainability is concerned with customer value rather than global and project value; hence, HMSO (2005) argue that the current sustainability model is unsustainable.

There is therefore a need for a new holistic model for sustainable construction or development.

CHAPTER SEVEN: RESEARCH METHODOLOGY

7.1 INTRODUCTION

This chapter is concerned with the description of the philosophical assumptions made for this research, and the methodology considered and selected to achieve the research aim and objectives. Furthermore, the chapter details how the wider methodology relates to this research and how the methodology chosen is appropriate to answer the research questions and meet the aim and the objectives of this research. This chapter discusses the selecting factors for the research methodology together with the relationship between the research methods and research objectives. This is to ensure that the most appropriate research methodology is selected and that every objective is accomplished using the suitable approach.

This chapter also presents the research design, through the use of case studies and qualitative interviews as a notable way of conducting qualitative research, then, a commentary is given in detail on the research process used. The chapter concludes with a summary of the rest of the chapters in this thesis.

7.2 CONSTRUCTION MANAGEMENT AS THE FIELD OF THIS STUDY

Construction management, where this study is situated, is a fairly new [21] discipline, which makes use of methodological pluralism drawing on influences from several philosophical as well as methodological paradigms (Fellows and Liu 2008, Knight and Ruddock 2008). Strategies used have evolved from social and natural sciences, and accordingly both quantitative and qualitative data collection techniques are utilised with respective modes of inference. This has led to an abundance of recognised research methods, which have been used to contribute successfully to knowledge. Several considerations have to be taken into account when choosing what method(s) to use. Numerous philosophies of science and scientific paradigms certainly play a significant role in this. Nevertheless, the appropriateness of the method and the conclusions thereof cannot be assessed on a philosophical position alone. Rather, it is the appropriateness of the research method, in conjunction with the applied research design to examine the research problem in its totality that is a key.

[21] Although its history could be traced back to the ancient Egyptian empire, it really became eminent post World War II (i.e. after 1945) as a discipline (Langford, 2009)

7.2.1 Competing Paradigms in Construction Management

According to Bryman and Bell (2011 p. 24), a paradigm is a cluster of beliefs and dictates in a particular discipline to influence what should be studied, how research should be done and how results should be interpreted. Many fields of studies have established paradigms (especially in science); however, construction management draws from both the natural and social sciences, therefore, many different paradigms compete for methodological dominance (Knight and Ruddock 2008). Runeson (1997) argues that construction as a discipline is hinged on natural science, and thus positivism. Bryman and Bell (2011 p. 15) define positivism as "an epistemological position that advocates the application of the methods of the natural science to the study of social reality and beyond". Knight and Turnbull (2008 p. 70) argue that positivism regards all knowledge as tied to observational forms of verification and methodologically founded on scientific experiment. One could argue that construction management as a discipline is founded on science. However, its operation revolves around humans, and so in broader terms, it is also human driven.

In the late 1990s, there was a debate among construction management researchers regarding the strategies suitable for construction management research (predominantly among, Seymour *et al.* 1997, Runeson 1997, Seymour *et al.,* 1998, and Harris 1998). This debate originated from the dominance of quantitative (positivist) paradigms in the construction management research. Then Seymour *et al.,* (1997) called for the debate with their publication in the Construction Management Economics (CME) Journal (tier 1 journal in the field). They claimed the debate was long overdue because, in their view, construction management researchers tend to underestimate or ignore the importance of the opposing strategies, the interpretive process. Runeson (1997) responded to this call from the positivist view. He argued that positivist research approaches are the best insurance against bad research. Again, he argued that construction management is a discipline based on theory or science. He further claimed that construction management is a set of functions where different techniques are employed and some of these functions are based on, or can be explained by, various scientific theories. He, however, acknowledged that there is some research in construction management that merits the investigation using a qualitative (interpretivist) approach. He also agreed that sometimes both quantitative and quantitative approaches can be used to complement each other in the same study. Similarly, Raftery *et al.,* (1997) in their response suggested that both quantitative and qualitative strategies are not mutually exclusive; thus, it is not useful to be restricted to one paradigm.

Knight and Ruddock (2008) advocate that the legacy of the debate is the establishment of an alternative paradigm, which has been embraced after a decade. Researchers therefore draw from both traditions, which remain sensitive to the theoretical and philosophical bases upon which the investigation is founded. This has resulted in methodological pluralism in construction management. Depending on the aim, objectives, research question(s), the type of knowledge the research intends to contribute to, researchers make use of both qualitative and quantitative strategies. Occasionally, both strategies are used together, which is normally called triangulation. Yet, the vitality of the issue is that the researcher using these paradigms should define carefully the ontological and epistemological assumptions for the study. Therefore, the next section presents the ontological and epistemological assumptions of this research as well as the theoretical position.

7.2.2 Theoretical, Ontological and Epistemological Assumptions

Bryman and Bell (2011 p. 7) suggest that the term theory has been used to denote several things; however, the most common meaning is an explanation of observed regularities. In their view, researchers should explain regularities in their data or information collected. The two opposing theories are the deductive and inductive theories. The former is interested in testing existing theory, whereas the latter is concerned with the developing of theory. Research theory is influenced by the ontological and epistemological position of a study, whether explicitly or implicitly stated.

Dainty (2008) defines ontology as the conception of reality, and in the broader sense it is concerned with the question of existence. The two extremes of ontological positions of research are normally referred to as objectivism and constructivism. Bryman and Bell (2011 p. 21) define objectivism as “an ontological position that asserts that social phenomena and their meanings have an existence that is independent of social actors”. They also define constructivism as “an ontological position that asserts that social phenomena and their meanings are continually being accomplished by social actors. This implies that social phenomena and categories are not only produced through social interaction but are in a constant state of revision”.

The understanding of these paradigms influences the type of knowledge the research contributes to, where the acceptable knowledge in a discipline is termed as epistemology. Similar to the ontological position, the epistemology of research is categorised into positivism and interpretivism. Knight and Turnbull (2008) argue that without a clear ontological and epistemological stance for the research, the researcher cannot strongly defend his or her contribution to knowledge. They believe that for a reseacher to specifically contribute to knowledge, he or she should know what knowledge is in their field of study and how it is acquired.

According to Fellows and Lui (1997, 2008), positivism and its relative quantitative strategy has been dominant in construction management research. Dainty (2008) suggests that this has encouraged a convention of applying a "natural science" strategy to understand social phenomena. Seymour *et al.* (1997) contended the dominance of this epistemology, positivism, in the construction management research. They argue that construction management differs from natural science because the "object of study" for most construction management studies is people (Seymour *et al.* (1997 p. 18). They suggest that in order for researchers to have influence on the construction industry, the culture and conventional stance must change. Bryman and Bell (2011 p. 16) explain that the positivism focuses on "explaining human behaviour", while its contrasting epistemology, interpretivism, focuses on "understanding human behaviour". They added that interpretivisim is concerned with the empathic understanding of human action rather than the forces that are deemed to act on it. Alternatively, Easterby-Smith *et al.* (2008) present contrasting implications of both positivism and constructionism, as shown in table 7.1.

Table 7. 1: Opposing implications of Positivism and Constructionism
(Source: Easterby-Smith *et al.* (2008 p. 59)

	Positivism (Objectivism)	**Interpretivism (Constructionism)**
The Observer	Must be independent	Is part of what is being observed
Human interest	Should be relevant	Are the main drivers of science
Explanations	Must demonstrate causality	Aim to increase general understanding of the situation
Research progresses through	Hypotheses and deduction	Gathering rich data from which ideas are induced
Concepts	Need to be operational so that they can be measured	Should incorporate stake holders perspectives
Units of analysis	Should be reduced to its simplest terms	May include the complexity of 'whole' situation
Generalisation through	Statistical Probability	Theoretical abstraction
Sampling requires	Large numbers selected randomly	Small numbers of cases chosen for specific reasons

Again, the issue of both the ontological and epistemological assumptions of research are also founded on the type of method(s) used to collect the data. Similarly the ontological position and epistemological position also influence the method(s) to be adopted. For example, Recker, (2008, p. 107) argues that semi-structured interview research can further be classified on the basis of the positivism- interpretivism debate. A similar debate arises in the adoption of case study. Although interpretivism and positivism rely on comparatively opposing sets of philosophy about nature and the construction of knowledge, in both epistemologies, interviews could be utilised. This is due to the flexibility of interviews as a method. From a positivist stand, semi-structured interviews are used to measure an individual's perceptions and attitudes towards pre-defined variables and to seek evidence for construed paradigms and their relationships. In contrast, interpretivism uses semi-structured interviews to understand the complex nature of a phenomenon and educe knowledge about apparently irrational processes and settings in social contexts (Recker 2008, p. 107). Interpretivism is also considered when doing an exploratory approach (especially in the identification and exploration of suitable factors in the use of process modelling in contemporary project management settings). Hence, one could argue that this research is placed under the banner of interpretivsm.

The very essence of this study is to develop a conceptual understanding of construction project management, and develop an innovative and holistic planning and control technique to improve the current practice. Thus, it is to "understand human behaviour" rather than "explaining human behaviour". Again, Seymour *et al.* (1998 p. 111) demonstrated that good planning is not necessarily based on using probability theory. They agree with Dant and Francis (1995) that planning may be better conceived as a contingent practice, an opportunistic process dependent on and subject to various local concerns. Seymour *et al.* (1998) argue that the practical importance of planning should be based on what is known rather than the probabilistic of the unknown. In addition, LPS[22] also implicitly adopted the interpretivist approach, thus viewing planning from social constructivism.

Seymour *et al.* (1998 p. 110, 111) continue to argue that planning could be explained only by asking the construction managers or the people involved. Although they did agree with Runeson's argument that doing that might be subjective or biased, they argue that doing that (asking the construction managers or the people involved) is inevitably the appropriate choice. Both Seymour *et al.* (1998) and Runeson (1997) agree that with regards to project planning the idea of the normative cannot be taken out.

Therefore, mapping the arguments above to the present research aim and objectives, it is established that the epistemological and ontological assumptions of this study are far from a positivism and objectivism orientation respectively. Therefore, the epistemological and

[22] LPS is discussed in detail in chapter three

ontological orientation of this research is appropriately situated within interpretivism and constructionism respectively, whereas the theory used is inductive, thus, generating theory and the time horizon is longitudinal. Table 7.2 presents the snapshot position on the scale of the study. The red arrow indicates the researcher's position on the position scale.

Table 7. 2: Position of this Research and Difference in Paradigms

Theory	*Deductive (testing of theory)*	*Inductive (generation of theory)*
Epistemological Orientation	*Positivism*	*Interpretivism*
Ontological Orientation	*Objectivism*	*Constructionism*
Strategy	*Quantitative*	*Qualitative*
Time Horizon	*Cross Sectional*	*Longitudinal*
Position of this research	*Position Scale*	

7.3 RESEARCH DESIGN

When undertaking a research project, it is important to choose the correct methodology to ensure specific research objectives, questions and/or aims can be met and the findings validated, i.e. the type of knowledge to be discovered, such as descriptive, explanatory or exploratory (Naoum 2007, Yin 1994, 2003, 2009; Robson 2011, and Fellows and Liu 2008). Strauss and Corbin (1998) define methodology as "a way of thinking about and studying social reality. According to Bryman and Bell (2011 p. 718), "a research design provides a framework for collection and analysis of data". The purpose of designing and performing research can be categorised into two main groups, i.e. 1) the aim and objectives of the research 2) the type of contribution the research intends to make.

7.3.1 The Aim and Objectives of a Research

The aim of this study emerged from the need to overcome the limitations of the current project planning and control techniques. This need for improvement has led to focusing on current practice and proposing an appropriate system to enhance this practice and to give deeper understanding of construction project planning. It is therefore worth repeating the specified research aim and objectives for this particular study.

The aim of this research is to develop a holistic planning and control system through the incorporation of production models to enable the delivering of sustainable construction projects and enhance the current practice.

The specific objectives of this research are to:

1. Critically review the literature on the concept of project management, planning and control, and production modelling techniques as it applies to the construction industry. In addition, review the concept and understanding of achieving sustainable construction in a project management context.
2. Empirically investigate the understanding and definition of a construction project and other projects in order to conceptualise the construction project management managerial process.
3. Empirical investigation of industrial problems associated with project management, and planning and control.
4. Identify the requirements, factors and task flow for project planning and control.
5. Adapt the methodologies identified to suit the construction process and from the first four objectives develop an innovative holistic project planning and control system called the Total Planning and Control (TPC) system.
6. Implement and evaluate the TPC system through the case study projects.

This research endeavours to address practical problems to enhance the current planning and control techniques in construction. In so doing, the concept of construction project management was addressed. Paul Wells once said "there is no practice without theory and no theory without practice…" (Wells 2007 p. 9). This is to emphasise that the theory and new technique complement each other.

This study is classified under both descriptive and explorative research from the logic of the type of knowledge research discovers. This research falls under descriptive research because it seeks to understand first the industrial problems (although commenced from a theoretical stance). This research therefore described the reality, in terms of the existing problems. Conversely, in this research context, it is explorative because it adapts and explores a mainly used manufacturing modelling technique to develop the Total Planning and Control (TPC) system. Notwithstanding, the main objective of this research focuses on the development of a holistic but innovative technique for project planning and control to manage construction project to enhance current practice. Thus, this research is inclined to an explorative study.

7.3.2 The Type of Contribution the Research Intends to Make

The type of contribution research intends to make is about how the research will be utilised. According to Collins and Hussey (2009), the type of contribution the research intends to make is the outcome of the research, which can be put into two groups, (1) Basic (Pure or Fundamental) and (2) Applied (Practice).

The basic research is concerned in advancing basic knowledge; i.e. it focuses on theories that explain how the world operates. In other words, the research contributes to general knowledge rather than solving a specific problem. In contrast, applied research attempts to solve specific problems or help practitioners accomplish a task. It focuses less on theory but more on the detail of specific questions or specific issues (Collins and Hussey (2009). Neumann, (1994) argues that it is usually intended to be descriptive research and it possesses the advantage of immediate practical use.

Designing empirical research, the researcher must ensure that both the data collected and the knowledge generated is valid and reliable. Validity is about the integrity of the research and its conclusions. In much broader terms, it is concerned with the trustworthiness of the findings of the research, whereas, reliability is about the consistency of the research representation, the results of the study are repeatable. The reliability is to ensure that the results of the study can be repeated in equivalent settings with similar results. Bryman and Bell (2011) argue that quantitative methodologists normally use both terms, reliability and validation. They claim that qualitative methodologist propose alternative terms which seem parallel with those of the quantitative researchers. The criteria for evaluating qualitative research are credibility, transferability, dependability and conformability. Table 7.3 presents views from both qualitative and quantitative researchers. It could be concluded that both stands are parallel and thus research should be evaluated regardless of the strategy adopted.

Table 7. 3: Evaluation Criteria for Qualitative and Quantitative Research (Adapted: Bryman and Bell 2011, pp. 42-43)

Qualitative Evaluation	**Quantitative Evaluation**	**Description**
Credibility	Validity (Internal)	How believable are the findings?
Transferability	Validity (External)	Do the findings apply to other contexts?
Dependability	Reliability	Are the findings likely to apply at other times?
Conformability	Objectivity	Has the researcher allowed his/her values to intrude to a high degree

Critics of qualitative research consider it to be methodologically weak in terms of reliability and validation. Therefore, to increase and strengthen the information collected and the findings, measures were put in place (this is discussed in detail later in this chapter).

Although it may be concluded that this study is applied research as it tends to improve the current practice, however, it is also in some part basic research as theory is developed for construction PM. Construction management and PM have both been acclaimed as established fields of research; however, construction PM is relatively struggling in terms of theory (Koskela and Howell 2002).

7.3.3 Research Strategy

Robson (2011) suggests that research strategy is the general broad orientation taken in seeking answers to research questions. The research strategy normally denotes the methodology in the combination of techniques used to enquire into a specific situation (Easterby-Smith *et al.* 2012). The strategy for data collection is classified in two main extremes, either the qualitative or quantitative route, albeit, both approaches could be used together. Bryman and Bell (2011) present a contrast between the two opposing approaches. Table 7.4 shows the differences as well as similarities between the two strategies.

Table 7. 4: Contrast between Quantitative and Qualitative Strategies

Quantitative	Qualitative
Numbers	Words
Point of view of researcher	Points of view of participants
Researcher distant	Researcher close
Theory testing	Theory emergent
Static	Process
Structured	Unstructured
Generalisation	Contextual understanding
Hard, reliable data	Rich, deep data
Macro	Micro
Behaviour	Meaning
Artificial settings	Natural settings

Alternatively, Hunter and Kelly (2008) presented a useful categorization between the strategies as shown in figure 7.1 below, which also shows the methods classification.

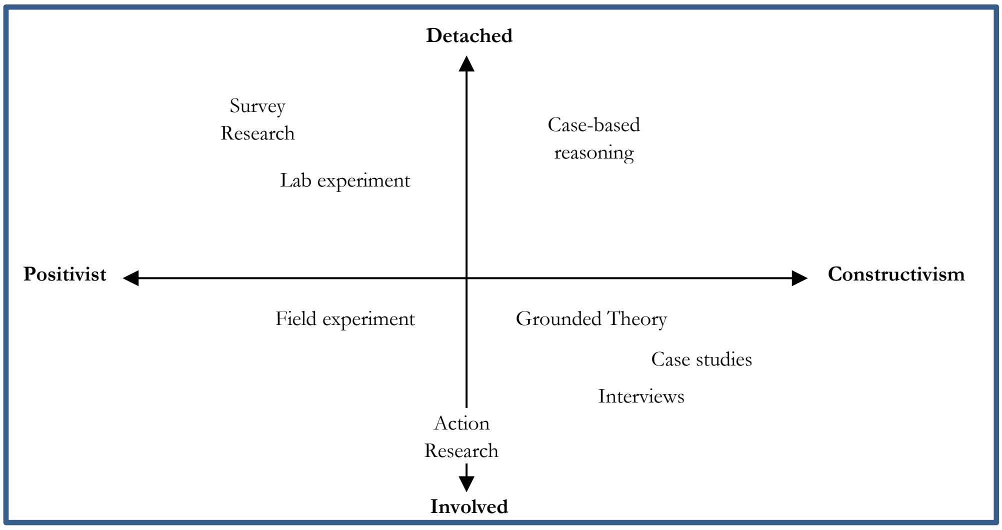


Figure 7. 1: Research Strategy (Hunter and Kelly in Knight and Ruddock 2008 p. 87)

The nature of the study suggests that the strategy to be adopted is qualitative, which is consistent with both the interpretivist and constructionist stances previously discussed. The key aim of qualitative research is used to address practical problems. Maxwell (1994 p 21) argues that qualitative research is advantageous in: (1) generating results and theories that are understandable and experientially credible, both to the participants and others; (2) conducting formative evaluations that intends to enhance existing practice, and (3) engaging in collaborative study with practitioners or research participants. Hence, this present study, similar to many other exploration studies, is conducted mainly using the qualitative strategy. Easterby-Smith *et al.,* (2012) also suggest that applied research, as in the present study, which intends to address a specific issue, usually adopts the qualitative approach.

The data collection strategies classification varies between authors. For example, Farrell (2011) suggests seven data collection approaches: (a) action research (b) case studies, (c) surveys, (d) experiments, (e) ethnography, (f) ground theory, and (g) narrative enquiries. Yin (1994, 2009) classifies them into: (a) experiment, (b) survey, (c) archival analysis (d) history and (f) case study.

According to Hunter and Kelly (2008), the research strategies for the qualitative (constructionist) strategy are grounded theory, case studies, interviews and action research (where action research is just on the border line). These approaches are discussed in detail in the next section.

7.3.4 Qualitative Strategy

In the previous sections, the ontological and epistemological assumptions of this research were clarified. Similarly, it was indicated that the qualitative strategy is the main approach for this study. This section presents a critique on the qualitative strategy and its consideration.

Strauss and Corbin (1998 p. 10) define qualitative research as; "any type of research that produces findings not arrived at by statistical procedures or other means of quantification. Mile and Huberman (1994) claim that qualitative research focuses on naturally occurring, ordinary events in natural settings to demonstrate strongly what "real life" is like. Maxwell (1994 p. 17) also argues that the qualitative method is not only a contrasting method to quantitative in doing the same thing; rather, they have different strengths and logics and are often best used to address different questions and purposes.

The strength in using a qualitative strategy stems mainly from its inductive approach, which focuses on specific situations or people. A perfect example is this study, which focuses on a specific problem within the construction industry (i.e. delivery planning and control). This stance of the present study is contrary to the traditional approaches of planning. The latter is based on statistical procedures, maybe because of the common assumption that all projects[23] are the same. Dainty (2008) established that fewer than 9% of papers published in CME Journal (up to vol. 24) used the qualitative method exclusively. This established the dominance of the quantitative method in construction management; thus, they do not allow managers to really understand their social reality. Easterby-Smith *et al.* (2012) stress that the aim of qualitative research is invention, while its outcome is "understanding". Furthermore, Bryman and Bell (2011) stress that explorative research relies on being qualitative, which is consistent with this study.

In addition, this research focuses on understanding natural reality in the context of construction planning and control. Thus, the experiences of practitioners are vital to the understanding of the problem in totality. This is consistent with the strength of qualitative research. Maxwell (1994 pp. 17-18) discusses the purposes of qualitative research, which best fit this study, and they are summarised below.

I. Understanding the meaning[24], for participants in the study, of the events, situations, and actions they are involved with and the accounts that they give of their lives and experiences. Where the events, situations and actions are the reality the researcher wants to understand.

II. Understanding the specific context within which the participants act, and the influence that this context has on their actions. This enables the researcher to understand how events, actions and meanings are shaped by the unique situations in which they happen.

III. Identifying unanticipated phenomena and influences, and generating new grounded theories about the latter.

IV. Understanding the process by which events and actions take place. This is where the researcher's interest is focused on getting processes that lead to the outcomes.

V. Developing causal explanations. Quantitative researchers tend to be interested in whether and to what extent variance in *x* causes variance in *y*, whereas qualitative researchers are interested in how x plays a role in causing y, what the process is that connects *x* to *y*.

Furthermore, this study deals with a complex issue within complex industry, and aims to develop a holistic technique to enhance the current practice. Mile and Huberman (1994)

[23] Including construction projects, which is, however, people driven compared to other projects.

[24] Meaning denotes cognition, affect and intention normally termed the participants' perspective

advocate that qualitative research data has a richness and holism with the potential for revealing complexity, which provides "thick descriptions" that are vivid, nested in a real context. In conclusion, qualitative research is considered appropriate for this study; hence there is the need to discuss how to implement qualitative research.

7.3.4.1 Implementing Qualitative Research

Bryman and Bell (2011) present a generic model for implementing qualitative research. They presented six main steps in conducting qualitative research, as shown in figure 7.2 below. This figure served as a guide template in conducting this research. This approach presented by Bryman and Bell (2011) is similar to what Strauss and Corbin (1998) describe as grounded theory. According to Strauss and Corbin (1998 p 12), grounded theory means theory that was derived from data, systematically gathered and analysed through the research process.

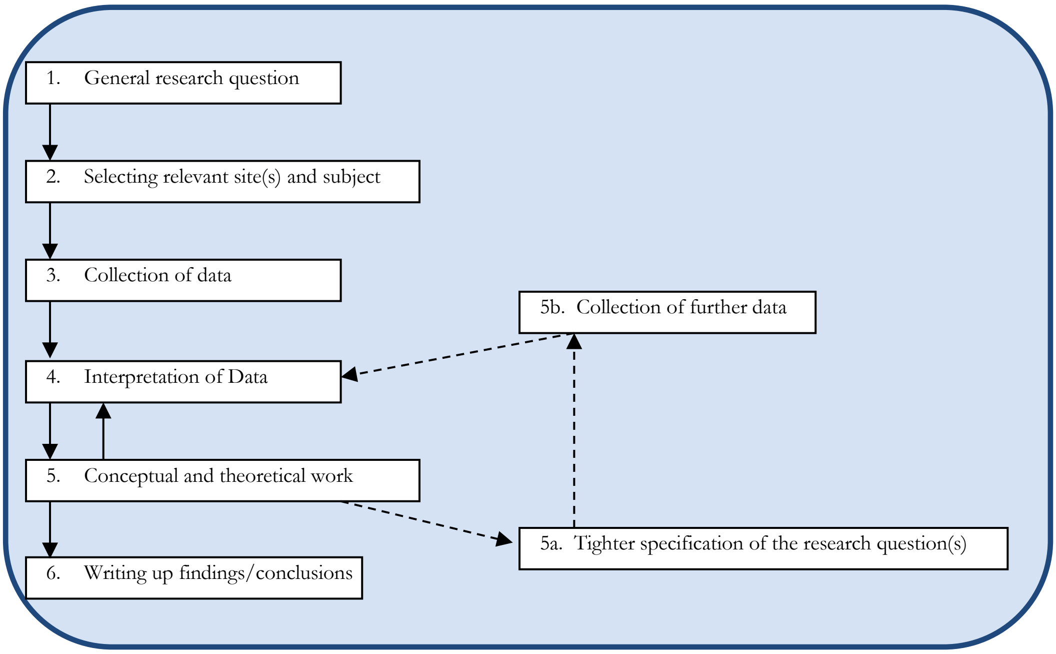


Figure 7. 2: Main steps of Qualitative Research

7.3.4.2 Limitations of Conducting Qualitative Research

As with all other strategies, a qualitative method has its own criticisms especially from the opposing camp[25]. Bryman and Bell (2011) present these criticisms as; being too subjective, difficult to replicate, problems of generalisation and lack of transparency. These criticisms are generally based on a particular method employed but not necessarily associated with all

[25] Where the opposition camp are the quantitative (positivist) researchers

qualitative methods. Similarly, Easterby-Smith *et al.* (2008) presented the strengths and weaknesses of using the qualitative (interpretivist) approach as shown in table 7. 5 below.

Table 7. 5: Strengths and Weaknesses of using Qualitative (Constructionist) approach

Strengths	Weaknesses
Good for process and meanings	Can be very time consuming
Flexible and good for theory generation	Analysis and interpretation are difficult
Data collection less artificial	May not have credibility with policy maker (based on subjective opinion)

The researcher being aware of the weaknesses of using this approach put measures in place to mitigate these issues (predominantly using the recommendations of these studies: Yin 2009, Easterby-Smith *et al.* 2012, Bryman and Bell 2011, Strauss and Corbin 1998, Knight and Ruddock 2008, and Farrell 2011).

7.3.4.3 Evaluation of Qualitative Strategies

Four main qualitative strategies, as discussed earlier, were evaluated for this research. This section presents the discussion of the strategies and appropriate choices for this research.

Action Research

This is an approach in which the action researcher and a client collaborate in the diagnosis of a problem and in the development of a solution based on the diagnosis (Bryman and Bell 2011 p. 413). This means the researcher and a client work together in solving a particular problem. There is always a loop in the data collection, testing (validating) and improvement where possible. As Smith (1995) stressed, action research involves an iterative process of problem identification, planning, action and evaluation. In that stance, the researcher must be greatly involved in the settings of the research organisation to have a particular understanding of the problem to be investigated. Bryman and Bell (2011 p. 415 citing Eden and Huxham 1996) claim that the theory generated from action research is "grounded in action". They believe that action research allows a rich insight into practitioners' specific problems. However, critics claim it lacks repeatability and has a consequent lack of rigour; it also concentrates mainly on an organisation's action at the expense of research findings (Bryman and Bell 2011). Hunter and Kelly (2008) in their categorisation of research methods placed action research on the borderline between positivism and constructivism (see figure 7.1).

Action research is deemed not fit for this study. This is due to mainly the practical restrictions of using this approach. Although the researcher has experience in the field of study, he has no prior involvement and pre-arranged organisation to conduct the investigation. Furthermore, this research is not particularly centred on a specific organisation. It is therefore discarded as the primary approach for this research.

Grounded theory

The often cited grounded theory was introduced by Glaser and Strauss (1967). Hunter and Kelly (2008 p. 86) explain that grounded theory is a "methodology that involves a systematic process of gathering and analysing a finite set of data to develop a theory based upon the data". This description of grounded theory is in keeping with Strauss and Corbin's (1998) definition of grounded theory. The word "grounded" was used to denote that theory is drawn from the data but not from speculation or preconceived ideas. Soon after Glaser and Strauss's publication, both had different ideas of grounded theory moving forward. Glaser believes it is inductive, whilst Strauss and his colleague Corbin believe it deductive. Hunter and Kelly (2008) present the differences between the Glaser, and Strauss and Corbin stances on grounded theory as shown in table 7.6.

Table 7. 6: Variation of stances between Glaser, and Strauss and Corbin (Source: Knight and Ruddock 2008 p. 88)

Characteristics	**Glaser**	**Strauss and Corbin**
Preconceived theory	No	Theoretical statement used
Inductive/deductive approach	Inductive	Deductive
Use of literature review prior to theory development	No	Yes
Technique focused	Creative approach	Linear approach prescriptive in technique
Level of detail	Area of study	Phenomenon or issue of study
Coding: open, axial, selective	Open and selective	open, axial, selective

Heath and Cowley (2004) suggest that if the combination of the approaches is used "the boundaries between the two should be maintained rather than a synthesis attempted". Hunter and Kelly (2008) concluded that the grounded theory approach is inductive research, which is contrary to the traditional scientific approaches. The data collection methods used for this approach are normally interviews, field notes and existing literature. A researcher may use interviews in case studies to generate theory, which will presume that it falls under grounded theory. However, the collations between the data collection and analysis differ. Strauss and Corbin (1998) believe that the data collection, analysis and eventual theory stand in close relationship to one another. This means data collection should be conducted in conjunction with the data analysis. Strauss and Corbin (1998 p. 13) stress that "analysis is the interplay between researchers and data". This makes the researcher highly involved in the process, thus making the data collection subjective and biased. Dainty *et al.* (2000) identify the common difficulties related with grounded theory as; data over loaded, complex procedures and lengthy analytical phase.

In grounded theory, generating theory remains the main focus of contributing knowledge in the field. In as much as this study seeks to develop a new theory, the main purpose is to use the theory to develop a holistic applied planning and control technique. It is therefore inappropriate to solely adopt grounded theory; however, its analytical technique is feasible for this study.

Interview

The types of interviews may vary from author to author, for example, Yin (2009) classifies them into structured, focused and in-depth interview, which is parallel with Bryman and Bell (2011) types of structured, semi-structured and unstructured respectively. According to Bryman and Bell (2011), there are basically two types of interviews, i.e. structured and qualitative interviews. They argue that structured interviews are classified under the banner of quantitative and the positivist approach. In this approach, the researcher's interest lies in quantifying the views of the interviewees, which does not fall under the banner of this research strategy, which is qualitative.

Bryman and Bell (2011) assert that there are two main types under qualitative interview, that is, semi-structured and unstructured. They describe the unstructured interview as similar in character to conversation. In this case, the interviewer may ask just a single question but allow the interviewee to freely respond with the interviewer responding to vital points and seeking clarification accordingly. Yin (2009) argues that an interview is a guided conversation where the interviewer follows a line of inquiries. Yin (2009) suggests that interviews have two main operative purposes, (1) satisfying the needs of the inquiry and (2) putting forth friendly and nonthreatening questions simultaneously. One of the main limitations of this approach is its inability to be replicated.

In a semi-structured interview, the interviewer has a list of questions and specific areas of interest to his enquiry. These lists of questions are carefully prepared and it is called the interview guide. However, questions that were not written in the guide could be asked as a follow up to the interviewee's answers. Both approaches are similar in their flexibility.

The qualitative interview approach (semi-structured and unstructured) is deemed appropriate for this research. As this research seeks to investigate industrial problems which require some in-depth interviews and focused interviews, according to Yin (2009), which is parallel to Bryman and Bell's (2011) unstructured and semi-structured interviews (all together seen as qualitative interviews). This strengthens the source of evidence and enhances the reliability of the findings. Again, interviews remain a popular method for data collection within the field of this study, according to Haigh (2008).

Case Study

The third method reviewed was the case study method. Proverbs and Gameson (2008) describe case study research as extremely applicable to a project driven industry, which is made up of different types of organisations and businesses. Notwithstanding this strength, its application in construction management research is fairly low as compared to other fields of research. This could be due to many factors but is mostly due to the dominance of other approaches as discussed previously. The case study method is widely utilised in social science research and has, in many situations, been used to investigate individual, organisational, social and/or political phenomena.

The case study method is an empirical inquiry that investigates a contemporary phenomenon within its real-life context. It is helpful especially when the boundaries between the phenomenon and context are not clearly evident. Arguably, a case study is not essentially qualitative in nature, but it is mostly used in qualitative research within construction management. Case study was deemed appropriate in this present research.

In conclusion, mapping the aim and objectives together with the research questions, case study and interviews are the appropriate strategies for this research. Consequently, the next section discusses in detail the research tactics adopted for this research and how these fit into the research questions. Robson (2011) asserts that research tactics in the "real world" are the specific methods used for the particular investigation.

7.3.5 Research Method

The research method is defined as a technique for collecting data, which can involve specific instruments, such as questionnaires, interviews, observations, and documentary data (Bryman and Bell 2011). Yin (2009), and Strauss and Corbin (1998) argue that the type of research question posed is one of the main criteria for choosing research method(s). Again, Yin (2009) argues that a research question is probably the most important step to be taken in a research study. Therefore, from the research aim and objectives, two main questions were formulated. The questions are:

Q1 What are the industrial problems and challenges associated with project planning and control, and what are the essential drivers and flows required for successful task completion?

Q2 How can the project planning and control problems identified in Q1 be addressed in an innovative system to enhance the current practice?

Both Neuman (1994) and Robson (2002) agree that explorative research like this addressing that "what" question normally uses the qualitative approach. Similarly, Yin (1994, 2009) argues if the "what" question is exploratory research, any strategy could be used. The case study is highly relevant to an industry that is project-driven (Proverbs and Gameson 2008) and it is a preferred method when "how" or "why" questions are being posed (Yin, 2009). This fits the subject area and the questions and/or aim of this research.

However, choosing a method may be beyond the criteria of the type of research question (say, what, how and why) posed. All methods have their advantages and disadvantages; however, choosing the appropriate method is not only to suit the research problem or question but also how well it fulfils the practical limitations that are undoubtedly set on the study e.g. time, resource constraints and access to data (Farrell 2011). The method adopted should be adequately applied so that important elements are not missed out or constrained, thus suiting the problem under investigation.

7.3.5.1 Consideration of methods within the considered strategies

This study attempts to address practical problems to enhance the current practice. In addition, this research develops a holistic but innovative planning and control system to address the current problems as well as to evaluate it to ensure it has achieved the research aim and objectives. This required collecting data using diverse methods.

Strauss and Corbin (1998) argue that the methods used to collect qualitative data include, interviews, observations, documents, and records. They argue that qualitative study is more analysed by interpreting the data. Although they did agree that some of the data collected may be quantified as with background information or census, they stressed that the bulk of the data should be interpreted. As discussed in the previous sections above, qualitative interviews (semi-structured and unstructured), and case study were chosen as the appropriate approach for this research. Also, interviews, observations and documents data collection methods were considered as appropriate within the case study approach to meet this study's aim and objectives.

Interviews

There are many forms of Interviews, which include open-ended, structured, focused, and survey-like. However, according to Yin (2003 and 2009) and Robin and Robin (2004) the most commonly used are the semi-structured interviews. Using semi-structured interviews, the interviewees are asked questions about a topic of the study following a pre-defined interview protocol. The interview processes are flexible as new questions can be brought up during the course of the interview as a result of what the respondent says. The interview process is conversational and that allows follow up questions and both way discussion about the topic (normally the interviewer's view is kept vague). This generates other topics and links that emerge in the course of the interview. Interviews possess the advantage of being targeted and the focus is directly on the selected topic and its understanding. Table 7.7 presents the strengths and limitations of using qualitative interviews.

Table 7. 7: Advantages and Limitations of Interviews (Initially presented by Robson (2002) pp 269-290 and also summarised by Recker 2008 p. 109)

Advantages	Limitations
Can be used for thematic and issues analysis	Time-consuming in terms of actual interview and corresponding analysis
Useful for small samples (that is preliminary fact finding)	Training of interviewers (sensitivity, interpersonal skills) is preferable
Allows subjects to speak for themselves	Usually a need for transcripts
Allows teasing out underlying issues	Potential lack of precision
Enables gathering of rich and deep knowledge	Need for rigorous thematic analysis e.g. by means of computer-based tool support
Can serve as foundation for extending the study, e.g. formally test the emergent patterns and relationships	Potential lack of trust and time

Semi-structured interviews are one of the most important data gathering tools in qualitative research. The semi-structured interview helps the researcher to compare data across sources, which is useful in answering variance questions. According to Yin (2009), methodologies for interviews include ethnographies, action research, and ground theory studies; however, it is most used in case studies research. Saunders *et al.* (2009) compare the uses of different types of interview as shown in table 7.8. This establishes that explorative research utilises both unstructured and semi-structured interviews; hence, this present research follows suit and adopts both the semi-structured and unstructured method.

Table 7. 8: Uses of Different types of Interview (Saunders *et al.*, 2009 p. 323)

Type of interview	Explorative	Descriptive	Explanatory
Structured		More frequent	Less frequent
Semi-structured	Less frequent		More frequent
Unstructured	More frequent		

Case Study

The consideration of case study stems from the importance of establishing an informed all-inclusive opinion about the nature and complexity of a natural phenomenon. Proverbs and Gameson (2008) argue that a case study draws from multiple source of evidence and also shows both in-depth and broad understanding of the related issues and context. In addition, the case study method provides a variety of data collection tools, which makes the study less vulnerable to the practical issues concerning time. Yin (2009 p 102) categorised these sources of evidence into six. These are, (1) documentation, (2) archival records, (3) interviews (4) direct observations, (5) participant observation, and (6) physical artefacts. Mapping these sources of evidence to the present study, documentation, interviews and direct observations were deemed applicable to the aim, objectives and research questions. Therefore, the remaining three methods were considered inappropriate to this particular study. This is because archival records deal with information of the past. Participant observation focuses on the behaviours and motives of participants, whilst physical artefacts are concerned with the physical and cultural parts of the case. Table 7.9 presents the strengths and weaknesses of the sources of evidence deemed appropriate and used for the case study strategy.

It must be acknowledged that due to the case study's ability to utilise many methods, critics have considered it methodologically weak. It is claimed not to be representative and is open to bias. Yin (1993, 1994, and 2009) acknowledged these criticisms, and to mitigate them he advocated that the research has to be theoretically grounded and should have a research design to meet these criticisms. Again, according to Yin (2003), multiple sources of evidence improve findings, interpretation and conclusion. Therefore, the researcher uses the multiple case studies approach to increase and strengthen the findings of the study.

Table 7. 9: Strengths and Weaknesses of the source of evidence used for case study (Adopted: Yin 2009, p 102)

Source of evidence	Strengths	Weaknesses
Documentation	• Stable - can be reviewed repeatedly • Unobtrusive – not created as result of the case study • Exact – contains exacts names, references, and details of an events • Broad coverage – long span of time, many events, and many settings	• Retrievability- can be difficult to find • Biased selectivity, collection is incomplete • Reporting bias- reflects (unknown) bias of author • Access-maybe deliberately withheld
Interviews	• Target-focuses directly on case study • Insightful – provides perceived causal inferences and explanations	• Bias due to poorly articulated questions • Response bias • In accuracy due to recall • Reflexivity – interviewee gives what interviewer want to hear
Direct observations	• Reality – covers events in real time • Contextual – covers context of "case"	• Time consuming • Selectivity – broad coverage difficult without team of observation. • Reflexivity – event may proceed differently because it is being observed. • Cost – hours needed by human observers

7.4 RESEARCH PROCESS

The previous sections of this chapter were concerned with philosophical assumptions and research design mainly. This section focuses on the research process adopted for this study. It presents the relationship of the strategies, methods with the research objectives and questions.

Yin (2009) asserts that a research process is the logical sequence that connects empirical data to a study's initial research questions and, ultimately, to its conclusions. Therefore, this research used the following five separate, yet, interrelated and overlapping stages. The first stage is based on the existing knowledge, while the other four are the contribution to knowledge. The following are the main stages:

1. Literature Review
2. Conducting interviews (1)
3. Using multiple-case studies
4. Interviews (2)
5. Develop Total Planning and Control (TPC) systems and its implementation
6. Establish an expert evaluation group to offer feedback

Table 7. 10: Realisation of Research Objectives

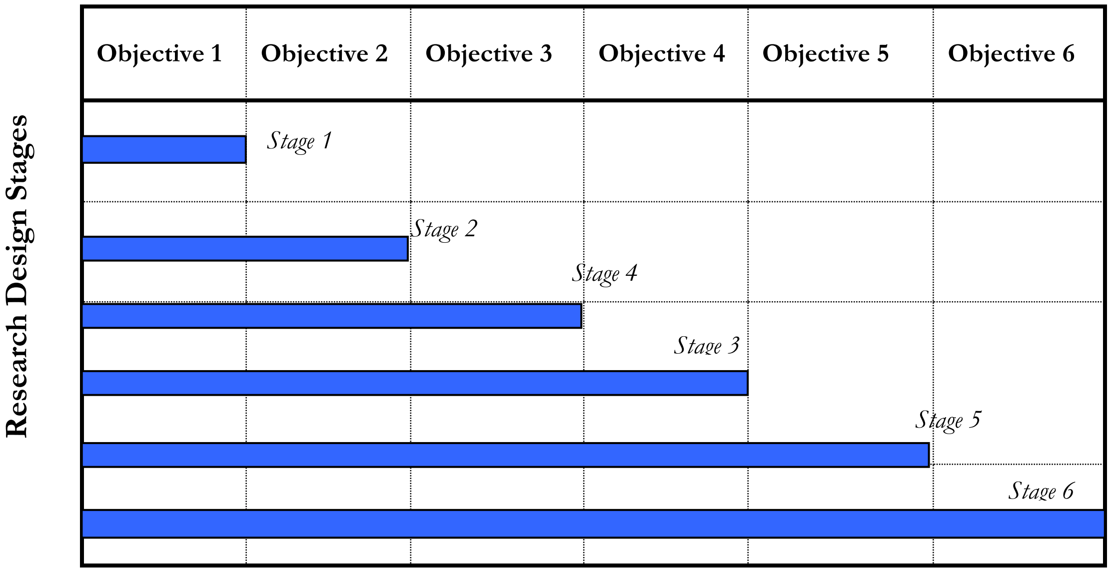
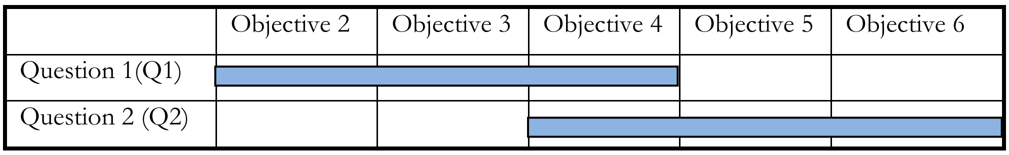


Figure 7.10 presents the realisation of the research objectives. This aligns the reseach design along with the research objectives. It shows that stage 1 will completely answer objective 1; stage 2 answers objective 2; stage 3 responds to objectives 3 and 4, whilst stage 4 answers objective 3; and stages 5 and 6 are meant for objectives 5 and 6 respectively. Similarly, figure 7. 11 shows how the research questions are aligned to the research objectives. This illustrates that question 1 was derived from objectives 1, 2, 3 and 4; similarly, question 2 from 1, 4 and 5. This shows that objective 1 and 4 are common between both questions.

Table 7. 11: Realisation of Research Questions and Objectives



A more detailed representation is shown in figure 7.12, which shows the realisation of research objectives and questions and the research methods. The fulfillment of the reseach objectives and questions is clearly presented and deemed approrate fo this study. The next section is a detailed representation of how each stage was conducted.

Table 7. 12: Realisation of Research Questions and Objectives

Research method				Question 1			Question 2	
				Objective 2	Objective 3	Objective 4	Objective 5	Objective 6
Data Collection	Literature review							
	Semi structured interview 1							
	Case Studies	Observation						
		Documentary						
		Interviews	Unstructured					
			Semi-structured					
	Semi-structured interview 2							
Data Analysis	All data Analysis							

7.4.1 Stage 1: Literature review

Hart (1998 p. 13) suggests that a literature review is "the selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed". Collis and Hussey (2009) also advocate that a literature review is an evaluation of the available body of knowledge on a topic, which forms a basis for investigating the topic and guides the researcher to identify a gap in the existing knowledge. Bryman and Bell (2011 p. 91) summarise a literature review as a vital part of every research. They ascertain that this is because, firstly, it ensures the researcher knows what already exists or is known about the area or the topic and, secondly, develops the argument about the significance of the research and where it leads. Hart (1998) suggests that the aim of a literature review is to demonstrate skills in library searching; to show command of the subject area and understanding of the problem; to justify the research topic and also the design and methodology. He stresses that a literature review should be an analytical synthesis, covering all known literature on the problem. It should be a summative and formative evaluation of the previous study on the problem. Therefore, the researcher ensured that all these have been fully covered in the literature review chapters (chapters 2 to 6, see figure 7.3).

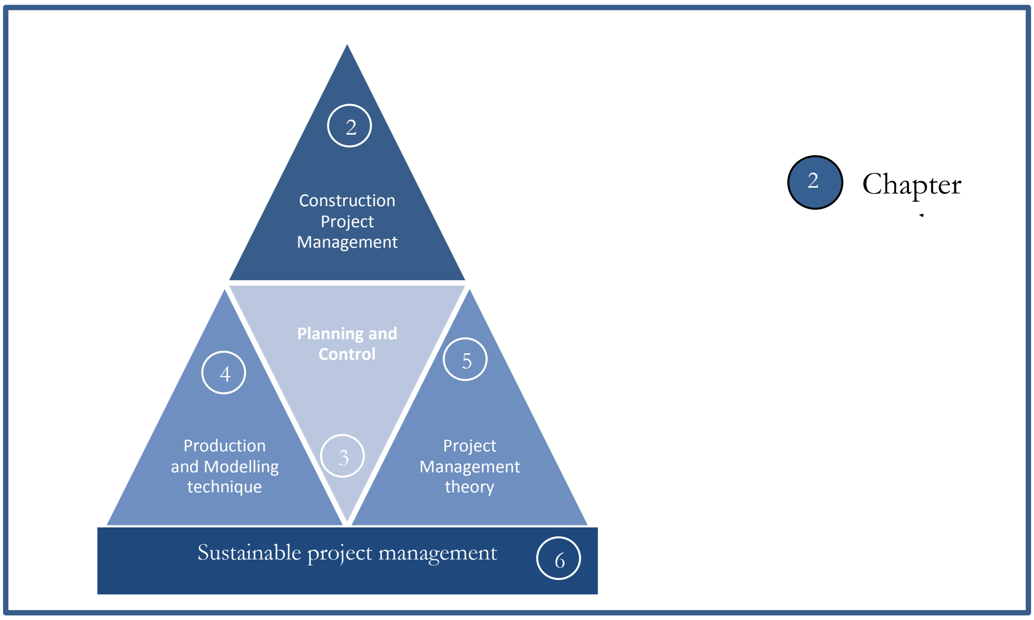


Figure 7. 3: Patch Relationship of the Literature Review

In the course of this research, the literature review process runs through the entire duration of the study, where a continuous critique of both published and unpublished studies was conducted. This ensured that relevant materials were not over looked and were up to date with knowledge in the field of study. The researcher endeavoured to the use different sources to ensure that every relevant study and work in the field was reviewed. The sources include examining academic and technical journals, technical reports, articles, conference proceedings, theses and dissertations, text books, case studies, internet and websites, government and professional guidelines, commercial CD-ROMs as well as library search catalogues. Key words and phrases were developed and inputted into search databases including Google scholar, Zetoc, Compendex and the Nottingham Trent University database. This brings out, where possible, many resources but the advanced search allowed the researcher to streamline the data. Many studies were downloaded from these databases and others that could not be downloaded were loaned from the libraries (including external libraries such as inter library loans, and the British Library). The review starts with an overview and then focuses on discussion of previous studies and conclusions drawn from the review of each chapter. All the studies used in this research have been cited in the references and others that were associated but not cited were included in the bibliography.

7.4.2 Stage 2: Interviews (1)

Fellows and Lui (2008 p. 153) stress the importance of using interviews. They argue that the interview is used where the researcher is interested in the depth of study as compared to surveys. This is in keeping with the aim and objectives of this study.

Stage 2 of the research process was the conducting of semi-structured interviews. This commenced after the initial literature review (i.e. stage 1 above) and identifying knowledge gaps. This stage was designed to answer research objective 2, which is to investigate the understanding of some key terminologies in the context of construction project management. Firstly, there is an assumption in existing project management literature that all projects are the same, including construction projects; thus, the researcher attempts to investigate and address this issue. In addition, Construction project management has been adopting methodologies from different fields. Hence, there was a gap to understand how these methodologies fit into construction project management. Secondly, as this research aims to develop a planning and control technique through the incorporation of production models, it was important to investigate who would use this technique apart from planners? Existing literature suggests that planning is predominantly done by planners. However, there are other management roles that are similar, thus needing more investigation. There was the need to investigate the factors or roles within project management and the techniques or tools used in the country of this study, the UK. Thirdly, what is the understanding of construction as production and other modelling technique, especially IDEF0, since it was considered an appropriate modelling technique for this research. The interview process shown in figure 7.4 basically involved six stages, planning, interview protocol, sampling, interview sessions, note taking and transcription, and analysis and sharing (writing up or publishing). This process is discussed below.

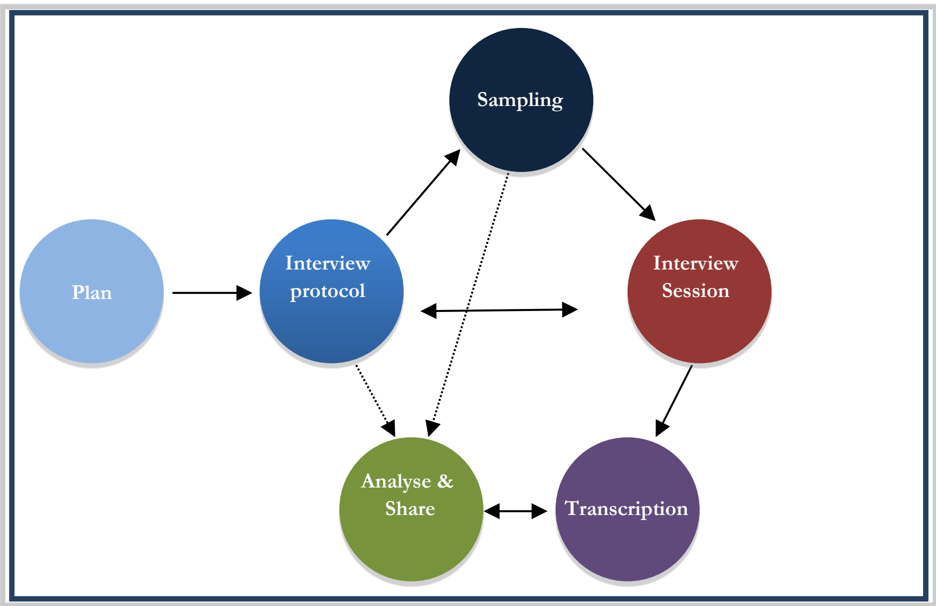


Figure 7. 4: Interview Process

7.4.2.1 Interview plan

The interview plan focuses on the decisions on the interview process and how the interviews will be conducted, as illustrated in figure 7.4 above. At the planning stage, the researcher considered each process and how it could be achieved as well as achieving the aim and objectives of the interview. The aim and objectives for the interviews were reviewed and mapped against the process. Where possible the researcher acquired the required skills and competence to conduct each process successfully. This includes the decision to pilot the process with a construction management student and with the PhD supervisory team. In addition, the researcher ensured that the previous studies that adopted similar techniques have been reviewed and their strengths and weaknesses identified.

7.4.2.2 Interview Protocol

The interview protocol provides a framework and a guide for the interviews. Given that the interview protocol is used in a semi-structured interview, it gives it an edge over other interviewing methods. These advantages include but are not limited to the following:

- They are less intrusive to those being interviewed because it encourages bidirectional conversation.
- They can be used to confirm what is already known whilst at the same time providing the opportunity for learning. Normally, information gathered during the interview will offer the reasons for the answers but only give answers to the questions.
- Semi structured interviews allow respondents to discuss normally more sensitive issues due to personal conversations rather than a structured interview.

The interview protocol is vital for any interview process as it allows the researcher to consider the questions, techniques and ethics required to conduct the interview. This view has been stressed by Knox and Burkard (2009) who argue that the interview is concerned with understanding the experience of other people and the meaning they make of their experience. Again, the interview protocol helps to save time in achieving the aim and objectives, ensures that vital questions and/or subjects are considered, and ensures the process is well organised. The type of interview used was semi structured, where the questions include open endings and few close endings. The questions asked were the same for all respondents; however, other questions were asked as a result of the respondent answer or explanation for clarification.

The protocol was designed to include the consent arrangement, general details of the interviewee (which include years of experience, academic and professional qualifications, and affiliations) and the main questions. It was concluded with a closing down question and a thank you remark (see appendix 4 for copy). The main questions were divided into three main parts. Part one seeks to investigate the definition and understanding of some terminologies, roles and/or factors and techniques (tools) within project management. Part two is about the differences of responsibilities among the top management (specifically, contract(s) manager, project manager and construction manager) with construction industry. The third part was to investigate their respective understanding of construction as a production and modelling technique (especially IDEF0). The consent form was clearly read out to each interviewee with him/her given a copy before the actual interview commenced. This clearly states the aim of the interview as well as the rights of the interviewee. This was piloted and modification was made before the main data collection.

7.4.2.3 Sampling

Saunders *et al.* (2009) suggest that the sampling methods are mainly in two groups, either probability (also called representative) sampling or non-probability (also called judgemental) sampling. Probability sampling is concerned with estimated characteristics of a population and is normally associated with survey and experiment (quantitative approach). On the contrary, non-probability is associated with qualitative approaches.

This research being qualitative in nature considered non-probability sampling. Saunders *et al.* (2009) categorised non-probability sampling into five types: these are, quota, purposive, snowball, self-selection, and convenience sampling. Saunders *et al.* (2009) advocate that quota sampling is used for interview surveys. Bryman and Bell (2011 p190) describe the quota as the "almost as good as probability sample". Purposive sampling, also called judgemental sampling, ensures that the researcher selects cases that enable him/her to answer his/her research question(s) (Saunders *et al.* 2009). This sampling is normally utilised within the case study approach, where very small samples are required. This sampling method is used for research that focuses on: key themes, in-depth, importance of the case and are illustrative. It is the common method used for qualitative research. Snowball sampling is used where it is difficult to identify members of the desired population. Therefore, the researcher needs to identify one or two cases which will lead him/her to identify further cases. In contrast, the self – selection sampling is typically individuals who show their desire to take part in the research through publicity of the need for the cases. Finally there is convenience sampling, which is concerned with the cases that are easiest to find typically through random selection. Among all these types of sampling, purposive and snowball were considered applicable to the objectives of this stage and were consequently used.

Three sampling groups were identified and these encompassed, senior members in academia, senior industrial practitioners and university students involved in construction project management. These groups were carefully considered to investigate the general perspective on the field. These groups were chosen so that the researcher will have an unbiased understanding from university students (who are the future of industry and they learn from both academics and practitioners), academics (facilitators) and industrial practitioners (implementers). Purposive sampling was used for both selections of academics and practitioners. The criteria for sampling the industrial practitioners were similar to that of the academics. The minimum criteria for selecting the academic participants included that, the interviewee should:

- Be a senior member (lecturer or reader in a UK university)
- Be involved in PM (teaching and assessing construction project management module)
- Have at least five years' experience
- Have awareness of the current issues within the construction industry especially regarding PM

The researcher, being a chartered builder, and a professional project and commercial manager, used his network to identify prospective interviewees.

Snowball sampling was used for selecting student participants. The criteria for student interviewees were that the student should be in a construction PM course and if an undergraduate, however, he/she should be least in the second year. The academics and practitioners made some recommendation for participants.

The sampling size was not predetermined as opposed to quantitative research. The interviews were carried out to a point that the desired data saturation was achieved. In broader terms, data saturated means there was no new information or themes being collected.

Initially, thirty interviews were conducted, which included ten academics, ten industrial practitioners and ten university students. Then, further interviews were conducted with five academics and five industrial practitioners, in which data saturation was achieved. Therefore, a total of forty interviews were conducted with fifteen academics, fifteen industrial practitioners and ten university students. This is graphically represented in figure 7.5. Participants were contacted via telephone and emails before the interview sessions.

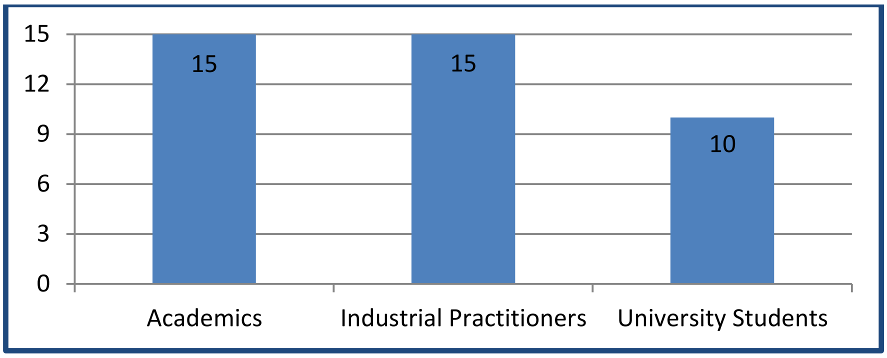


Figure 7. 5: Grouping of the Interviews for Stage 2

The experience range among the interviewees was between 5 to 45 years (total of circa 626 years amongst them). Out of the fifteen academics interviewed, six have achieved PhD; six have a Masters degree and three have a Bachelor degree. Similarly, among the fifteen practitioners interviewed, three had a PhD, five had a Masters degree (MSc/MA) and six had a Bachelors and one had a Higher National Certificate (HNC). The students were made up of five second year bachelor students and two in third year (seven in total), two masters and one PhD student (this is represented in figure 7.6)

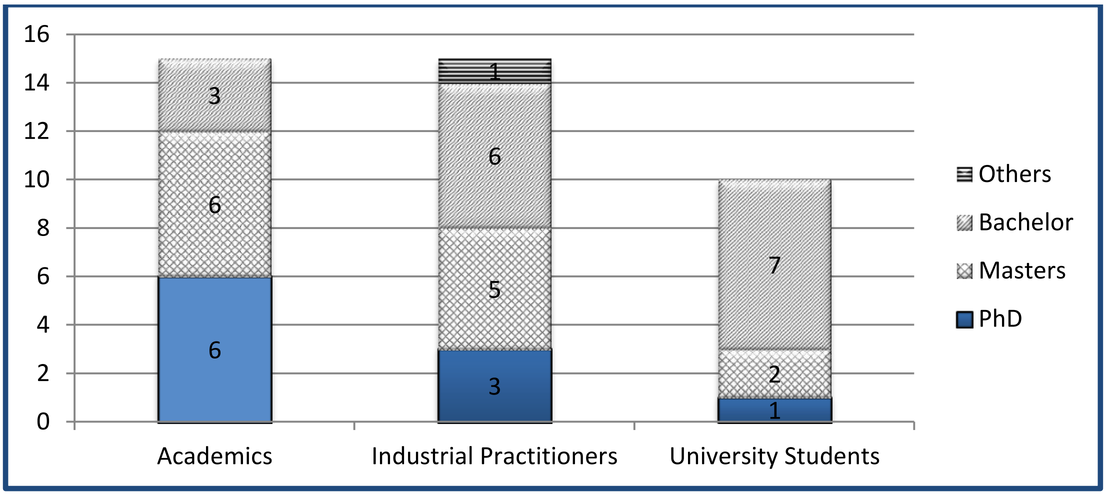


Figure 7. 6: Interviewees Educational Qualification

Most of the interviewees, academics and practitioners, have professional qualifications, predominantly from Chartered Institute of Building (CIOB), Association for Project Management (APM) and Royal Institution of Chartered Surveyors (RICS). Details of the participant information are presented in the next chapter.

7.4.2.4 Interview Session

Saunders *et al.* (2009, p 324) established that "managers are more likely to agree to be interviewed, rather than completing a questionnaire where the interview topic is seen to be interesting and relevant to their current work". Therefore, the researcher ensured that the objectives of the interview where clearly communicated to the interviewees, which was found to be very interesting. The interviews were conducted in a place of convenience for both the interviewee and the researcher, normally, at the interviewee's meeting room (at their office and/ or university).

The interview session commenced with an introduction from the researcher and the reading of the consent form. The researcher assured the interviewees, from the list on the consent form, that they have the right to withdraw at any stage of the interview without being penalised or disadvantaged in any way; that the information collected will be confidential and agreed not to be disclosed to any other third party; however, the researcher will use anonymised quotes in this thesis and other publications. In addition, the researcher assured the interviewees that the anticipated length of the interview was not going to exceed 60 minutes. The actual length of all the interviews was between 30 minutes to an hour depending on the interviewee's enthusiasm to elaborate on the subject. The average length of the interviews was a little short of an hour (51minutes totally up to 2,040 minutes).

The approach of the questioning was based on the interview protocol. The researcher started with the general questions, which included the interviewee details. Then, after the icebreaking general questions, which allowed the interviewees to loosen up into the main interview, interviewees were asked a number of detailed questions. The understanding and definitions of some key PM terminologies were explored. This included their understanding of 'what is a project', 'what is a construction project', 'what are the differences between them' and 'what is construction PM'. The interview also covered some specific questions, such as the roles and factors within project management, the tools and techniques used or available, and the difference between the top managerial roles in construction. The final part of the interview explored construction as production, and the knowledge and understanding of modelling techniques. The interviews were concluded with running down questions, which included, in one or two words, describe project and project management in the context of construction.

The researcher ensured that the interviewees were comfortable in their perspective and reflecting through their experience. The interview progress was flexible and during the course of the interview, some questions emerged as a result of an interviewee's answer. The interview process was conversational that allowed follow up questions and both way discussions about the topic. This generated other topics and links that emerged in the course of the interview. The most common comment amongst interviewees was, "*some of the questions seem very simple and fundamental but hard to explain in relation to construction*". In this response, most of the interviewees insisted they want to see the final results of the research. This was a good and encouraging comment that shows that the investigation of the subject is long overdue.

In the course of the interviews, notes were carefully taken by the researcher and follow up questions were asked where the interviewee did not appropriately cover the topic. In a few cases, the interviewee wanted to express him/herself by using sketches/diagrams; the researcher gave them the opportunity to do so in his notebook.

The interview was conducted until all points were fully covered during the session. The entire interviews attained the saturation point, which prompted the researcher that the objectives have been achieved.

7.4.2.5 Transcription

All the interviews were carefully transcribed. However, not all of the interviews were audio recorded. The researcher noticed during the first few interviews that some of the participants were not comfortable with the recording due to many factors. These factors included their position, their relationship with the research supervision team and that sometimes they wanted to change their answer to a particular question(s). This prompted the researcher to adopt two approaches to transcription that achieved the same results. One of the approaches used was transcribing during the course of the interview and reading out to the interviewee for approval and amendment where possible. In contrast, those who were audio recorded were carefully transcribed as soon as possible after the interview session. The former approach was very tedious but saved time in the long run in the analysis due to the type of questions being asked; whereas, the latter was found to be very time consuming. It must be acknowledged that it was a really challenging but appreciated learning process. It was challenging in the sense that the researcher should be very attentive and quick in transcribing, whilst appreciating the learning in the process.

7.4.2.6 Analysis and Sharing

The data collected were qualitatively analysed. The analysis was to collate and synthesise the data collected through the interviews as well as the existing knowledge. The analysis focuses on the use of conceptualisation. Saunders *et al.* (2009) consider this type of analysis that is based on developing a conceptual framework as inductive and a grounded approach. Hunter and Kelly (2008) claim that the grounded approach is a form of content analysis, where coding is used for the analysis. There are three different types of coding within this approach. These types are open, axial and selective coding. Open coding comprises of defining the codes, axial is concerned with relating the properties to categories, and selective focuses on the relationships and commonalities that lead to the development of the theory (Bryman and Bell 2011, Strauss and Corbin, 1990 pp 61 – 116). The difference between the grounded approach and other qualitative analysis methods is that the grounded approach focuses on developing theory (grounded theory has been discussed earlier in this chapter).

Saunders *et al.* (2009) categorise qualitative analysis processes in three main types, that is, (1) summarising (condensation) of meanings; (2) categorisation (grouping) of meaning; and (3) structuring (ordering) of meanings using narrative. Summarising encompasses condensing a large amount of text into a few words (p 491); categorisation comprises developing categories and subsequently attaching these categorises to meaningful chunks of data (p 492); and structuring using narrative involves the organisation of data both temporally and with regards to the social or organisational contexts of the interviewee and usually the data collection method is in-depth (unstructured) interviews (p 497).

In the light of these, the researcher adopted a bespoke grounded approach for this analysis that allowed for a literature review before the data collection. In addition, the processes used were summarising and categorising of meanings. The literature review process and data collection process have been discussed in the early section in this chapter. Thus, this section focuses on the analysis process of stage two of the research process.

The researcher initially attempted to analyse using Nvivo[26] for the interview data, due to its recent popularity with construction management researchers (King 2008). However, given the objectives for this stage and type of interview questions, the researcher deemed that manual analysis is appropriate for this stage. Furthermore, the data collected was not very large in volume, thus doing it manually was appropriate. This ensured the collecting of data, organising and thinking stages were conducted solely by the researcher.

The analysis process started with the coding of the participants' transcriptions and categorising them into their respective groups, for example, P01, S01 and A01. The first letter represents the group (A denotes Academics, P is Practitioners and S is for Students) and the numbers are the numbering systems. This was done so that all participants' views were anonymously represented in this thesis. This was followed with the summarising process. The

[26] Nvivo is computer assisted qualitative data analysis software (CAQDAS).

researcher then categorised each interviewee response using the interview guide. For example, all responses for 'what is a project?' were grouped using a table (for each group of interviews) for visual representation, which makes it easier to analyse. In almost all the cases, the data fitted into a specific category. This led to interpreting the data across the three groups. Common themes were then identified hierarchically, and later some of the themes and codes were amalgamated. The relationship of the themes and categories were explored and interpreted. The results, categories and sub categories are presented in chapter 8 of this thesis.

After the analysis, the data were interpreted in detail and discussed along with the existing literature. This led to the conceptualisation of construction project management and other established factors which streamlined the other stages of this research. The interpretation and discussion is then shared coherently and integrated to form chapters 8 and 9 of this thesis. The researcher ensured that the validation process for the qualitative data collection process and specifically for this research was adhered to.

7.4.3 Stage 3: Multiple Case Study

Stage three of this research process focuses on achieving up to the fourth objective as discussed above. This is the core of the research data collection for the development of the model for planning and control. A multiple-case study was adopted as the strategy for this stage to achieve the study's objectives. The usefulness in the case study approach is its ability to obtain deep and raw results in a specific field as compared to other techniques. In addition, a case study gives an in-depth investigation of a particular problem within a particular field (Fellows and Lui 2008). A multiple case study is generally more robust as compared to a single case. Moreover, it improves the results and findings for generalisation. Yin (2009) also advocates that multiple sources of evidence improve findings, interpretation and conclusion.

Sampling of the cases targeted the prominent construction companies in the UK, which include engineering companies and small companies (subcontractors). The author and his supervisory team ethically used their contacts to get access to the case study companies as recommended by Yin (2003). Four case studies were conducted separately yet overlapped.

The methods used for the data collection were unstructured interviews, semi-structured interviews, documents and observation. The researcher designed the case study research process to achieve the objectives of the process and the study as a whole. The next section discusses this process in detailed.

7.4.3.1 Case Study Planning

At the planning stage, the researcher was concerned with how the entire case study process should be designed and conducted. Yin (2009) advocates that in several occasions, case study researchers have been criticised as being sloppy and not following a logical process. Therefore, the researcher, having reviewed the strengths and weaknesses of the case study approach, and the methods for the data collection (presented earlier in this chapter), developed a process model as shown in figure 7.7.

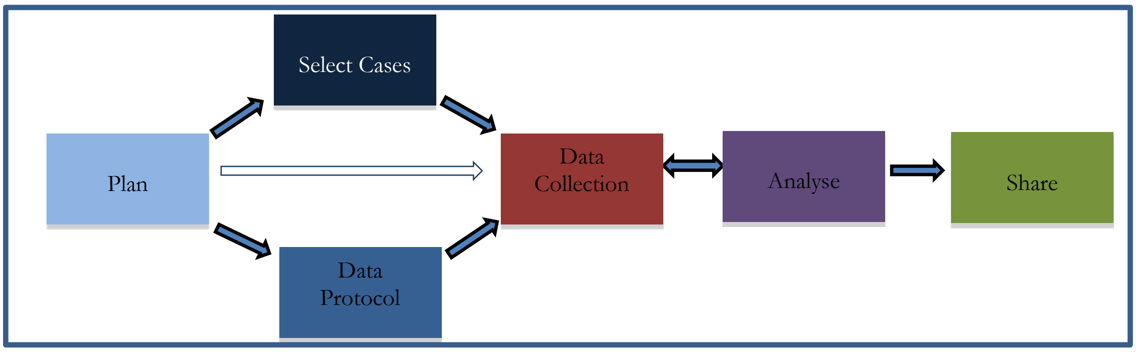


Figure 7. 7: The Case Study Process

The planning stage also ensures that each process is carefully considered and planned to achieve the main aim and objective of the research. One of the major constraints in case study research is time and this research was no exemption. Therefore, the researcher ensured that time was properly managed. However, it must be acknowledged that the entire process, especially, the data collection took longer than expected. This was due to many factors including the availability of the interviewees and access to documents. All the case studies were conducted between April 2011 and May 2013.

7.4.3.2 Selecting Cases

Among the many qualitative sampling methods available, the purposive approach was found to be appropriate and it was adopted. This sampling method is usually applied in case study research where very small samples are required. The purposive approach allows the researcher to choose case(s) to answer to a particular question(s). This approach is advantageous for research like this, which focuses on key themes, is in-depth, and shows importance of the specifics in case(s). The criteria for selecting the cases include: type of project and company, procurement route, use of advance project management techniques and the researcher's resource availability to successfully conduct the investigation.

Stake (1995) agrees that case sampling is a vital part in case study research; he however asserts that balance and variety are equally important to strengthen the findings. Planning and

Control, which is the core of this research is predominantly carried out by contractors. Also there are different types of organisations for contractors in the construction industry. In the construction industry, this is made up of different types of companies, which include small and medium enterprises (subcontractor), main constructor, and engineering construction companies. Therefore, although the researcher's main interest was targeting the prominent construction companies in the UK, the balance and variety of the companies were also considered. The cases were largely selected based on the type of project. The cases selected were on-going projects within notable companies in the UK. This reflects the fact that this study is interested in both previous and current problems associated with construction planning and control. Notwithstanding, the current problem is the main focus.

The author and his supervisory team ethically use their contacts to get access to the case study companies as recommended by Yin (2003, 2009). Among the many shortlisted companies, four cases were selected for this research. Besides the factors of selecting a case as discussed earlier, selecting these cases also depended on the researcher's resource availability, access to the required data and interviewees, and the willingness of the stake holders to use their project and organisation for an academic case study. The selecting of the cases cut across the construction industry, as one of the cases involved subcontractor (SME), two cases involved main contractors and one case involved an engineering construction company. The number of the cases is a reflection of the organisation the researchers deemed as representation of the construction industry. Most PM especially, planning and control are being carried out by main contractors, thus, two cases were chosen from this category and similarly, one each from a subcontractor and engineering construction cases. This ensured that cross organisations are accessed as it is claimed that the small or medium size companies form the core parts of the construction works.

This was necessary to give the opportunity to sample amongst the wide range of project management principles. Two of the projects were also chosen based on the advanced use of PM tools. These projects also used the Design and Build (D&B) procurement, which is deemed appropriate since many procurement literature claim that D&B procurements benefit from time and cost certainty. Hence, it could be concluded that the PM, and planning and control techniques used, must be the best possible.

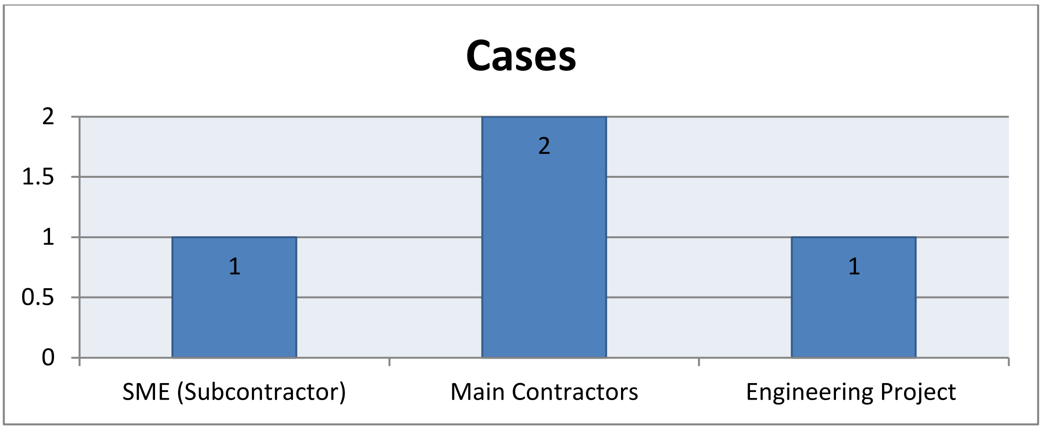


Figure 7. 8: Representation of Case Studies

Three of the cases were based in the Midlands in England, UK and the other one was in East Lothian, Scotland. Most of them were in England due to the location of the researcher and his university, which turned out to be very economical as compared to travelling across the nation. In the same way, it allowed the researcher to effectively investigate the issues without a rush or constrained by time and cost. The selected case studies are briefly discussed below.

Case Study 1: CS-01[27]

The CS-01 is a project in Scotland, UK. The main contractors (CS-01-main) have over 150 years' of experience in the construction industry. CS-01-main is a highly reputable firm in both building and civil engineering projects in the UK. The company has produced several landmark buildings throughout the UK and Ireland. It has five main divisions, comprising building construction, civil engineering, facilities Management and Small works, frameworks and specialist Joinery. CS-01-main has international accreditation, on quality, health and safety, and sustainability. They have been the winner of numerous awards in the field, which include Royal Society for the Prevention of Accidents (RoSPA) Occupational Health and Safety Gold award, British Safety Council International Safety Award 2012 and Considerate Constructors Scheme 2012 National site Award. They are one of the first construction companies to achieve FSC chain Custody Certification and are the installer of the UK's first Grid Connected Tidal Turbine. The researcher gained access to CS-01 through this main contractor. However, the researcher tended to focus the study on subcontractor (CS-01-sub) within the case. This was important for the researcher to first understand project management from a subcontractor's standpoint and, secondly, to use it as a pilot stage for the other bigger

[27] For the confidentiality of the case study, codes were used. For example CS-01 denotes case study one.

cases. The project management and planning procedures of the CS-01-main were investigated together with interviews with managers. However, the focus of the study was on the subcontractor's procedures of construction PM, especially planning and control, and the issues associated with them.

In the categorisation of UK and European firms, CS-01-sub falls under SMEs'[28] (European Commission 2011). However, the firm is a reputable one with a lot of project success. The firm has been carrying out many projects for councils, especially in the southern and the middle belt of Scotland.

The CS -01 project is a construction of educational building and the project cost was circa £7 million with a project duration of a year and five months. The section of the project, which was of interest to this study, was the "construction of an underground pipeline across an existing road". This part of the project was designed by the CS-01-main and constructed by CS-01-sub. The researcher had the opportunity to investigate the project from the design to the construction stage. The project adopted traditional procurement that means it is in the sequence of, design, procurement and construction. The entire project process was circa 60 days. The result is presented in the next chapters.

Case Study 2: CS -02

The CS-02 project is in Nottingham, UK, which was an on-going project where the investigation was conducted but the project was completed in September, 2012. This project later won the construction project of the year in East Midlands. The project comprises the demolition of an existing City Council Treasury building and the construction of a new office block providing two levels of below ground parking and nine levels of above ground office space providing 105,000square feet net internal area as a new Centre of Excellence for Retail business within the heart of Nottingham. This project was a Design and Build (D&B) project executed by CS-02-main (main contractor). The preliminary design of the project was initially performed by the project's Architecture and engineering firms but later novated into CS-02-main.

CS-02-main was established circa 90 years ago and is currently recognised as one of the most successful privately owned UK construction and engineering companies. CS-02-main has

[28] Medium business are classified as firms with less than 250 employees and less than 50 million Euros annual turnover, while small business have less than 50 employees and less than 10 million Euros annual turnover.

offices across the nation (UK) and offers a nationwide service with a regional emphasis. CS-02-main is classified as one of the largest construction companies in the country, the UK. They directly employ over 1700 people, excluding many other subcontractors in the supply chain. CS-02-main has nine different sectors in the construction industry but this study is interested in CS-02. Thus, focusing on CS-02, they have over 25 years in commercial and office construction, and fit out sectors. During this time in the sector, they have completed more than 280,000 square meters`[29] of commercial space for developers investors, tenants and owner occupiers (this is just to focus on a similar experience to CS-02). CS-02-main have an exceptionally high standard in Health and Safety with a Gold medal recognised by RoSPA and many recognised awards. CS-02-main was ranked 53rd in the Sunday Times Top Track 100 most successful private UK companies for 2010. This is to emphasise not only the background of the company but also their experience to adopt an advanced project management, especially, planning and control system. Thus, the problems associated with this type of firm or case may be applicable to many similar types of companies, if not all.

The researcher had the opportunity to investigate most of the construction stages of CS-02, and the results and discussion are presented in the next chapters.

Case study 3: CS-03

The firm for the CS-03 project was an engineering firm (CS-03-main). The CS-03-main is located in Nottinghamshire County in the UK. It is recognised as one of the most innovative engineering companies in the county with many notable awards. CS-03-main has six different sectors including engineering construction, which is of interest to this study. Thus, this study concentrated on the engineering and construction sector as appropriate for the objective of this study. CS-03-main has been operating in this sector for over 27 years. During this time, they have been involved in many prominent projects in the UK. These include Millennium Stadium, London Underground, Imperial War Museum (IWM) and Thelwall Viaduct. They were also part of the leading edge design team that created the multi-awarding winning American Air Museum at the IWM. The CS-03-main was chosen based on their success but also to understand the industrial problems associated with planning and control as well as to evaluate the implementation of the TPC system in typical engineering construction settings.

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[29] This is a little over 3 million square feet

Case Study 4: CS-04

The firm for CS-04 is a respectable worldwide recognised organisation with different sectors. This study is concerned with the sector (CS-04-main[30]), which was responsible for executing the CS-04 project. CS-04-main has just a little over a century of experience in the UK construction industry and has delivered many landmark buildings and structures across the UK. CS-04-main has over four and half thousand workforce with an annual turnover of £1.3 billion. Their success and recognition is classified as one of the biggest, if not the biggest, in the UK. In this course, they have set a standard for many other firms specifically and in the construction industry at large. CS-04-main was the construction industry ambassadors in the UK going around schools sharing their skills to foster student interest in construction. This means investigating the problems associated with construction project management (especially, planning and control) will be a nationwide problem, arguably, a worldwide problem.

The CS-04 project is the design and construction of multi storey educational block. The project also includes sport facilities, a student union, and an entertainment venue and retail space. CS-04-main has been working with the architects and engineers from the outset of the project, which makes it full D&B projects. The researcher had the opportunity to be involved in the project from November 2012 to May 2013. The next section presents the data collection protocol for these case studies.

7.4.3.3 Data Protocol

A data protocol was designed for the collection of data. The case studies primarily utilised interviews (both unstructured and semi-structured), documents and unstructured observations as the main sources of evidence to address the research questions. The unstructured interviews are useful for in-depth understanding of the issue(s), while the semi-structured interview is a powerful form of formative assessment and it allows generalisation of results and conclusions from the case study. The documents evidence and observations are important as they corroborate the evidence from other sources and in obtaining the basic factual information about the case (Knight and Ruddock 2008). The data protocol was designed for the entire case study data collection process, which comprises of all the three main methods. It should be recognised that it requires considerable time for pre-planning as advocated by Haigh (2008).

[30] Much of the commentary on this organisation is withheld for confidential reasons due to its worldwide reputation.

The procedures were in two parts, (1) the actual data collection and (2) introduction and evaluation of the TPC system. The latter is discussed later in this chapter. This commenced with the researcher clearly listing all the procedures for data collection (see appendices 3 and 11 for sample). A consent form also included the procedure list, and both rights and obligations of the process. The researcher ensures that the consent form is properly signed for every case (a copy of the consent form can be found at the appendix 3) and kept in the researcher's file.

A detailed protocol was designed for the interviews. This was done after some documentary review and observations, which gave the researcher enough knowledge and understanding of the projects as well as the organisation. The protocol was divided into six parts, comprising the introduction, interviewee details, general questions, detailed questions, specific questions and closing questions. The introduction covers the procedure of conducting the interviews (semi structured and unstructured), the reminder that the interview was going to be recorded and the signing of interview consent form if not signed already. The interviewee details covers the interviewee position, responsibilities, academic and professional qualifications, and years of experience. This was followed with general questions that explore the interviewee's perception regarding the case and the organisation. The detailed questions concentrated on the case and the objective of the research, whilst the specific questions were developed through the documentary review and observations. The closing questions cover the running down of the interview and general remarks.

In conducting a comprehensive case study, like this, where varied data collection techniques are used at the same time and the researcher is expected to spend significant time on the case, a written protocol is far from being enough, thus, an interpersonal protocol should be employed. The researcher called the two types of protocol the soft and hard protocol. The soft protocol is the interpersonal relationship the researcher should develop with the case (including the people within the case). The hard protocol is obviously the one that is well documented for the data collection. The researcher ensured that both approaches are effectively deployed. The researcher, being a member of most of the respectable professional organisations in the UK and beyond with several years' experience in the construction industry, ethically developed a "soft protocol" with the case participants and the case. This gave him unlimited access to the documentation, and project site and he was allowed to take photographs as per their consent. One of the notable parts of using the soft protocol was when the researcher was initially denied access to the cost file on CS-02. However, in the process of conducting the data collection, there arose an issue regarding cost where the researcher ethically made suggestions to the project manager that assisted positively. This built a stronger relationship, then finally, he was allowed access to those documents. It is therefore noted that in a comprehensive case study, both "soft and hard protocol" are very important in achieving the best possible data which will improve the research findings. On completing the entire research data collection, the researcher showed his appreciation by providing the case with a fully signed thank you card and assurance of the final version of the TPC system together with the findings of the thesis, upon completion of the PhD.

7.4.3.4 Data Collection

The data collection for this stage was in three main separate forms, yet in an overlapping process. These sources of evidence comprise documentary review, observation and interviews. Figure 7.9 shows the representation of the data collection and how they connect.

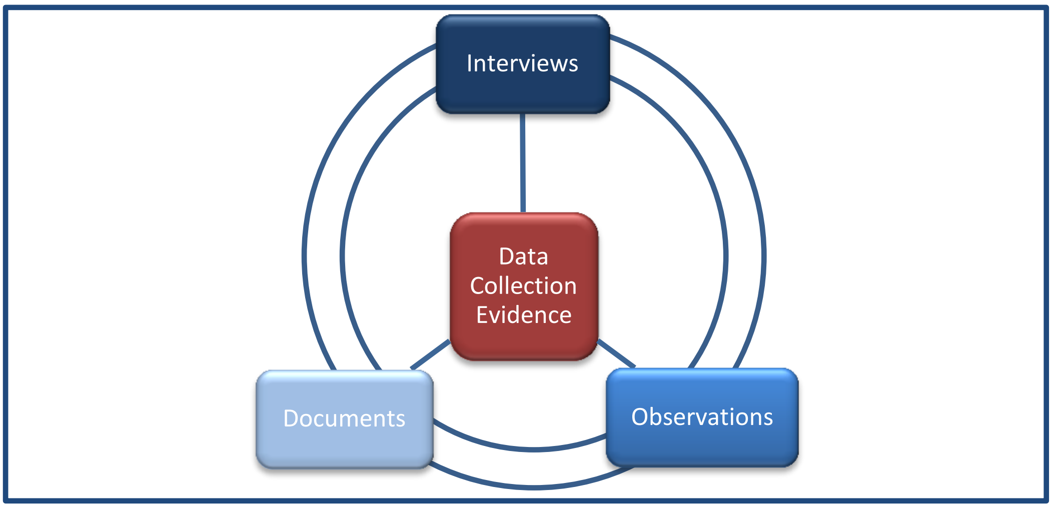

Figure 7. 9: Data Collection Representation

Documents

Documents provide a rich evidence of data; however, many times it is overlooked by researchers. Robson (2011) advocates that this is due to the dominant use of other methods such as surveys and interviews. In this research, documentary data was used together with other methods to achieve the main aim and objectives of the research.

Having received the consent from the case study companies, the documentary review commenced. The documents reviewed are predominantly associated with planning and controlling of the projects. These documents include the so-called planning (programme), projects minutes, procurement sheets, progress reports, drawings and inspection review. The researcher also ensured that other relevant administrative documents were reviewed. This assisted the researcher to establish the current practice adopted by the case. In addition, the researcher identified the main collective requirements and documentation for successfully completing an activity. Upon the receipt of the approval from the case study companies some documents were photocopied and photos were taken, which were later analysed and discussed, and this is presented in later chapters.

Observation

In considering enhancing the prevailing practice, observation was vital for the researcher to understand the prevailing conditions and problems. Thus, observation was one of the best methods to achieve this purpose. One may argue that the essence of a literature review is to understand the existing practice; however, solely using literature is inadequate for such a 'real-world' problem in construction. The observation focused on how the project was being managed in the real-world (Robson 2011).

In this research, the observation was unstructured and conducted during regular project site visits. Although the observation was unstructured, the researcher focused on the behaviour towards planning, monitoring and control of the activity or the project. The researcher attended project meetings as an observer where necessary and observed the progress against work done. The observation at the project office is particularly concerned with the PM, and planning and control process. Observation at the construction site focuses on the requirements for successful completion of a task and the requirements of controlling a task. Occasionally, a lack of proper co-ordination among tasks was observed and noted. All the observation was recorded in the researcher's jotter or on the observation sheet. Photos were also taken where necessary together with the notes taken. Some of the observations made formed part of the unstructured interview questions with the aim of seeking clarification and deeper understanding. This process of observation was done throughout the duration of the data collection process.

Interview

This research used both unstructured and semi-structured interviews as part of data collection methods. The unstructured interview helped the researcher to expose practical perceptions in real-world settings. The unstructured interview was used to explore deeper understanding of the subject. In addition, it helped the researcher seek clarification of documentary review and observations. Using an unstructured interview, the researcher is not obliged to follow a particular order of questioning. Thus, the process was more conversational, which allowed free flow in speech. Although the interview concentrated on the research subject, the interviewees were allowed to express their views with any examples and sketches. The unstructured interviews were conducted with the top managers[31] in the case study projects. In total, seven unstructured interviews were conducted with the top managers of the cases. Two interviewees each in all cases studies were held, except CS-04-main where only one was conducted. This is graphically represented in figure 7.10. These comprise of two contracts managers, two senior project managers, an operation director, managing director, and a commercial manager.

The semi-structured interviews were conducted to explore the appropriate situations of project planning and control as well as the inductive cognition to develop the TPC system. In addition, it helped the researcher to know the state of practice as well as the existing problems, thus understanding the complexity in the real world. Contrary to the unstructured interview, in a semi-structured interview, the researcher has open ended pre-determined questions to be followed. The semi-structured interview process is no different from the one discussed in stage 2 above. The interview progress was flexible and, during the course of the interview, some questions emerged as a result of an interviewee's answer. The interview process was conversational which allowed follow up questions and both way discussions about the topic, thus, generating other topics and links that emerged in the course of the interview. Notwithstanding, in very few cases, questions were skipped depending on the interviewee's knowledge and willingness to discuss the issue. The semi-structured interviews were conducted with the managers[32] in the cases, a total of 19 interviewees. These comprise of 3 interviewees from CS-01, 9 from CS-02, 5 from CS-03 and 2 from CS-04. This is illustrated in figure 7.10.

In both interview methods, the researcher followed the interview protocol[33]. The interview session commenced with the author introducing himself as a PhD researcher, thus representing NTU and academia. The author assured the interviewees that the interview has no association with any third party and any details of material discussed were confidential.

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[31] The top managers are the highest managers in the project available: these include, Contracts Managers, Project Director, Operation Directors, Senior Project Managers and Commercial Director

[32] These managers include, contract managers, project managers, construction (site) managers, cost managers (quantity surveyors), planners and engineers

[33] Both soft and hard protocol used. The soft protocol ensured that the researcher uses ethical means to collect the data without stressing the interviewee to answers a very sensitive issues that he/she is not willing to discuss.

However, the researcher has the right to use anonymised quotes in this thesis and any academic publications.

The interview was planned not to last for more than an hour for the semi-structured interview, but the unstructured interview were scheduled to last for an hour and thirty minutes. During the course of the interviews, several questions were asked and, where possible, the researcher interrupted to get further clarification. However, in many cases, the researcher listened attentively and made notes.

The interviews comprehensively covered the subject of construction project management, especially planning and control. Furthermore, it thoroughly explored the current situations, factors, problems, and possible improvements associated with construction project management, and planning and control. Overall, 26 interviews were conducted across all the case study projects as shown in figures 7.10 and 7.11. The interviews were conducted to the desired level of saturation, where the researcher noted that the responses were being repeated and no new ideas were emanating. All the interviews in the case studies were audio recorded based on the consent of the interviewees.

It should be acknowledged that it really requires significant time to carry out the case studies as anticipated initially. This is due to the fact that the projects were on-going projects, which were being monitored and as such the key interviewees were very busy. However, personal relationships were developed which facilitated the process.

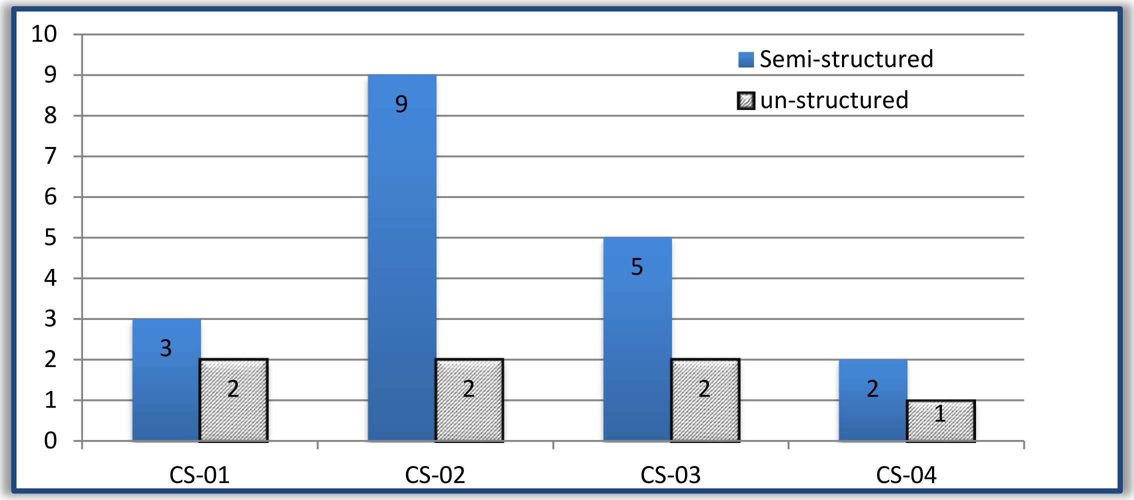

Figure 7. 10: Representation of Interviewees in the Case Studies

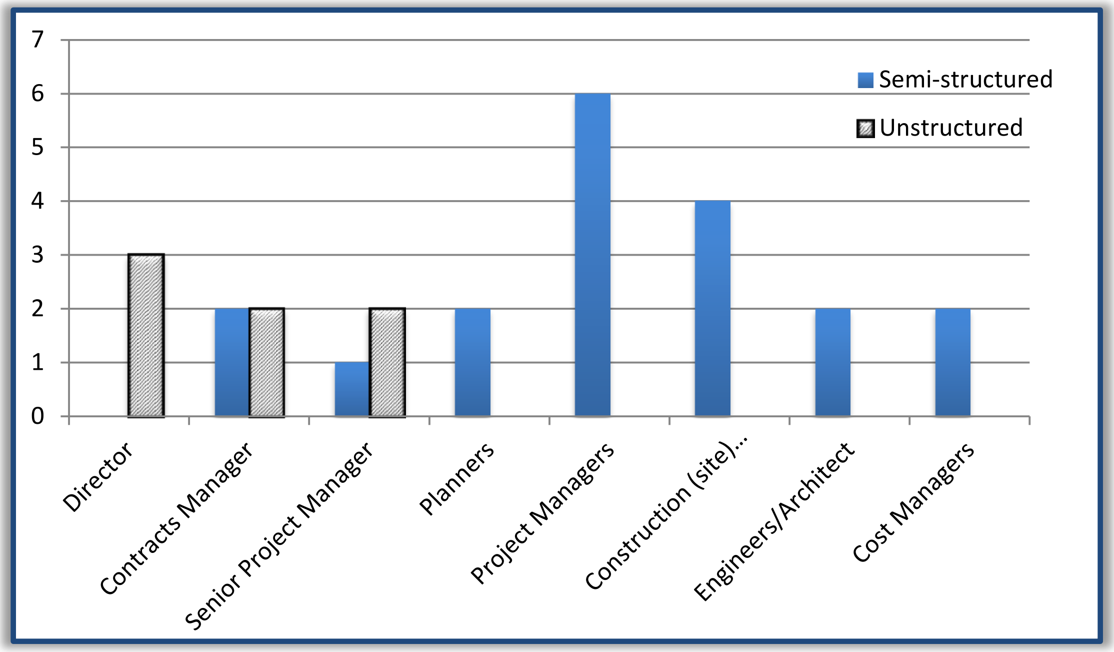

Figure 7. 11: Representation of the Interviewees' job position

Data Collection Evidence

The data collected were then carefully and safely stored electronically where possible and in folders depending on the type. All the case studies interviews were audio recorded; therefore, they were carefully transcribed. Although transcribing is a very time consuming task and is challenging, it was perfect for the researcher to be conversant with the data which enhanced his knowledge for the analysis. The transcribed data were then matched with the researcher's notes so as to increase the reliability and validity. The interviews clarified some issues identified in the documentary evidence and site observations, gave clarification and understanding of current project management as well as setting the basis for developing the TPC system.

Data Analysis

The main purpose of data analysis is to make sense of the data collected. The qualitative strategy was used for the data collection; as a result a qualitative data analysis was employed at this stage of the research. Three methods were used for the data collection. These methods were initially analysed separately, then cross analysed to strengthen the validation and reliability of the study. This method of data analysis is shown in figure 7.12

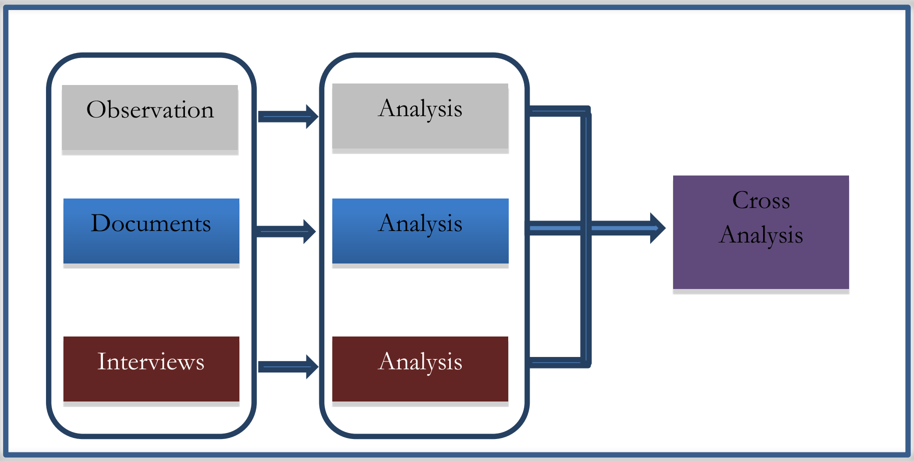

Figure 7. 12: Representation of the Data Analysis Process

In analysing the data, the researcher ensured all the data were re-assembled into one format, which is Microsoft Word[34] (Ms Word); this included the photos. The researcher ensured that the interview notes, observation notes, and the documents were transcribed (retyped) using Ms Word so that it was consistent with the interview transcriptions. This was done for two main reasons; first, a qualitative study is more concerned with understanding things or behaviours, and as a result it centres on 'meanings' and having all the data in one format ensured a stress-free analysis. Secondly, it simplifies the storing and shifting of data as well as enabling the researcher to have easy access to the data, wherever it was required. As was stressed by Bryman and Bell (2011), the difficulty with qualitative research is the very large volume of data it generates.

As discussed in stage 2 above, the researcher adopted a bespoke grounded approach for all the interviews, where he undertook a literature review before the data collection. Again, the researcher adopted the Saunders *et al.* (2009) categorisation process of qualitative analysis of summarising (condensation) of meanings and categorisation (grouping) of meanings.

Given the large volume of data collected, the researcher used Nvivo software to facilitate the analysis[35] and for the storage of data. Nvivo is part of the revolution in qualitative analysis and it falls into the brackets of Computer Assisted Qualitative Data Analysis Software (CAQDAS). According to King (2008), it is currently used and accepted among the qualitative researchers in construction management. One of its inherent advantages, which is often cited, is the speed

[34] Document and word processing software designed by Microsoft. For this research the 2010 version was used.

[35] The analysis is done by the researcher but not the software itself. The thinking and the coding is done by the researcher; however, the software facilitates the process, just like any software such as Ms Word.

of using CAQDAS. Another advantage is that of its digital coding system, which enables the researcher to have a general picture of the process. Bazeley (2007), and Bazeley and Jackson (2013) present a comprehensive review on the use of Nvivo.

The analysis process commenced with the coding of the case studies, such as CS-01, where CS denotes case study and 01 denotes the number of the case. Another example is CS-02-main, where 'main' denotes the main contractor and in CS-01-sub denotes subcontractor. The interview in each case was given a code with the case number and reference code. Then the actual data coding and categorising commenced.

According to Bryman and Bell (2011), coding in the sense of qualitative research is the process whereby data are broken down into component parts, and then are given names. Therefore, the researcher commenced the coding by breaking down the data into specific sections. The researcher then grouped them into defined categories and properties. Strauss and Corbin (1990) ascertain that the process of coding in the grounded approach is in three stages (that is open, axial and selective coding). Open coding comprises of defining the codes, axial is concerned with relating the properties to categories, and selective focuses on the relationships and commonalities that lead to the development of the theory. The researcher ensured that the categories and properties chosen were fairly general for openness towards interpretation. In the process of coding, a few categories were amalgamated to form a new category.

The process of analysis continued until there was theoretical saturation. This is the point where the researcher clearly noted that similar subjects were reoccurring. The saturation view is strongly advocated by qualitative researchers such as Hunter and Kelly (2008), and Glaser and Strauss (1967). The researcher then maintained a close connection with the data and the conceptualisation. This ensured that there is a reflection of the data and the analysis, and a better relationship is identified for generalisation. Bryman and Bell (2011) called this procedure constant comparison. The analysed data is then interpreted and discussed against the existing literature, where a new theory emerged (See figure 7.13)

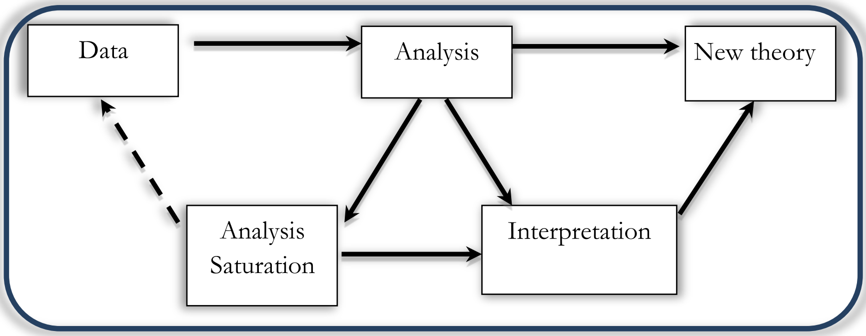

Figure 7. 13: Research Analysis Process

Sharing

Sharing is the presentation of the analysis and interpreted data in a narrative form. This includes the discussion of the process. Yin (2009) describes the sharing stage of a case study as the writing up and presenting of the argument.

7.4.4 Stage 4: Interview (2)

Stage 4 of the research process was conducted to achieve objective 3 and also for question 1 (Q1) as illustrated in tables 7.10 to 7.12. Stage 4 is designed to investigate the expert perceptions on Q1 outside the case studies. This was important to give a deeper understanding of the problem under investigation from experts outside the cases. The process is similar to that of stage 2 of this research process (see figure 7.4 above). However, this process is briefly discussed.

7.4.4.1 Interview sampling

The sampling technique used for this stage was the purposive sampling method. This allowed the researcher to choose cases that permitted him to answer the research question, as is advocated by Saunders *et al.* (2009). The criteria for selecting the participants include the following that the individual should:

- Be a senior member and working in prominent organisations in construction or with a relationship with construction.
- Be involved in project management, planning and monitoring/control.
- Be at least a member of reputable professional bodies in the field.
- Have not less than ten years' experience in the construction or related field.

The target participants included senior members within construction companies, consultancy firms, developers and clients, to have their respective understanding of the problems and how they think these could be improved. As a result 15 interviews were conducted with industrial experts in respectable organisations including all the stake holders. These comprise of six participants within consultancy, four contractors, a developer and four clients. This is shown in figure 7.14 below.

The interviewees were contacted first on the telephone and then confirmed using emails. The date for the interview was later arranged through email and phone.

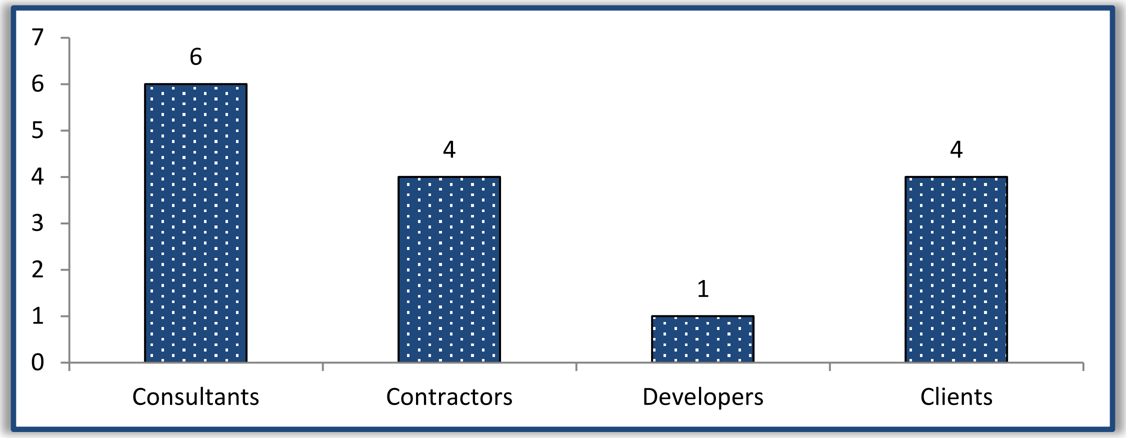

Figure 7. 14: Representation of Interview (2) participants

7.4.4.2 Interview Session

The interviews were conducted in the offices of the interviewees. The session commenced with the researcher's formal introduction of himself to the interviewee as a researcher and thus representing academia. The consent form was clearly read out and agreed before the actual interview. The interviews were conducted using the prepared interview protocol. The interview covered four main areas all relating to construction project management, planning, and monitoring or control. The ice breaking question was the details of the interviewee. This was followed with the main questions that were, the success factors, the problems and the possible improvements. It was concluded with a closing down question and any other comments from the interviewee. Upon exhausting all the questions and with no other comments, finally, the researcher thanked the interviewees for their contributions and availability. Each interview duration did not exceed 30 minutes. During the course of the interview, the researcher took notes on the key points and some other points that needed further clarification.

7.4.4.3 Data Analysis and Sharing

In the analysis, focus is shifted to making sense of the data collected. In this case, the researcher identified themes and drew representation of meanings that institute the representativeness. The analysis commenced first with the researcher ensuring that all the data were in one format. Secondly, the process of coding was followed with categorisation of themes and, thirdly, relationships were then drawn. The analysis was manually conducted by the researcher due to the smaller amounts of data collected and the objectives of the interview. The manual analysis process included the coding via highlighting sections, extracting themes and their relationships. This was time consuming but it was an interesting task. The process allowed the researcher to interact with the data with as much detail and as objectively as possible.

The analysis was complemented with the interpretation and discussion along with the literature, which led to some common factors and some new factors emerging. This is shared or presented in the subsequent chapters.

7.4.5 Stage 5: Developing the TPC system

Stages 1 to 4 discussed above were set as the foundation of this stage. This stage centres on the development of a holistic but innovative planning and control system, the Total Planning and Control system. Its name, "Total" was derived from its holistic and innovative approach to combining task flows, planning requirements, and monitoring and control requirements visually together. For a better understanding and developing of a real-world technique, modelling plays a key role in this. Therefore, at stage 1, modelling techniques were reviewed and the IDEF0 model was considered appropriate to this study (this has been discussed in chapter 4 in this thesis). A model is an abstract representation of the reality. According to the Oxford dictionary (2001), the word model was used to represent "a set of plans of building in the 16th centuries". Plans of building are developed to understand the components or representation of the building. Thus, in developing a planning and control technique, the researcher is interested in the understanding, components and representation of planning and control.

In developing TPC, the requirements for successfully completing projects were identified from the previous stage (1 to 4), which is called task flow. Some of the themes or requirements were merged to a higher-level theme. These were categorised using IDEF0 ICOM drivers, which were input, control, mechanisms and output. Requirements for planning and control were also identified and categorised separately. However, later, all the requirements and the categories were integrated into one model. This formed the TPC model. This integration affected some of the common functionalities of the IDEF0 model. Therefore, an amended procedure was developed by the researcher, which integrated the conceptualisation of construction PM and its managerial process to develop the TPC system. The TPC system was developed with these criteria:

- *Holistic approach:* TPC should be a system that integrates project planning, control and monitoring and evaluation of each task and the project as a whole. The techniques should facilitate the identification of risks and costing of the task[36]. In addition, TPC should promote integration of the project team.
- *Presentation:* The construction industry uses models (diagram or plans). Thus, the researcher ensures that the modelling technique adapted was simple and thus the TPC falls into that requirement.
- *Easy to use:* TPC must be easy to use and understandable by the intended users and the team (intended users are managers).
- *Applicability:* TPC must be applicable to construction projects most importantly.
- *Enhancement*: TPC should make planning as realistic as possible and also improve the learning of the cycle within the industry. Again, the TPC system should facilitate effective management and delivery of a project.
- *Sustainable:* TPC should be sustainable and should facilitate sustainable project management. Again, it should have the potential for computer application[37].

The TPC system is developed using a collection of things; these include a management model, the conceptualisation of construction PM and its managerial process, requirements for planning and control and task flows, and the possible improvement to the industrial problems and the success factors. These will be discussed in detail in subsequent chapters. TPC was developed to:

1. address many of the limitations identified in the planning and management of construction projects to make it applicable in the real world.
2. overcome communication barriers within planning and management projects.

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[36] The costing aspect was not explored in detail; however, the researcher attempted some costing of tasks which gave very positive results.

[37] The computer application is not covered as an objective of this study. However, it is recommended for further research.

3. promote collaboration due to the inter-disciplinary nature of the industry.
4. overcome lack of understanding and workflow problems.
5. overcome limitations of evaluation, thus promoting learning and improving skills.
6. be set as a foundation for other related functions such as improving logistics and cost estimating.

The TPC system methodology is a revolution to the current practice. The methodology is discussed in detail later in chapter 11. TPC was introduced and implemented through the case studies.

7.4.6 Stage 6: Introduction, Implementation and Evaluation of TPC

The researcher upon the initial development of TPC, piloted it with a "PhD" as a project. Although using a 'PhD as a project' the processes may be different from a construction project, it ensured that the researcher applied TPC to a known field that people can easily contribute to. The piloted implementation was presented to a group of PhD students and renowned academics in a construction project management workshop, in Nottingham, UK. The researcher was given valuable feedback and encouragement that the study has great potential to fulfil a major gap within the industry. The researcher took the feedback on board, thus improving the initial development of TPC.

The researcher used AutoCAD in the modelling of TPC; this is because there was no software to facilitate its implementation. One may argue that the researcher could have used the software for IDEF0 since it was the modelling technique adopted for the development of TPC. It is important to repeat this in this chapter, although it will be discussed later in the subsequent chapter that TPC turned out to be different from the accepted IDEF0 model, both in function and representation. However, it is acknowledged that IDEF0's ICOM is still instrumental in the development of TPC. Given that the modelling using AutoCAD and other software, it was very time consuming for the modelling process.

TPC was first implemented in CS-01 from the design to the handing over of the project, which showed a lot of positive potential for the industry. It was then implemented in CS-02, which was a more complex project. Implementing it in CS-02 resulted in some modifications for improvement and clarity in the process. Similarly, it was introduced and implemented in CS-03 and CS-04.

An evaluation group, people with expertise, from each case study was established, which predominantly included senior managers and external senior academics with an interest in the study. The primary task for this group was to offer feedback on the TPC system for necessary improvement. The researcher presented a section of the case study project using TPC to all participants. After the presentation, the researcher gave an evaluation form (copy attached in appendix 7) to all the participants. The evaluation form included some ranking and comments for possible improvements. Positive feedback was received and they all commended the study. They gave some practical recommendations for improvement, which were not incorporated during the implementation of the TPC system. Their suggestions were then incorporated into the technique for implementation in the final TPC and fourth case study and accordingly presented in this thesis. The implementation was successful and the attitudes of the participants were positive. The TPC system was greatly recommended.

7.5 QUALITY OF THE RESEARCH

Qualitative research has received its fair share from its critics, including validation and reliability of the research. The terms validation and reliability are closely associated with quantitative research (Bryman and Bell, 2011). Yin (2009) describes these as the four tests to establish the quality of the research. Yin (2009, p. 41) aligns the tactics against the four tests (construct validity, internal validity, external validity and reliability). However, Bryman and Bell (2011) advocate that qualitative researchers adopt alternative terminologies which are parallel with those of quantitative researchers. This was discussed earlier in this chapter and presented in table 7.3. Combining Yin (2009) and Bryman and Bell (2011), the four tests for qualitative research are: credibility, transferability, dependability and conformability.

To increase the quality of the findings of this study, the following actions in table 7.13 were put in place before, during and/or after research design, data collection and data analysis.

Table 7. 13: Researcher's actions to strengthen the Quality of the study

Qualitative: 4 Tests	Description	Researcher's action
Credibility	How believable are the findings?	• Provided the participants with initial findings and their feedback was received. • The research process is explained in detail throughout chapter 7 of this thesis. • The TPC model was introduced, implemented and evaluated in the real-world, which is presented in chapter 11. • Some key documents were copied and stored in researcher data storage and photographs were taken to support the evidence • The data collection tactics and the TPC were piloted.
Transferability	Do the findings apply to other contexts?	• Multiple case studies were used with different project settings. • Provided a detailed description and the context of the study as well as the case studies. • The sampling of the case(s) covered prominent and many different types of organisations within the construction industry.
Dependability	Are the findings likely to apply at other times?	• An interview protocol was developed. The use of the interview protocol, aside the questions, also contains the procedures and the general rules for conducting the interview (see appendices for sample). • Maintained the consistency before and during the research process. • Information gathered is then stored in an interview database and analysis conducted critically. • The interviews were recorded and carefully transcribed verbatim. • Research methodology clearly presented, clarifying construction management as a field of study; theory, ontological and epistemological assumption of the study. Moreover, the chapter details the research design and process.
Conformability	Has the researcher allowed his/her values to intrude to a high degree	• Multiple sources of evidence were used during the case studies. • Multiple case studies were used and an individual case was analysed separately before cross analysis of all. • The researcher took a neutral position in the data collection • The researcher and the supervisory team ethically used their contacts to get access to the cases study companies as recommended by Yin (2003).

7.6 ORGANISATION OF THE SUBSEQUENT CHAPTERS

The previous chapters 2 to 6 have been focused on the existing knowledge and identifying of the knowledge gaps as well as establishing the context of the study. This chapter, 7, presented the research design and methodology adopted for this study. Now, the focus of the subsequent chapters shifts to the data presentation, analysis and discussion, development of TPC and its implementation and evaluation, and finally the conclusions drawn for the thesis.

Chapters 8 to 10 present the analysis and discussion of the study (Researcher process Stages 2 to 4). Chapter 11, stage 5, centres on the development of TPC and its implementation and evaluation. Chapter 12 is the conclusion of the study, which summarises the study by re-evaluation of how the aim and objectives have been achieved. This leads to the recommended further studies. Figure 7.15 presents the layout of the subsequent chapters.

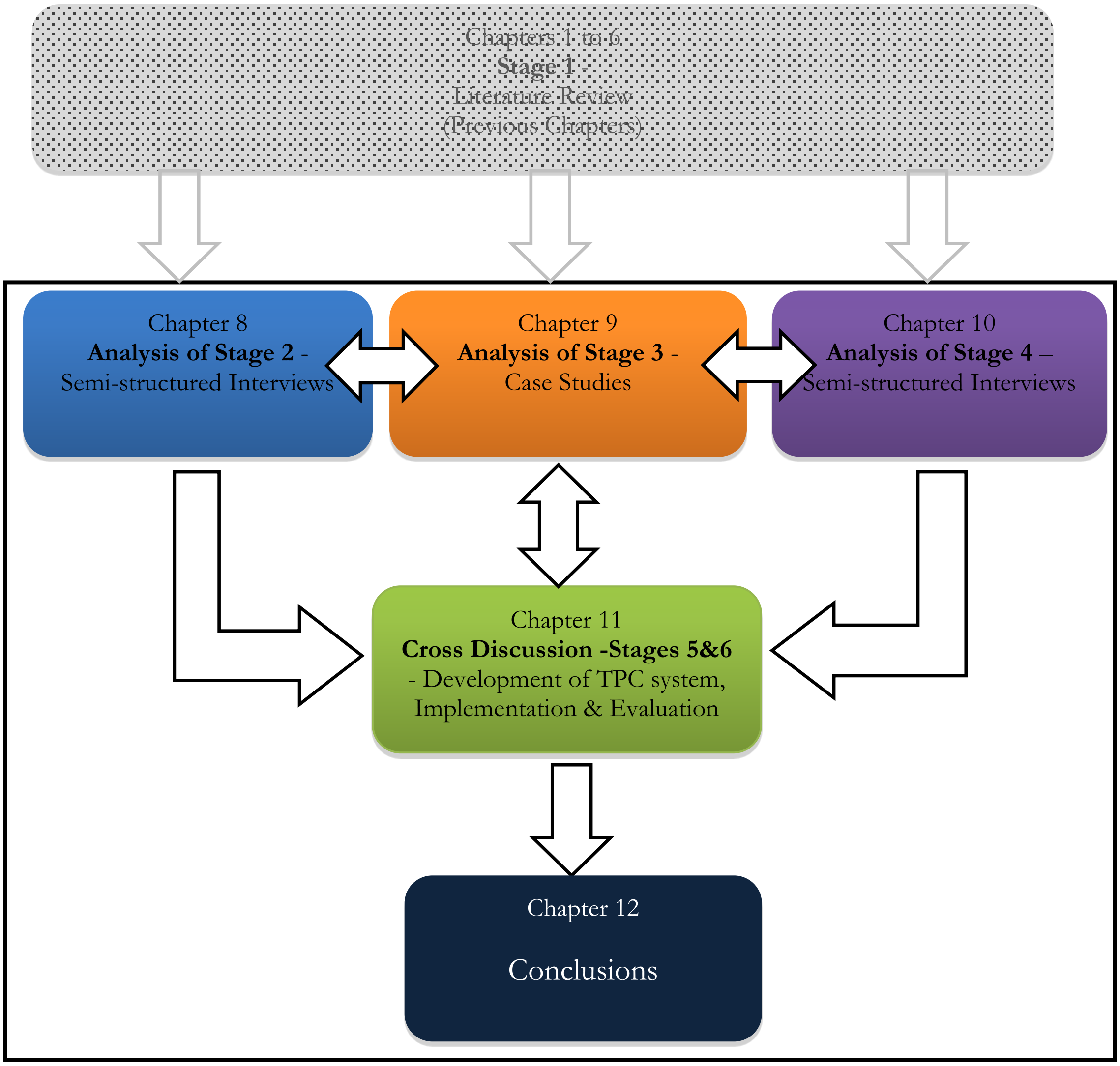

Figure 7. 15: Layout of Subsequent Chapters

CHAPTER EIGHT: ANALYSIS OF STAGE 2 – SEMI STRUCTURED INTERVIEWS

8.1 INTRODUCTION

In this section, the analysis of the research process stage 2 is presented. The data collection method for this stage, as discussed in detail in chapter 7, was semi-structured interviews. This chapter explores the understanding of construction project management (PM), the existing PM techniques, whether construction is production, and if yes, the type of production, and knowledge and understanding of the modelling technique considered for this research. Furthermore, it explores the differences between some management responsibilities within the construction industry, particularly, project manager, contract manager and construction manager. This is because the very essence of this study is to introduce a novel planning and control technique, which these professionals are part of the target users. Again, the introduction of any technique should have its anticipated users, which the new technique, and the Total Planning and Control (TPC) system is not exempted.

Altogether, 40 interviews were conducted. The analysis of the interviews started from the interview sessions notes taken, then to the transcription and a detailed analysis, which is presented in this chapter. The structure of the analysis presentation commences with themes, which are derived from the attributes (levels 1 and 2), and from the interviewee's quotations (shown in italics). The themes are also discussed against the literature to identify the similarities and differences. The chapter is presented in three sections; section one presents the understanding of a project and construction project. Section two focuses on PM, the differences between its related roles and the existing techniques. The last section presents construction as production, and knowledge and understanding of the IDEF0 model, which has been explained in chapter 4. Finally, conclusions are drawn with the summary of the main findings which are further discussed in chapter 11.

8.2 OVERVIEW OF INTERVIEWEES INFORMATION

The interviewees fall into three groups, academics (15), practitioners (15) and university students (10). These groups were chosen to bridge the knowledge gap between them, as it could be argued that the academics are the facilitators, the practitioners are the implementers and the students are the future of the industry. The codes for the interviews are "A" 'P' and 'S', which denotes academics, practitioners and university students (detailed in chapter 7 and appendix 2a).

8.2.1 Respondents Academic Qualifications

Most of the practitioners have master's or bachelor's degrees, i.e. a total of 12 out of 15 practitioners. Specifically, 5 respondents have achieved a masters degree, 6 have a bachelor degree, one has HNC and 3 have a doctorate degree. This illustrates that the management of construction projects has moved from the general perception of vocational to degree holding managers; although one may argue that it is not a general perspective of the industry, there are managers with a doctorate degree.

Equally, 7 out of 15 academic respondents have achieved doctorate degree, 6 have a masters degree and only two have a bachelor degree. This is consistent with literature that indicates academics in construction endeavour to achieve higher academic qualification in recent decades (see details in figure 7.6).

8.2.2 Respondents Professional Qualifications

12 out of the 15 practitioners interviewed were professionally qualified, which is more than two thirds of the participants as compared to the circa half the academics who are professionally qualified. This means that practitioners endeavour to be professionally qualified as compared to academics (see figure 8.1). Perhaps, academics endeavour to achieve a professional qualification have effect on the students who are not even encouraged to be student members of the professional societies.

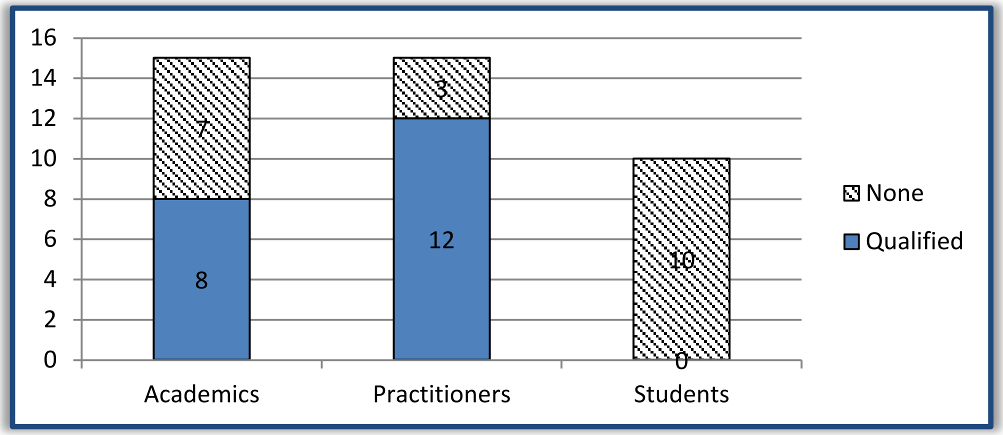

Figure 8. 1: Professional Qualification of the participants

The data shows that academics endeavour to achieve academic qualifications (doctorates degree), while practitioners' endeavour to achieve professional qualifications. In this respect, more than half of the practitioners have achieved two or more professional qualifications as compared to just a few of the academics.

8.3 WHAT IS A PROJECT AND A CONSTRUCTION PROJECT?

The rationale to seek the understanding of a project and a construction project has been discussed in detail in chapter two and seven of this thesis. The study seeks to examine **"whether a construction project is the same as any other project?"** this is owing to the fact that professional societies attempt to standardise the understanding of what a project is to include construction project and its conceptualisation [38]. The conceptualisation of a construction project will enable a better understanding of a construction project and become a platform upon which the new technique, TPC will comfortably be grounded. The conceptualisation of a construction project has not been properly explored, thus, this study explored the conceptualisation of a construction project from the understanding of experienced academics, practitioners and university students. It should be recognised that although the aim was to conceptualise "construction project", it cannot be in isolation from understanding a 'project'.

According to respondent A7, the term 'project' in the construction industry is used by construction companies, i.e. a project with higher cost value, which is being built by using very big organisations. The respondent differentiated between a construction company and a contractor by the virtue of the cost and the end user. The respondent states

… project has a value above certain amount and has a particular end user. In the industry project is a work carried out by a construction company. A contractor is responsible for a 'contract'. The client calls it [project] a contract. It [project] is used in the highest part of the industry… (A7)

The respondent therefore defines a construction project as *"same as a project but undertaken by a construction company but not a contractor"*. This respondent is a notable scholar with both experience in industry and academia. This emphasised the significance to investigate the understanding of some construction terminologies.

All participants were asked the same questions, which are: 1) what is a project? 2) What is a construction project? and 3) what are the difference between other projects and construction project, if any? The most common comment amongst interviewees was, "*some of these questions seem very simple and fundamental but hard to explain in relation to construction*". In this response, most

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[38] The conceptualisation ensures the empirical establishment of the construction project and PM constraints, and the Construction Project Management Managerial Process (CPMMP) as well as a workable definitions for both construction project and PM.

of the interviewees insisted they want to see the final results of the research, which was a good and encouraging comment to the researcher. This shows the interest of the results of this investigation and arguably shows that subject is long overdue. The three questions are analysed separately in this chapter and concluded with a cross discussion.

8.3.1 Q - What is a Project?

There was no common agreed understanding of the term 'project' among interviewees; however, there were some common themes identified in the interviews. This uncommon understanding is not peculiar as it is consistent with the literature discussed in chapter two. The practitioners define a project as simply as *"a challenge with a financial end"* (interviewee P9) to others including "*a method of changing the present situation through physical amendments*" (interviewee P1). Practitioners understanding a project as 'task oriented activity' with a specific purpose and transformed through a process. Academics understand projects from a different perspective as compared to the practitioners. From interviewee A7, the term "contract" is used for works with higher cost with some particular end users. This view is peculiar to existing literature; nevertheless, it shows the uncommon understanding of the term, project. Many of the academics define project from a more conceptual perspective; for example, an interviewee defines project as *"realisation of ideas"* (A2) and another as *"change in response to a set of objectives"* (A10).

Table 8. 1: Generally Categorisation of "What is a Project?"

Themes	Attributes 1	Attributes 2
Delivery	Undertaking	Task Work Job Activity Building Install Operations
Concepts	Concepts	Ideas Create Clear Scope Agreement Realisation
Transforming to achieve specific purpose in specific time	Specific purpose	Goals Aims Objectives Outcomes Unique
	Transformation in specific time	Time frame Change Planned work
Process	Procedures	Means of improvement Process Series of events

Organising	Organising	Planning Organisation Overall goal Time frame Team work

8.3.2 Q – What is Construction Project?

The above analysis of 'what is a project' was setting the context for this section. This study is situated in Construction Management as a field of study; it was prudent to understand the term construction project as discussed in the earlier section and chapters. The understanding of a construction project is not explored in the literature; therefore, this study examines its understanding and conceptualisation. Although, it is not the main aim of this study, developing a holistic planning and control system should be grounded in conceptual understanding (this ensures CPMMP is established as discussed later in this chapter).

During the interview, when respondents were asked for their understanding of a construction project, there was misunderstanding of what is 'construction project'. Some of the interviewees consider a construction project to be buildings or something to do with buildings, while projects such as roads, dams, and bridges were classified under civil engineering (P9, P10, A1, A7, S5, and S10). Although this was not part of the questions, in their attempt to give examples of construction projects, the issue was recognised. Another intriguing issue that arose from one of the interviewees was that, construction refers "to build"; even though, in some cases it involves de-construction. This argument was further developed that construction revolves around building (as putting it up), refurbishment and demolition (deconstruction). It was very clear from the interviewees that one of the problems within the field of construction was lack of common understanding. This is not a peculiar issue because it is parallel to literature, which have uncommon understanding on project and that of construction project is not clearly defined. This research therefore states that construction refers to all works under Architectural, Engineering and Construction (the Built Environment), more specifically both building and civil engineering works.

The academics responses indicate that some respondents believe a construction project is the same as other projects such as A2, A3, A5, A7 and A12. The practitioners do not believe that construction project is the same as other project except P2 and P8. Among the student respondents two out of ten suggest that a construction project is the same as other projects. Most of the respondents, who indicated that a construction project is the same as other projects, varied their answers or provided inconsistent answers to the former when the researcher asked them what is the difference between a construction project and other projects? Respondents defined construction projects as extreme as *"…the change to existing stale of building, land or water course…"* (A10), to simple as: *"a specialist activity to create something with a set timescale" (*P12) and the explanatory as *"a team working together to build a predetermined building"* (S8).

8.3.2.1 Analysis of what is construction project?

The analysis of a construction project commenced with that of a 'project' since some of the respondents suggest that a construction project is the same as other projects. There are common themes between project and construction project, for example, undertaking, procedures, organisation, and transformation. Yet, there are new attributes that emerged, such as practical delivery, public purposes and detailed concepts as presented in table 8.5.

Some respondents believe that a construction project is a tangible (practical) delivery where its attributes include structure, physical material, development, conversional, erection and construct. This shows tangible (physical) delivery of a task in the form of building or civil engineering works. In broader terms, a construction project is a tangible delivery. Similarly, other respondents suggest that a construction project is for a specific purpose and for public use. In essence, a construction project is initiated by human beings to benefit them; therefore a construction project is partly socially driven. This is in keeping with Reiss's (1995) definition of project as a *"human activity that achieves clear objective against a time scale".* This definition acknowledges the human element of a construction project. Furthermore, the respondents stressed that a construction project requires detailed concepts, such as ideas, designs, clear concept, vision and realisation. This illustrates the conceptualisation stage of construction project.

The theme construction project is categorised into two, theme 1 and 2. Theme 2 adopts the terms widely understood in the construction industry while, theme 1 uses a conceptual terminology. This enables the generalisation of the theory to be developed. The themes are categorised into four as presented in table 8.5 (the summary of the data collection). These comprise delivery or execution, reality or purpose use, imagination or conceptualisation, and process or transformation.

Table 8. 2: Categorisation of what is construction project?

Themes 1st	Theme 2nd	Attributes 1st	Attributes 2nd
Delivery (Specific)	Execution	Undertaking	Task Work Job Activity Building Install Operations
		Practical Delivery	Erection Specialist activity Construct Physical Material Conversional Reconfiguration Development Structure
Reality	Purpose use	Public Purpose	Human need Civil life Professional
		Specific purpose	Goals Aims Objectives Outcomes Unique
Imagination	Conceptualisation	Procedures/Organisation	Planning Organisation Overall goal Time frame Team work
		Detail Concepts	Quest Ideas Design Create Clear concept Agreement Realisation Creation Unique Vision Temporary
Process /conversion	Transformation	Transformation in specific time	Time frame Development Change Planned work Process Conversional Reconfiguration

Delivery/Execution

Interviewees also described a construction project as a delivery as discussed earlier in this chapter for project. Respondents such as S1, S2, A2, A7, P2 and P8 describe a construction project as 'work' that is implemented on a construction site. Other respondents suggest that a construction project is a new structure. For example respondent A4 clearly defined a construction project as *"…new structures like building and roads…"* This view indicates that a construction project is a structure, which is tangible, thus practical delivery. Respondent A1 stated a construction project is *"…a process of creation of building…"* This means construction projects require practical execution. Interviewee P4 defines a construction project as *"a work which delivers a structure or facility…"* Consequently, respondents P9, P10 and P12 take the discussion to another level. Respondent P9 describes that construction project is *"something that has to be constructed in professional and workman-like manner to achieve the highest quality"* . Respondent P10 also described it as "*a job which involves the modernisation or refurbishment or construction of a building"*. However, respondent P12 believes a construction project is *"a specialist activity to create something…"* These respondents suggest that a construction project is different to other projects and it is a specialist work that its product is tangible for a purpose use (detail will be discussed in next section). In the same respect, respondent describes construction project as *"…item of infrastructure…"* Respondent S9 states that construction project is *"erection, reconfiguration or change of uses of a structure…"*. Respondent S4 emphasises that it is *"…involves the development of physical materials brought together by many specialists…"*. It is therefore evident that construction project is a delivery of tangible structures through its execution. This tangibility delivery of a construction project was implicitly expressed in definition CMAA (2010) that explains the construction project is from *"…conception through design and construction…"* This tangible delivery is to meet a specific predetermined purpose and the end product must also be for social purpose. The next section discusses this theme.

Reality / Purpose Use

As discussed in the previous section, a construction project is delivered for human purposes and interviewees describe as its reality is for a purpose use. This 'purpose use' theme comprises of both specific and public purposes, which is the reality of a construction project. Reality is defined as *"the state of things as they actually exist…"* (Oxford dictionary, 2001). The word 'reality' was from the word 'real' in Latin *realis*, from Latin *res* meaning 'thing'. Reality refers to the physical thing done or created for a purpose. The 2nd attributes classified under reality and purpose use, themes include, human needs, civil life and professional needs (see table 8.5). This means that the product of a construction project has both specific and public benefits. The reality of construction project is human initiated for a specific social need(s). Some of the definitions discussed in chapter 2 suggest that the reality of a project is a desired outcome, such as Tuner (1999), CMAA (2010), PRINCE 2 (2009) and APM (2004). The APM (2004) has been superseded with the latest APM definition 2006 and 2012 but do not make mention of the desired outcome. PMI (2004) suggests that the outcome of a project brings about beneficial change. It could be argued that the desired outcomes or change may not necessarily add value, socially. This argument could be excusable, due to the fact that the definition was not solely for construction project.

The most common themes for project in literature are temporary, unique and time bound. This view is shared by some respondents. Respondent P3 described a construction project as *"unique work that causes change to meet the client requirement"*. In this respondent's stance, a construction project is a unique work (which is a specific purpose) to meet a client's needs (public or social purpose). Similarly, other respondents categorised a construction project into a specific purpose and social need(s), for example, P5, P12, A9, A11 and S7. Respondent S7 clearly stated that a construction project is "*a build, design and plan which is carried out to meet the clients need and requirement"*. Similarly, interviewee A10 believes construction project is *"the change in physical structure to meet a set of objectives"*. Equally, respondent P12 believes that project does not only it meet a specific purpose, it is *"… a specialist work…"* In the view of these respondents, construction project is 'real' and its reality is for social purpose use.

This view is taken further by the statement of respondent S4 who describes construction as *"a project that involves the development of physical materials brought together by many specialists to accommodate human needs"*. Respondent S4 believes the process of attaining the 'reality' is through the development of physical materials, which is put together by many specialists to accommodate human needs. The respondent demonstrates the complexity of construction project as compared with other projects. Similarly, respondent S7 considers a construction project as "*design plan and a build, which is carried out to meet the clients need and requirement"*. Respondent A5 capped it by arguing that reality of construction project is *"…connected to civil life"*. Respondent A7 when asked the difference between construction project and other project stated that *"construction project occurs where the greatest skills is with the human element of creation, emphasis is "human"*. Therefore, the reality of construction project is that, it must be fit for social purpose use and the defined objective. This is contrary to literature that only concentrates on the objectives but not social benefits. This leads to the next theme of analysis, conceptualisation or imagination.

Imagination / conceptualisation

A construction project was categorised into a theme of conceptualisation or imagination. This means a construction project requires ideas to meet its reality or purpose use as discussed above. Respondent S4 stated that the ideas for construction project are brought "*….together by* ***many specialists*** *to accommodate human needs"*. Respondent A2 also described construction project as *"…activities involved in realising the ideas"*. In these stances, a construction project commenced with imagination or conceptualisation, where this imagination is to be translated into 'reality' for social use.

Imagination is defined as *"the faculty or action of forming new ideas, or images or concepts of external objects not present to the senses"* (Oxford Dictionary 2001). Therefore, the attributes shown in table 8.5 illustrates the essence of imagination theme. The two main attributes 1 are procedures and concepts, which are combined to form conceptualisation or imagination theme (see table 8.5 for details). Albert Einstein once stated:

"Imagination is more important than knowledge; for knowledge is limited to all we know and understand, while imagination embraces the entire world and all there ever will be to know and understand". (Kaden *et al.* 2009 p.119)

This is to explain that construction project is 'unique' because of the different imagination from clients, designers and social-culture of the location of the project, which is translated through delivery to its 'reality', for social use. The imagination theme is consistent with the main literature attributes such as unique and temporary.

Mostly the academic respondents contribute to this theme of construction project as imagination or conceptualisation, such as Respondents A1, A2, A8, A13 and A14. Respondent A1 suggests that a construction project is *"…a process of creation of building…"* and respondent A14 believes it is *"designing and putting into action client's ideas"*. As respondent A1 considers construction project to be a process of creation, A14 believes it is designing and putting ideas into action. In this view, designing is 'conceptualisation'; thus, it is 'imagination'. Respondent A8 also states that a construction project is "*…design and construction of building…"*. This is consistent with the respondent A14 where putting the ideas in action is the process of creation of building, reality.

Some practitioners describe the imagination stage as planning, design, inception and quest. For example, respondent P7 suggests construction project to be "*a quest to construct a desired building/item of infrastructure"*; respondent P9 elaborates that it is *"something that has to be constructed* *in professional and workman-like manner to achieve the highest quality"* while, P12 described it as "*a specialist activity to create something with a set timescale"*. Equally, respondent P15 stressed it in term of *"…creating a version of a customer…"*.

Other attributes expressed by respondents under this theme include teamwork, overall goal, planning and organisation. Respondent S8 suggests construction project is a *"team working together to build a predetermined building"*; respondent S5 also describes it as *"the planning, organisation and management of building"*. In broader terms, a process of creation of building is the transformation process of transferring the concepts (imagination) to the purpose use (reality). This process requires concepts such as planning, organisation, teamwork, and management. Therefore, the next section analyse the process or transformation theme.

Process/Transformation

The above analysis establishes that a construction project is a concept(s) that is delivered for a social purpose use. This is arguably a process and this is a transformation process, i.e. imagination is converted to reality.

This theme has been heavily discussed under analysis of project above but some intriguing statement from respondents such as S3, A1, P1 and P12. Respondent P1 believes a construction project is *"the change to existing state of building, land or water course"*. There is a shape contrast between literature and this respondent view. In this respondent's view, change occurs in building, land or water course, which is arguably, a fact. Respondent A1 advocates that a construction project is *"a process of creating of a building for a client"*. This view means the process of creation is mostly interested in new building as compared to respondent P1, which covers building (including renovation and refurbishment) and civil engineering project. Similarly, respondent S3 argues that a construction project is *"an on-going process in which land and its contract is developed"*. This view seems parallel to respondent P1; although respondent S3 stresses that the process of construction is progressive, that include usage and demolition.

Despite the fact that, many practitioners describe a construction project from its realistic perspective, vis-à-vis academics describing it from conceptual (imagination) stance, both stances complement each other. This is because the reality comes out of imagination. Although, there are some practitioners respondent who did not explicitly admit conceptualisation or imagination theme of construction project, they implicitly do so because concepts are the notion of a thing coming to 'being'.

8.3.3 Q - Is a Construction Project the same as any other Projects?

This question could be addressed by using the first two questions discussed above (Q-what is a project and what is a construction project?) but the researcher deems that cross examining the interviewees with two other questions strengthens the reliability of the data collected. Therefore, two questions were asked: (1) The differences between project and construction project and (2) a single description of construction project.

8.3.3.1 Q - The differences between project and construction project

This question was asked to verify the interviewees understanding of the previous questions (about project and construction project). The researcher believes that cross examined questions helps to validate the main question(s). There was no major new theme identified in relations to 'what is construction project'. Some of the respondents shared some similarities and others the differences. Only 3 out of 40 respondents in total believe that construction project is the same as any other project (A5, P6, and P8) Respondent A5 and P8 suggest that the main difference is *"…one is in the construction industry..."* (P8). Respondent P6 stated *"…no difference, all deal with time"*. This is not consistent with the number of respondents who said they were the same when they were asked for their understanding of 'construction project'. Five academic respondents initially said a construction project is the same as any other project but only respondent A5 maintained this stance. Despite the 3 respondents suggesting that a construction project is the same as any other project, they did admit that **construction is a specialised type of project**, exclusive to construction industry. They explicitly admitted when the researcher asked them in a "single description of construction project", for example respondent A5 replied *"civil life"*, P6 said *"production system"* and P8 stated *"complex job"*. These views were exhibited in interviewees' responses to single word description of construction projects as discussed below.

8.3.3.2 Q – Single description of construction project

All respondents were asked to describe construction project in a single or two words. The results and themes identified are no different from that of what is a construction project? Table 8.6 presents the levels of the attributes and it could be noticed that respondents described the construction process as complex (this is parallel with respondents to construction as production system discussed later in this chapter). This suggests that using planning techniques based on linear theories as discussed in chapter 3 and 5 is obsolete.

Table 8. 3: The levels of the attributes for a single description of construction project

Attributes	**Level**
Building/Structures	Most common
Complex	Most common
Physical change	Very common
Concepts/creation	Very common
Bespoke work/job	Common
Social/civil life	Common
Profit	Common

This could be concluded that respondents unanimously agreed that **construction is not necessarily the same as any other projects.** This, therefore, means that attempts by PM societies to standardise the understanding and concept of PM is arguable part of the root causes of construction problems. For example, respondent A2 differentiated construction project and other project by suggesting *"construction projects are physical activities involved e.g. building something while other projects are very general"*. Equally, this is what respondent A1 stated as:

"project can be anything really, like organising a party tonight but construction projects are within defined boundaries of the term of construction, while project is something with beginning, middle and end with set of aims and objective to achieve"

According to respondents such as A1, A4 and S10 a project could be anything as suggested in literature by the PM societies but construction is a specific type of project. Respondent S7 suggests that *"other projects can be on-going without a set of goals but mere ideas, they can be non-profit..."* This suggests that a construction project is also profit driven. Other respondents express that a construction requires physical change, manpower skills, fragmented and location based. Respondent A7 stressed that "…*construction project occurs where the greatest skills is with the human element of creation; emphasis is human"* In the attempt to differentiate between a construction project and other projects exposed the constraints for construction project. Therefore, the next section presents the construction project constraints.

8.3.3.3 Construction Project Constraints

Literature suggests that Time, Cost and Quality (TCQ) as discussed in chapter 2 are the constraint for all projects including construction projects. However, from the respondents, construction project constraints are into two main groups which are subdivided into five. Most of the respondents described a construction project as complex and they believe it holds risks. The complex theme is consistent with interviewees response when they were asked the type of production construction is (this will be discussed later). It is argued that project being complex does not mean intertwined. This was stressed by respondent P4

"construction projects tend to be more complicated since they often involve many stakeholders as well as site specific challenges, whereas projects are planned with set of interrelated tasks which are executed over a period and within an agreed and affordable cost"

Similarly, respondent P2 stated *"construction project involves combination of manpower skills and materials/equipment. It turned to be more complex than other projects"*. The complexity is a constraint described in terms of the scope or size of project, the space, resources, involvement of many stakeholders and specific challenges such as environment and mechanisms to be used. Respondent P12 differentiates as: *"construction projects are very complex which incorporate various specialist activities/sub-contractors. Construction is or can be very litigious. Construction is very fragmented with specialist trade"*.

This view was expressed by other respondents such as A3 who did not explicitly state that it was complex, rather admitting that other projects are simpler as compared to a construction project.

"construction project falls within clear discipline mainly Engineering and Architecture. Construction projects requires the involvement of professionals e.g. M&E, Architect Surveyors, Engineers etc., while other projects are simpler than construction project"- A3

It is evident that a construction project is constrained by being complex, which is contrary to the TCQ dominated literature. However, identifying complexity as a construction project constraint has been stressed by other definitions, Gittinger (1982) described projects as "*the whole complex of activities in the undertaking that uses resources to gain benefits"* albeit he was referring to agricultural projects. Similarly, Lock (2007) ascertains that project management *has evolved to plan, coordinate and control the complex and diverse activities of modern industrial, commercial and management change"*. These authors acknowledged that complexity is one of the main constraints in projects. Owing to this complexity, construction projects hold high risks as suggested by the interviewees. Interviewee P5 states that "*the stake and liabilities are higher with construction project and it tends to be more complex"*. Thus, risks are the next constraints discussed.

Kutsch and Hall (2010) argue that risks potentially endanger the project manager to meet predefined project objectives of scope, time and cost. In the view of the authors, risks encompass scope, time and cost. This is expressed by interviewee P15 as he stated *"construction* *project has enormous risks to achieve cost, time and quality as the primary requirements to be achieved safely as possible".* In this view, it is suggested that so called TCQ identified as the main constraints in literature falls under the main constraints of risk. Interviewee P11 explains that *"tight timescales on construction projects, requirements of information to complete tasks…"* Respondents S7 looks at this from the profit perspective while, interviewee A4 believes the *"difference is that, construction project is a specific and not continuous or short term but other project maybe long-term".* Respondent S7 emphasises on profit (cost) while respondent A4 stressed on time. Also, respondent P6 advocates on time but interviewee P7 examines risks from different perspective outside the TCQ, therefore, claiming that

"all projects whether construction or otherwise are unique. Construction is very dependent on external influence – weather and market conditions"

In this stance, it is argued that due to the location based of construction projects, it has some external factors as part of the main risks. Respondent P7 made mention of weather and market conditions; this could be expounded as the environment, the socio-political and governing policies. This is what interviewee P9 believes that *"other projects do not have conformity that construction has…"* and S10 describes as *"a construction project requires a higher level of detail than other projects".* This emphasises that construction projects are constraint mainly by its complexity and risks. Bertelsen (2004) argues that, a project is a complex and dynamic phenomenon. The complexity of a project will enable the understanding of the entire project (Steiner 1969). The so-called TCQ are the major risks to be identified but there are other risks as presented in figure 8.2. Therefore, it could be concluded that construction project constraints are complexity, risks, time, cost and quality as shown in figure 8.2.

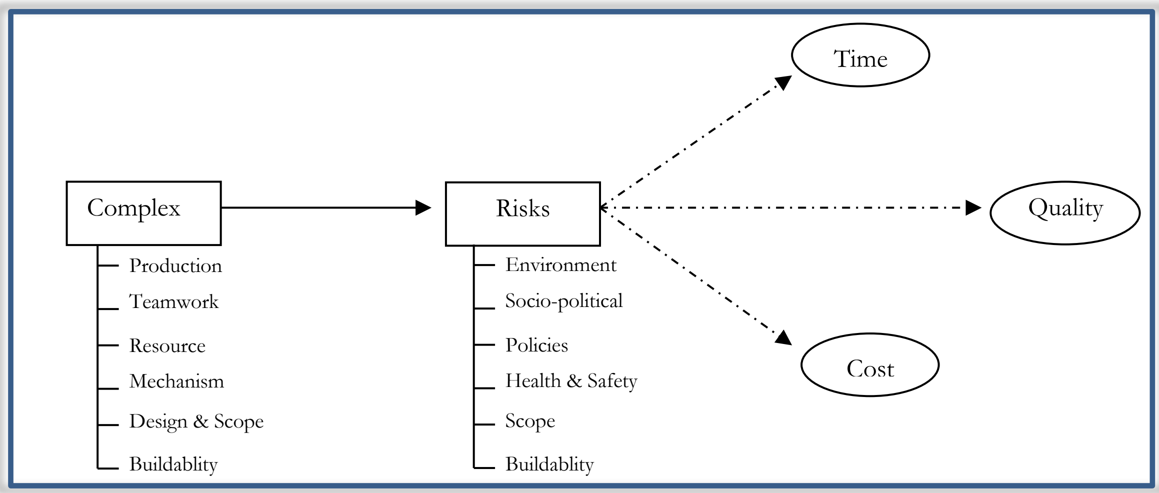

Figure 8. 2: Construction Project Constraints

8.3.4 Conceptualisation of Construction Project

One of the very essences of this section is to conceptualise a construction project, thus, previous sections focus on the analysis of construction project. The themes identified are imagination or conceptualisation, delivery or execution and reality or purpose use. The transformation process is the physical change of the entire process to achieve the reality of purpose use. The transformation process is done within a specific timeframe and boundaries of construction as presented in figure 8.3. It is therefore concluded in this study that construction project is "a *reality produced out of an imagination within an explicit period and boundaries for both specific and social benefits"*; OR "*concepts transformed through execution to purpose use within explicit period and boundaries"*

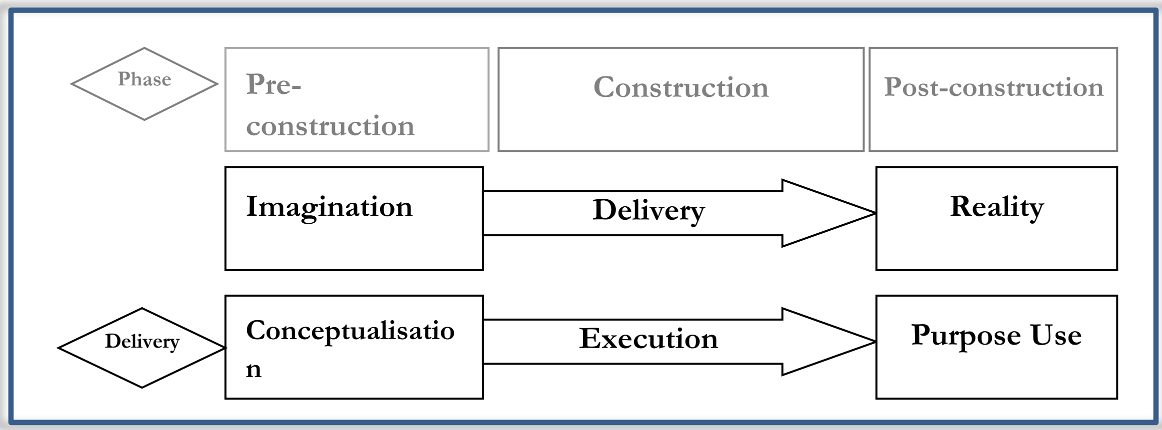

Figure 8. 3: Conceptualisation of Construction Project

The conceptualisation presented in figure 8.3 is in keeping with the construction project phases discussed in the literature (CIOB 2002, Darzenta *et. al.* 2000 and BRE 2000) which suggests the phases of construction are pre-construction, construction and post construction. The pre-construction is the imagination or conceptualisation stage of the project, the construction stage is the delivery or execution stage and finally the post-construction phase is where the reality of the project is verified of the intended purpose.

8.4 CONSTRUCTION PROJECT MANAGEMENT

This section of the analysis focuses on the understanding of construction PM, the roles of PM, the current PM techniques and the responsibilities of some key management roles and finally a single description of construction PM. In total, five questions are analysed in this section.

8.4.1 Q – What is Construction Project Management?

The main purpose of this question is to investigate interviewees' (the practitioners, academics and university students) understanding of construction PM and its managerial process. To achieve the purpose of this question, two questions were asked: the first of the two questions asked was 'what is construction PM?' and, second question, which is verification of the earlier question, is 'single description of construction PM'. From single description of construction PM, interviewees stated some common themes including, effective tool, planning and implementation, control, coordination, organisation, delivery project and resource management. These are no doubt part of the roles in PM discussed in literature. The most intriguing descriptions from the respondents include 'overall management' (A6), People and Process (A1) and 'necessary' (P5). According to respondent A5, PM is necessary for a project and respondent A6 believes PM is the overall management of a project. Interviewee A1 described it in term of its core elements, i.e. people and process. In this view, construction PM is a combination of both social (people) and technological (process) paradigms. Both concepts are discussed in chapter 11 of this thesis where TPC system is present to fill this gap. Notwithstanding this section is particularly interested in the managerial process part of PM.

Interviewee A13 stated that it is *"…a procedure of managing a construction project to meet it objectives"*. Arguably, this is literally the core of PM. However, others respondents defined PM as process *"a process to meet the project objectives from inception to completion"* (A6) and from a leadership perspective as *"…leadership of the site team, ensuring that the project finishes on time, within a budget, to a high standard of quality and Health & Safety"* (P12). These two perspectives are shared by many of the respondents. Respondent P3 suggests that the PM process is

"monitoring and co-ordinating people to perform pre-determine roles and align the project team goals with the client project goals. In addition, monitor the progress and cost, taking remedial action to try to achieve stated project criteria".

In this interpretation, the process or procedure is monitoring and co-ordination of the pre-determine goals. This view is also shared by other respondents such as S2, A6 and P8. Interviewee S2 stressed on the co-ordination, thus stating:

"…the co-ordination between the client, architects and sub-contractors as well as suppliers. A project manager will also ensure that the client's desires on site are being fulfilled and finding out what the client wants"

Interviewee P8 combines the two ideas by describing PM as *"…control of producing the project"*. These respondents argue that the process is monitoring and coordinating which is combined to control, but the question asked is, what is to be monitored or controlled? In respect to this stance, other respondents suggest that planning is the key to be monitored or controlled. Respondent P7 believes PM is *"planning and influencing events in order to achieve the desired outcome* *within the given parameters of time, quality, cost and safety".* Similarly interviewees P10 and P11 described PM as *"to plan and ensure sufficient resources are applied to the task to hopefully meet a proposed completion date*" and *"planning and organising workload and workforce to achieve finished building"* respectively. Both P10 and P11 stressed on the planning; however, P11 introduces the organisation theme. This view is consistent with the description of PM by Lock (2007) as discussed in chapter 2. According to this author, PM is planning, organising and controlling in spite of the risks. Similarly, CIOB (2002) and British Standard for PM share this view that PM is all about planning, and monitoring and control. This stance of PM process is challenge the PMI acclaimed PM managerial process of initiation, planning, execution, controlling and closing up (PM BoK 4.0 guidelines page 6, PMI 2008).

Arguably, there are three main issues with the existing managerial process as compared with the analysis of PM above. Firstly, there is separation of the "initiating process" and "planning process". The dictionary meaning for the word "initiate" is *to cause something to begin or start* and the word "process" is also defined as *series of actions taken in order to achieve results* (Cambridge Dictionary 2008). This is to emphasise that the so-called initiating process could be part of planning process or it is the beginning of planning process. The same dictionary meaning of planning is the *"act of deciding how to do something*"; therefore, initiation is the start of planning but not sole process. Respondent P9 stressed that *"planning is most important in PM".* Jongeling (2006) argues that project planning includes all activities required in the total construction process from the conceptual development stage through design to hand-over to the client.

Secondly, there is the introduction of execution as part of the PM process which is a sharp contrast between this and the respondents. Generally, 'controlling' and 'execution' are parallel process, this means controlling/monitoring is done at the same time with execution and as such it could not be a separate process in project management. The project manager controls and monitors the execution[39]. According to Maylor (2010), execution is "doing it" level, while controlling and monitoring is PM level.

Thirdly, PMI introduces a 'closing up' process; closing up process denotes the ending of the project. Arguably, this is a generally useful process; however, it is a narrow concept in terms of PM. The question being asked is what happens to the main objectives of the project and how could the industry being improved? Every process should be evaluated at the 'closing' so

[39] This was verified in the case studies discussed in chapter 9

that lessons learnt could recorded and used to improved future work for the betterment of the industry in general. This is stressed in Maylor (2010) 4D model, which end with the D4 (developed it – improving the process with the experience and knowledge gained). This suggests that the last stage of PM principle is 'evaluation'.

The evaluation process has been a key process in many industries specially manufacturing, albeit not in construction PM. One may argue that construction process is a unique process which has a defined start and finish time. However, it is easily forgotten that the experience and knowledge gained in a project is transferrable to another. This is therefore the essence of evaluation process which is broader than closing. Amrina and Yusof (2011) discussed the importance of evaluation processes (discussed in chapter 2) in manufacturing, which leads to optimal performance and success. It could be argued again that, in construction there are kinds of evaluation system, such as 'snagging' and signing off forms as it was exhibited in the case studies discussed in chapter 9. In as much as practitioners may implement some kind of 'evaluation' it is not well documented as a major managerial process in PM.

It is therefore concluded in this study that the managerial process of construction project management is Planning, Control[40] and Evaluation. Thus construction project could be defined as *the planning, control and monitoring, and evaluation of every task and process to achieve the purpose use of project within an explicit period and boundaries.*

Otherwise, it could broadly be redefined in line with construction project discussed above as *the overarching procedure of attaining reality out of imagination within an explicit period and boundaries for both specific and social benefits*

8.4.2 Construction Project Management Managerial Process (CPMMP)

The above analysis and discussion established that Construction Project Managerial Process (CPMMP) are Planning, Control and Evaluation, therefore, figure 8.4 presents the CPMMP in line with the process of construction project. This established that under the pre-construction phase, it is planning; on the construction phase the managerial process is control and the post construction stage is the evaluation process. The CPMMP covers all the construction project constraints discussed earlier (mainly, complex, risks, time, cost and quality)

[40] Where control denote both monitoring and organisation

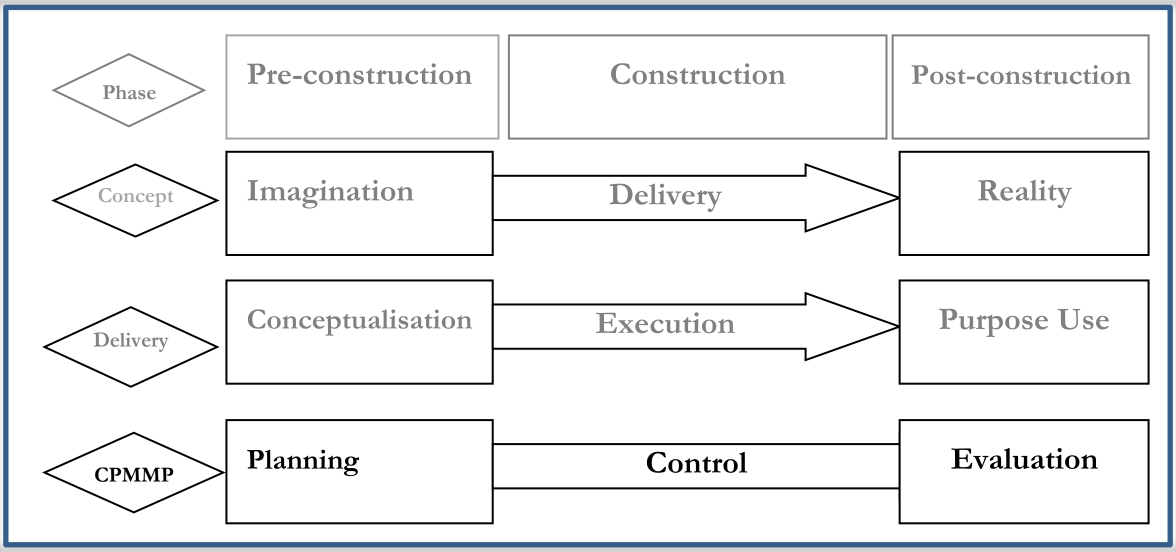

Figure 8. 4: Construction Project Management Managerial Process

8.4.3 Q – What are the main Factors or Roles of PM

This CPMMP was also confirmed when interviewees were asked for the main factors or roles in PM. Although, the response from interviewees is generally parallel with the CPMMP, there was however some few new roles for PM. Respondents believe that within the CPMMP, there should be other roles such as communication and motivation. For example, some respondents such as P7, S4 and respondents A10 and A12 believes that there should be motivation through the CPMMP. Respondent A12 considers motivation as a part of the CPMPM and S4 explains that experience and/or qualification is often essential to the CPMMP. However, interviewee P7 believes construction PM is

"planning, Implementation and Motivation. Motivation is a creation of ownership and pride within the workforce; creating and maintaining an effective and efficient team".

From this interviewee, motivation is a key to PM. This maybe because the interviewee coming from a contractor's perspective with many years of experience, suggest that motivation create and maintain effective and efficient team. This supposes to be a skill discussed in literature as "soft skills" for project managers, which is out of scope of this study, thus the researcher is not inclined to discuss it into detail.

Another interesting theme identified in the interviews is 'communication'. Interviewees believe communication is a major constraint to construction PM. Despite many of the respondents sharing the construction project constraints discussed above, communication is also believed to be one of the core constraints to construction PM. Some respondents including P3, P12, S7, S8, A3, A2, A10 and A11 believe communication is a major factor to construction PM. Respondent A2 stated *"…organisation and communicating with all the people* *involved in a project"* and interviewee A10 also suggests that *"…understanding the client's goals to ensure through negotiation and communication, these are achieved".* All these respondents suggest that since construction projects involve many stakeholders and agents, communication is a major part during its management. Interviewee A11 response to the question that

"…communication and coordination. One thing you should know is co-ordination and control remains through effective communication. Most project managers fail due to lack of effective communication. You may be brilliant, but lack of communication on a project you will fail. I will say communication is the main one".

In respect to the respondent, the CPMMP are hinged on communication, thus, making communication a major constraint together with the others identified for construction project. Communication is defined as *the imparting or exchanging of information by speaking, writing, or using some other medium* (Oxford Dictionary 2001). The word communicate derives from Latin *communicare* meaning *'to share'*. Since a project involves people, communication is a key constraint, that is, to share knowledge to have common understanding. Dainty *et al* (2006) refer to communication as "indispensable in the construction PM. Not surprising that ineffective communication cost the UK construction industry fortunes - over twenty billion pounds annually (BSI, 2010). Figure 8.5 illustrates the construction PM constraints with a star, meaning there are five main construction project constraints connected together with a circle of communication to represent the construction project management constraints.

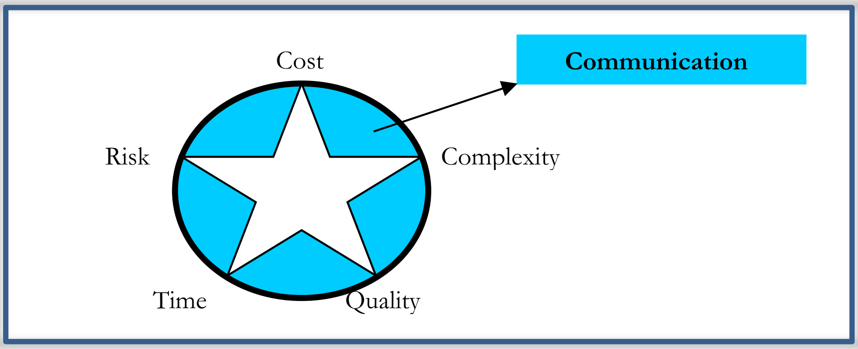

Figure 8. 5: Construction Project Management Constraints **(Star wheel constraints)**

8.4.4 Q- What are the main PM tool use or available?

As this research aims to develop a PM tool it is important to investigate the available or known techniques to the interviewees. One may argue that literature may have documented all the available techniques; however, it is prudent understand the real world experience as well.

Interviewees' responses generally concentrated on software and Gantt (bar) chart. Interviewee A7 responded *"…tools not sure but software are available, focuses on cost"* and interviewee A3 said *"…scheduling is the core of project management software like primavera is used".* Similarly, interviewee A1 said *"…detail programming normally using Ms [Microsoft] project, cost planning and cost control…"* These results are consistent with the case studies present in chapter 9. Practitioners gave varied choice of software, the academics response centred on Microsoft Project and Primavera while the university students only cited Ms Project

Figure 8. 6: Ranking of Interviewees responds on Software

Software	Ranking
Microsoft Project	Most Common
Primavera	Very Common
Asta Project Team Plan	Common
Project Commander	Common
Other Software	Limited

Despite the dominant response of the use of software and Gantt (bar) chart, there was some response on CPM, WBS, risk register, issue log, effective communication channels and organisation procedures.

8.4.5 Difference in some key management roles in construction

The main aim of this research is to develop a holistic planning and control technique to enhance construction project management. As any other technique that the propose TPC system is not exempted, it requires a proposed users, therefore this question is aimed to examine the difference in some onsite management roles. The TPC is a collaborative technique thus roles such as project manager, construction manager and contract manager are usually the issue since the adaptation of PM into construction industry.

A conclusion could be drawn from the interviewees that the three roles are different but their responsibilities differ depending on the company and the background of the interviewee such a contractor, consultant or client. There was consensus among the respondents that construction manager's main role is managing the actual construction on site. Except two of the practitioners' respondent who suggested that the role of construction manager is very similar to site manager dependent the size of the project. Respondents P7 and P8 suggest *"also referred to as site manager. Responsible for day to day site control of safety, quality and programme. Organisation and implementation of project plan on site"* and "*normally referred as site managers; looks at the day to day activities on site"* respectively.

The following are some quotes from the respondents arguing that construction managers are responsible for the managing of the construction on site:

"…managing the construction works" – P2

"overseeing that instruction by Architect and Engineers are carried out according to the specifications. Internal dispute resolution and managing subbies [subcontractors]" – P5

"dependant on the scale of the project, normally; responsible for all packages on the site. Direct and coordinate with all contract team including subcontractors" – A3

"…to manage the physical work on site, construction process and manage the site team" –A10

"manages the project on site" – S2

"manage material and trades on site. Ensure health and safety and other regulations are flowed. Monitor quality"– S4

Regarding the contract manager, respondents collectively suggest that their responsibilities also include the managing of the construction process but from the contractual stance. The following are some quotations from the respondent:

"…depending on the size of the project or contract; normally contractual issues" – P2

"…to identify clear requirement from the project in terms of cost, quality and time, and manages the construction manager to achieve the goals" – P3

"…overseeing the contract and future dispute in the contract/project" –P5

"…Achieving the work that has been awarded by the client. Co-coordinating with the consultants" –A3

"…in-charge of the contract mainly administrative" – A6

"…deal with the contracts part of the project (mainly administration)" –S2

Again, respondents agreed that a project manager's main responsibility is to manage the entire project. Respondent S7 stated that *"…oversee every aspect of the build*" while, interviewee S8 believes the main responsibility is *"…delivery the project on time and budget"*. Similarly, interviewee P6 describe as*"…sees to the running of the project and co-ordinating"* and respondent P9 claims *"…delivering the project through programming and financial controlling, either on or offsite"*. Despite the agreement among respondent on the main responsibility of project manager, few respondents argue that the project manager could as well be employed by the client rather than a contractor. Respondents such as P1 and P3 stated "*…to act as the employer's agent to oversee the whole project process"* and *"…appoint by the client and will be the client representative"* respectively. Furthermore, respondent A6 stated that "*project Manager is appointed by the client to oversee the project from inception to completion"*

Finally, respondents agree that all these three professionals may have different roles in managing of project; however, they have common role, that is, all of them are involve in some sort of project planning and control. This is the importance of the question to this study.

8.5 CONSTRUCTION AS PRODUCTION

Two questions are discussed under this section, which seeks to understand construction as production and interviewees awareness and knowledge of the modelling technique to be adapted for the development of the TPC system. The first question is whether a construction project is a production system and the second question is awareness and knowledge of IDEF0 model.

8.5.1 Whether a Construction Project is a form of Production and what form?

The conventional planning techniques are based on the scientific management theory which suggests that construction is linear production. There have also been discussions in literature that viewing construction as linear production is contrary to real world construction project. It is therefore important to investigate what type of production is construction from academics, practitioners and students.

A quarter of the total respondents believe construction is not any form of production while, the remaining three quarters believe construction is some form of production. In each group there were respondents who believe construction is not a production system. Respondent P2 believes construction is not a production system because

- *Construction is complex and the floor is determined by natural sequence of events (e.g. Foundations precedes ground floor; similarly, floor proceeds carpet)*
- *Construction drawings are not as detailed as production drawings (manufacturing)*
- *Construction assumes prior knowledge from the operative but do not explicitly define.*
- *Control is properly defined in production than in construction (e.g. Floor not being level and door frames not align before other trades are engaged.*
- *Construction has the problem of time.*

This could be due to the fact that production has been closing associated with manufacturing, wherefore; manufacturing and production are usually used interchangeably. Similarly, interviewee A2 also believes that theoretically construction is a production system but in practice it is contrary. Therefore, the interviewee stated

"construction as production yes but in practice, No. The external factors influence the production of construction, e.g. [the] same design in particular area will be different to another in a different area in terms of time and cost".

Notwithstanding, this argument, majority of the interviewees believe construction is some sort of production. Interviewee A6 argues that generally construction is a complex production by stating *"…gas line, motorway and railway are maybe a linear production, one off is point, generally complex"*. In the view of this respondent construction could be either linear production or complex production. Respondent P3 believes construction could be linear, lean or complex production, for example, "*construction as production depends on the size and type of the project, e.g. small office building is linear, new housing could be lean and stadia dams are complex"*. This respondent introduces a lean theme but this can be under any type of production in literature.

Notwithstanding, most of the respondents believe construction is a complex production. Respondents' classification of construction project as complex production is what literature refers to as 'project production' discussed in chapter 4. It could therefore be concluded that 'project production' in literature is described in construction 'real world' as 'complex production'.

8.5.2 Awareness and Knowledge of IDEF0 Model

As discussed in chapter 4 of this thesis, the concept IDEF0 model has been chosen as the appropriate modelling technique to be adapted to the development of TPC system. It is therefore important to examine the awareness and knowledge of interviewees about this model since it has been widely used in other industries although not as much as construction. Again, in construction it has been used in other countries for modelling but not in the UK where this study is being conducted.

All the 40 respondents have no awareness of IDEF0 model, not to talk about their knowledge about it. Therefore, the researcher asked them if they are aware of Structured Analysis Design Technique (SADT) and the response was equally negative. This response is consistent with all the case studies interviewees. The common response from the interviewees is "I don't know about it, what is it?" When the researcher explained most of them said it "it is a very simple concept" thus would like to read more about it later.

This research established that IDEF0 is seldom known and used in the UK construction industry, which the reasons could be one or more of the following reasons:

1. *Lack of Knowledge:* IDEF0 methodology is seldom known and used in UK construction industry. None of the interviewees had prior knowledge about IDEF0. However, after its introduction to them by the researcher, they found it to be simple and useful technique laudable to explore within the construction industry. The result was none after the first thirty interviewees; therefore, additional ten were carried out which was the same result. This also

consistent with Laitinen (1999) study conducted in Sweden, that state, IDEF0 is seldom known in construction industry.

2. *Limited exploration:* Some researchers in construction management suggest IDEF0 is used in the analysing of "as is" processes while others consider it is for IT programmes.

3. *Software distraction:* As discussed above, the shift of attention to extensive use of software for planning based on the traditional planning concepts. Lutz and Hijazi (1993) suggested this is due to relatively inexpensive microcomputers in the construction industry. However, Laitinen (1999) advocates that the current problems in the construction industry cannot be solved with IT alone.

It must be acknowledged however that, some participants questioned the desire of the construction industry to adapt to change. In as much as the construction industry has been criticised for lack of innovation and its conservatism approach, Sturges *et al.*, (1999) argues that, although the construction industry has adapted to change over the years, it is slow to drastic change. Consequently, IDEF0 has some commonalities with the existing accepted techniques; however, it is founded on different conceptual basis.

8.6 CONCLUSION

The focus of this data collection was to address objective two of this research. The analysis establishes the clear difference between construction projects and other projects. The study concludes that a project could be anything as discussed both above and in chapter 2, but a construction project is a specialist project. A construction project has concepts that are tangibly delivered for specific and social benefits. Again, a construction project is established to be complex which involves many stake holders. Therefore, a construction project is defined as "a *reality produced out of an imagination within an explicit period and boundaries for both specific and social benefits* **or** *concepts transformed through execution to purpose use within explicit period and boundaries"*

This study established new construction project constraints, which recognises complexity, risks, time, cost, and quality as the main constraints (figure 8.2). This is a development of only time, cost and quality in the literature. Understanding the complexity of a project elicits a lot of issues, including scope, resources, procurement route, strategic management, technology, specification, environment impact assessment, mechanisms and the implementation process. Procurement, which has been in the last decade a big issue in the UK construction industry from both scholars and practitioners, may be influenced by the complexity of the project.

Similarly, a construction project has inherited risks which include environmental, social-political, policies, health and safety, buildability and scope.

This study differentiates construction project constraints from construction PM constraints. The construction PM constraints are presented with a star connected with communication, where communication is the main difference between a construction project and construction PM (See figure 8.5).

The conceptualisation of a construction project and its management is presented in figures 8.3 and 8.4. This emphasises construction phases, concepts, delivery and CPMMP. It is established that the concept of a construction project is imagination, delivery and reality; the delivery is conceptualisation, execution and purpose use and the CPMMP is planning, control and evaluation. Therefore project management is defined as the *overarching procedure of attaining reality out of imagination within an explicit period and boundaries for both specific and social benefits.*

The study establishes the main differences between the key managerial roles in construction: project manager, construction manager and contract manager. All these managers are deemed to be involved in project delivery planning, thus project delivery planning is not the sole responsibility of a planner. As respondents believe that construction is a form of production system, they labelled it as ‘complex production’

Further, IDEF0 is little known and seldom used in the UK construction industry; however, it is believed to have to the potential to be explored in the UK construction industry.

Finally, it could be concluded that objective two of this thesis is addressed, which sets the platform to move to research process stage 3, discussed in the next chapter 9.

CHAPTER NINE: ANALYSIS OF STAGE 3 – MULTIPLE CASE STUDIES

9.1 INTRODUCTION

Stage three of this research process, which is the core of this study, data collection methods, focuses on the analysis of the case studies. As discussed in detail in chapter seven, four case studies were used and the data collection methods used were documents review, observations and interviews. This established empirical themes which show similarities as well as differences. However, across the case studies, it was evident the project planning is based mainly on Gantt chart. This research stage addresses objectives three and four, which is to investigate the industrial problems associated with project management, and planning and control; and identify the requirements and task flow for delivery planning and control respectively.

This chapter presents three main sections. The first section presents a commentary on the cases' delivery planning[41] and control. The data analysed for this section are mainly the document reviews and observations. The second section presents the industrial problems associated with project management, and planning and control. The analysis of this section is drawn from the interviews. The third section discusses the task flow and requirements for project planning and control. The discussions are made across all the data collection methods as well as the case studies. A conclusion drawn from the analysis will be carried on for further discussion in chapter 11.

9.2 OVERVIEW OF CASE STUDIES

The methodology chapter, seven, presents the data collection methods and the analysis procedures for this section, which entails a clarification on case studies project and the organisations. Four case studies were used, i.e. CS-01, CS-02, CS-03 and CS-04. In CS-01 the focus was on the subcontractor, whilst CS-02[42] and CS-04 were main contractors working a landmark projects in the UK. The CS-03 was engineering. The empirical data were collected through interviews, observations and documentary review. The analysis was conducted by establishing the primary themes within the case studies and through cross analysis which identified their similarities and differences.

[41] Delivery planning is usually referred to as project planning, thus this is used interchangeably in this study
[42] This project won the best construction project in the East Midlands, UK.

In total, 26 interviews were conducted. These comprise of 19 semi-structured and seven unstructured interviews. The analysis is concerned with interpreting the interviews rather than reducing the data to statistical counts. This is to retain the richness of the interviews conducted with highly experienced interviewees and other data collected. The analysis of this chapter was facilitated with the use of Nvivo. Detailed interviewees codes are presented in the appendix 2b. Each code is linked to the case study; e.g. CS-02-SSR1 denotes case study two, semi structured interview, respondent one, whilst USR2 denotes un-structured interview respondent two. All the interviewees have relevant academic and professional qualifications and with exceeding ten years of experience each.

9.3 PROJECT PLANNING AS IT IS PRACTISED

This section presents the background of the project delivery planning (PDP) adopted across the case studies. This data was collected through interviews, documentary review and observations. All of the case studies adopted the conventional planning techniques as the main tool; more specifically, Gantt chart, but using software. In practice, project delivery planning is usually referred to as programme; therefore, in this section these two terminologies are used interchangeably due to the interviews.

In CS-01, the subcontractor adopted the main contractor's programme for the project, which was Gantt chart. Therefore, the subcontractor claim to use narrative 'planning'. In this type of technique, the contractor is interested in the daily tasks schedule and when the researcher questioned where was that programme? They however, gave the researcher a Gantt chart produced using Microsoft Excel. In fact, they don't use the main contractors programme because they claim they are not *"involved in preparing the main programme"*. This was emphasised by CS-01-SSR1, who asserts

"…from my experience, project planning is not shared between interested parties but it comes from the client or the consultants and the contractor is expected to fit into this and for commercial reasons or for time reasons; if the contractor cannot fit into this then there is delay" (CS-01-SSR1).

There is no formal PDP in CS-03 (engineering construction). Factually, the programme is unwritten. The managers decide what 'to do' on daily basis. This is in keeping with CS-01 subcontractor. In addition, the observations from other projects also established that subcontractors PDP are mainly unwritten. One may argue that this is due to subcontractors adopting that the main contractors programme; others will argue that it is due to lack of integrated planning method available to main contractors.

In both CS-02 and CS-04, the PDP was mainly based on Gantt chart, which was produced using Team Plan and Asta power project software respectively. It is therefore suggested that current industrial PDP techniques are based on Gantt chart using software and that of subcontractors are unwritten. In this view that project planner asserts

"Well, obviously a big part of project is planning of the project. A lot of time is spent on planning at the beginning of the project, and if it is done right then it gives everybody something to work to. It is important that the programme is realistic as possible other than that it is not worth the paper written on. If a programme is not achievable then you must not have one. Yeah, it is very important to have workable programme to work to and also monitor against (CS-02-SSR8).

From this respondent's stance, and possibly from a principal planner's stance, planning is most important in project and should be realistic as possible or workable; therefore the next section is concerned with the analysis of PDP as practiced in industry.

9.3.1 Analysis of PDP used

As previously mentioned, both CS-02 and C04 used a Gantt chart produced using software. Therefore, this section presents some key descriptions of PDP in CS-02 as the researcher spent over a year on this case and had almost unlimited access to documentary data. The contact programme, as copies attached in appendix 11 shows the initial programme and the various revisions. These PDPs, which are mainly conventional bar chart, was the main PDP for all the cases. However, most interviewees believe that the PDP is unrealistic in many ways, which is consistent with literature. For example, interviewee CS-02-SSR2, who is the senior project manager on the case, admits that the programme was unrealistic by saying:

"the programme has been a problem because it is very very tight. You know the building yourself, it is very complicated and complex in shape. So for you to be able to plan, you need to discuss the complexity of it, the shape, the height because most buildings are normally five storeys high and you can reach easily"

The senior project manager asserts that this type of planning did not consider the complexity of the project. This implicitly suggests the underlying assumption that construction is a linear process, which is perhaps one of the main reasons for using the conventional planning technique more specifically, Gantt chart. This is consistent with the findings in chapter 8. Again, this respondent admits the mathematical calculation adopted for determining the durations and resources for a task is a problem, as the related risks such as shape and height were not considered. This respondent confirmed this again by saying *"…this has not quite* *worked off with the contract programme received"*. This view and many other new themes are discussed under separate headings below.

9.3.1.1 PDP as Schedule or Unwritten

The PDP for CS-01 (Sub) and CS-03 are unwritten. In CS-03, there are project managers and planners but they focus their time on site management and procurement. This was admitted by CS-03-SSR2 by saying *"Like I said, that is a problem; we don't write down anything, no no. what we do is on day to day basis, as we come in, and we have a production meeting on a Friday, where all the project managers will be there…"*

In CS-02, there were three revisions after the original programme dated 18/11/2010; the first revision 'A' was dated 16/12/2010, the revision B was dated 16/12/2011 and not long after revision C was issued which was 21st December 2011 [sic]. Later in the project, a target programme was developed, which was developed by the senior project manager, CS-02-SSR2[43]. They claimed these revisions were necessitated by the fact that the initial programme was unrealistic. The team argued 'they had more clarity on the project as they commenced on site'. However, all these revisions adopted a simple Gantt chart as the technique for PDP. This is the same in all the case studies and the focus of the PDP is 'time'. This is not to assume that schedule and PDP are the same because scheduling is only one part of PDP. Respondent CS-02-SSR2, who is the senior project manager, said

"you [researcher] have seen the programme that we do and that was how it was planned. That was done by our planner as part of the tender process and was developed into a contract programme. And that is what we work to and monitor with similar procurement schedule, which is in line with the contract programme".

This respondent confirms that Gantt chart is the main technique for PDP. Similarly, respondent CS-02-SSR1, who is the Contracts Manager and the Project Lead, explained how PDP was done by emphasising

"We tendered it using our project planner. He tendered the job in terms of programme, and preliminaries, that is, amount of staff that he thought they will be on site for the job, the crane, and the site accommodation. He planned all that part of it, in terms of subcontractors and getting the price right out, our estimators will be sending enquiries out at the tender stage to get prices back and put together and come to the client and say we would do it for this much and in this time. This is how it was originally setup".

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[43] Copies of these programmes are included in the appendix 11.

This respondent's (Project Lead) description confirms that the Gantt chart is their main technique for PDP; thus PDP is seen as schedule. However, he made another intriguing issue about the people involved in the PDP, which is discussed in the next section.

9.3.1.2 - PDP, the single responsibility of a Planner

Respondents CS-02-SSR1 as stated above, being the Project Lead, establishes that notwithstanding the importance of the PDP, its development is a sole responsibility of the Planner. This is confirmed by most of the respondents but the most important is CS-02-SSR2, who is the senior project manager, confirms by stating

"We have got a planner, who works at our head office and he works along with the estimators and the quantity surveyors putting tender packages together. And they decide what resources we need to be able to do the job. So I am not involved in the initial programme or planning."

This respondent who is responsible for delivering the project on site by monitoring and controlling was not involved in the initial programme. However, CS-02-SSR3, who was the Cost manager for the project, was partly involved. This respondent says *"I was involved with the job during the tender process. The estimators back in the office did the majority of the tendering documents. I did the final bit of the tender concluding the last few matters"*. It could be argued that the Cost Manager was involved because of the perception of 'cost' in PM but not necessarily the programme.

When the researcher asked the Contracts Manager "Do you think it would be better to involve people like yourself or the project manager in the programme? His response was strongly positive as *"Yes, absolutely, not just me and Ian but the subcontractors we need to talk to them. We need to talk to the subcontractors"* (CS-02-SSR1). In this respondent's view, collaborative planning is very essential to realistic PDP and perhaps increases the trust between the parties. Respondent CS-01-SSR1, who is also the Contracts Manager for main sub-contractor stated, "*in my experience it is the project manager or main contractors or managing contractor engaged by the client that does the planning and not from the contractor [sub-contractor]"*.

This respondent confirms that main sub-contractors are not involved in the programme of the project, which means they are given a duration to work to. In case study four, the Senior Project Manager, who is also the Project Lead, said he was involved in the programme maybe not from the initial programme but the developed programme.

"Yeah, yeah, we have planners. What we do is we put together a programme, which is just the start on. We have developed it now; this is done on power project, which is Asta power project. What we do is, I will sit

down and go through a process with our planner, we will look at the front end of the programme, what element of work is on there, is 'x' included on there or is 'x' not included on there, is there anything we need to change, move, what are the elements we need to do before the other". (CS-04USR1)

In the view of this respondent, planning cannot be separated from PM, which has not been properly discussed in literature. This view is consistent with the conceptualisation of PM in the previous chapter 8, where CPMMP was established as 'Planning, Control and Evaluation'. In spite of this respondent's confidence that planning is a core part of PM, he suggests that "*sometimes you get a project which has a programme, it has got a logistic plan, it has got the cost associated with it, no subcontractors and you got to develop it from there"* (CS-04-USR1). This is where the experience of the individual comes to bear as discussed in the next section.

9.3.1.3 Experience and Competence

The researcher attempts to understand the experience or competence of the individual responsible for PDP (normally the planner). The respondents implicitly suggested that the individuals responsible for PDP are either less experienced or incompetent with the construction process. One may argue that this is where collaborative planning is essential; others may argue that proper storage of lesson learnt on project is equally important (This will be discussed later in the chapter). However, this does not subdue the importance of experience and competence to lead the PDP process. According to CS-02-SSR3

"I still think it comes down to the quality of the individual. I don't think that is necessarily experience. In some respect experience is not a good thing. Experience breeds contentment and resistance to change. You have got somebody inexperience that is not always a bad thing, it depends on the nature of the project."

Although, this respondent considers that the experience of the individual depends on the nature of the project, the quality of the individual is key. This interview makes an interesting statement that 'experience breeds contentment and resistance to change'. In as much as this is an important fact, one may argue that it is all down to the quality of the individual as suggested. This respondent, CS-02-SSR3, takes the argument a little further by asserting

"There is a perception that if you put less people on a job it will cost less, and it will be probably being managed less effectively". I disagree with that; if you put the right people on a job it doesn't matter how cheap or expensive they are these individuals will make the difference".

This interviewee being a Cost Manager disagrees with the perception that less people will cost the project less. He believes it is not the number of people but having the right people is vital.

In other words, he suggests that the right people are people with the right experience or competence. Similarly, the office based planners believe, what they do is realistic but possibly it lacks comprehensive project control. On the other hand, some interviewees believe most unrealistic programme are allowed and approved[44] because of lack of experience and competence in this area, for example CS-02-USR1 clearly asserts

"We won the job based on tender programme, and one of the factors and one of the ways that contractors quite often win a job is say there is a job for £20million and five contractors all came and they said it is £20million job, so they all have the same price. The man who is going to get the job is the man who can build it quicker, that is, if it is what the client wants. So putting in a programme at the tender stage is quite often an important tool to try and help to win the job (CS-02-USR1)"

This respondent, who is the contracts director, argues that the PDP is usually tight because that is part of the selection criteria; therefore, it could be argued that completion date is important to such a client but not necessarily the realistic PDP. Most respondents argue that this leads to the excessive delays facing the industry. CS-02-SSR1 trusts the experience and competence for the client team is also importance. This interviewee says

"…he is the client but he is employed by his client as the project manager so he knows the industry. He also knows when people are telling important lies and being over optimistic with cost and programmes".

Although PDP may be dependent on the type of procurement and type of contract form used for the project, this respondent suggests that experience and competence of both the client and contractor planners are crucial for realistic programmes. It was noted that there were no flows or relationships between the activities in the construction programmes, which is discussed in the next section.

9.3.1.4 Linear or Assumed Relationship (PDPs lack of flow)

All the working programmes for all the case studies have no links or relationships between the activities as a copy is attached in appendix 11 (project control). As the conventional Gantt chart, every activity is represented with a bar, which shows the duration of the activity (discussed in chapter 3). The programme only shows the breakdown of the activities and its duration (i.e. the start date and the finish date). There is no relationship between the activities, thus there is no logic in the breakdown of the tasks. This confirms the construction industry's

[44] Allowed by the client representatives or consultants.

dependence on the conventional planning techniques; notwithstanding, the limitations discussed in numerous studies (see chapter 3). When the researcher queried this, the planner sent to the researcher a copy of programme with a relationship between the activities as copy is attached in the appendix 11 (copy of linked Gant chart). The planner and all senior managers interviewed established that it cannot be used because it is unreadable and clumsy no matter the size of the prints. When the researcher questioned the reasons behind the unlinked activities, this was the response of CS-02-USR1, *"we don't show the links because it might be wrong. Unless we are requested to do so which is rare? it is hidden; when our planner did the initial programme he indicated the links"*. This respondent, who is a Director, finally admitted after the researcher had shown him a copy of the linked programme that the programme with the links is unreadable; therefore he asserted

"Yes this is unreadable; the links are removed for clarity. The relationship between the tasks is read with experience. Bear in mind that without good understanding of the job you can't do links in a programme. For you to understand the project you need to talk to people (subcontractors) and team. Every activity is managed separately but you link them during subcontractors meetings".

This response incorporates previously discussed themes, such as the importance of collaborative planning, experience and competence and understanding of construction process. This view was equally advocated by most of the respondents. The interesting issue worth discussing further is "the relationship between the activities as assumed" but not clearly established which draws on issues such as communication and related functions of PDP. The former is obvious since there is no activities flow but the latter is discussed in the next section.

9.3.1.5 Related Functions

Some studies have established that PDP is a foundation for many related functions, which include risks, logistics, scheduling, project control, quality control and cost estimates. Yet, this is different in the industry; as discussed earlier, PDP is solely for scheduling. One may argue that literature has established that this is due to insufficient PDP techniques; this validates one of the main rationales of this study.

Evidently, the conventional Gantt chart available to the practitioners does not allow related functions as established in literature. Yet, when the researcher questioned the Planner and the Senior Project Manager on CS-02, they responded that some related functions can be included. They therefore, produced a new target programme, which shows the name of the subcontractors and some of their resources. They further argued that, the programme set for related functions, such as cost estimate and schedule can be founded. It is therefore concluded that the main relation function for the current techniques are based "time and cost". CS-02-SSR2 asserts that not having knowledge of the resources to be allowed for the project, could be one of the reasons they are not included in the PDP. This view again supports the issue of PDP being a sole responsibility of a planner; nevertheless, it stresses the importance of the perceived schedule and cost in PDP, thus ignoring other related functions. It is acknowledged that other related functions such as risks and logistic planning are done on separate documents; however they have no direct relationship to the programme. On this programme, which shows the resources, the planned percentage completion and actual percentage completed was showed, which indicates that the Planned Percentage Completed (PPC) was very low[45]. This finding is in keeping with Ballard's (1998 and 2001) conclusions that using the conventional PDP techniques give very low PPCs. This could be attributed to other factors such as unrealistic deliverables using the WBS.

9.3.1.6 Work Breakdown Structure (Unrealistic Planning)

It could be argued that WBS is a system that decomposes project into activities; hence, it is perceived that WBS is the main technique to breakdown a project into activities for the Gantt chart. However, the contention is that WBS is used to breakdown project into activities in homogenous levels as shown below, which is marginally different as compared to the PDP used in industry. On the programme are just list of activities not carefully grouped.

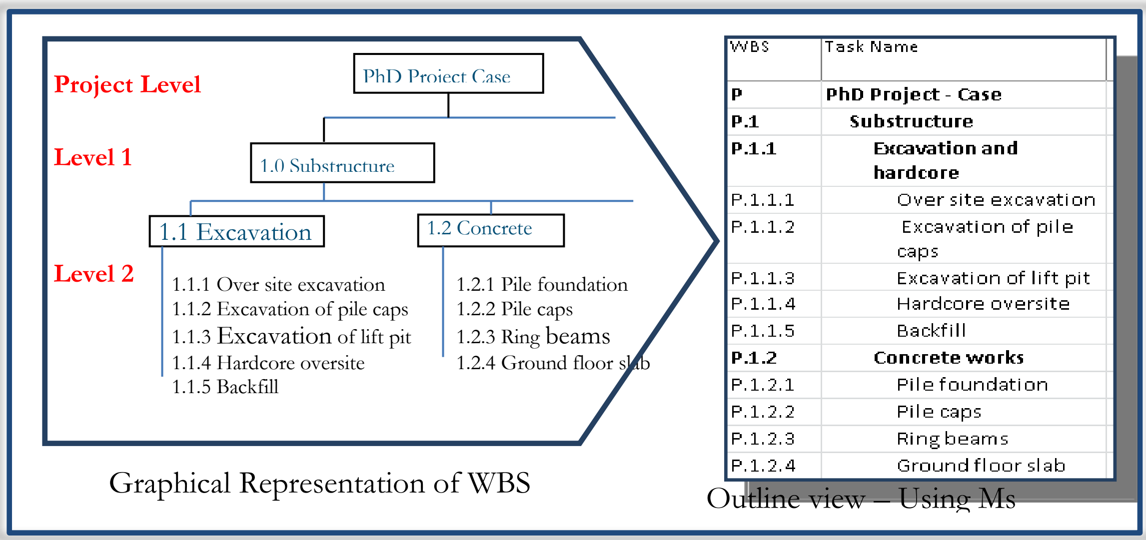

Figure 9. 1: Representation of WBS

[45] This is not the main focus of this section. It was evident also that PPC was low, thus there was no need for this study to conduct a detail calculation on the actual PPC, and it is also not part of the research scope.

The above examples are representations of WBS as discussed in the literature, which can be decomposed into much detail, although this is one of the pitfalls of using WBS. Arguably, WBS perfectly suits projects carried out by fewer subcontractors or more specifically by single point contractor. This is because it focuses on activities of the project rather than the deliverables. In this respect, some respondents consider the breakdown as deliverables, which are unrealistic whilst others suggest the entire planning is unrealistic.

"Planning generally should be a good indicator, isn't it? but it never works on well, anyway. When we tendered the job, we did a tender programme and contract programme but that changed massively when we came to site and we started to evaluate the proper bolt and nuts of the project. If you have to do as built programme you will realise, it will be completely different from what people envisage at the frontend of the job" (CS-02-SSR4).

This interviewee, who is a Project Manager, indicating that planning is unrealistic is a very honest admission. PDP should be realistic as possible, although one may argue that it depends on the information available to the planner. Notwithstanding, it should be a good indicator according to this respondent. This respondent challenged that there will be massive change should there be an 'as-built' programme. This is an interesting challenge as it could be incorporated into the lesson-learnt report for future projects (This will be discussed later in this chapter). However, interviewee CS-02-SSR1, who is the Contracts Manager, the line manager of the former interviewee, claims that although, the current programme is unrealistic, it is important to have some programme to guide the project team. He asserts that

"in the NEC[46] form of contracts, we are supposed to do that every four weeks. You have to update your programme logically with your progress line and predict a new end date and I think that is nonsense. You can't use open book for programme, it is nonsense".

This respondent implicitly admits that a programme should be revised but not 'open book', which means the slightest variation should not change the programme. He considers using open book system planning will not motivate the team to achieve deadlines (this study does not take this argument any further as it is outside the scope of this research). The senior project manager, CS-02-SSR2, sees it from a different angle. He says

[46] NEC denotes New Engineering Contracts, which is one of the alternative form of contract to the traditional JCT (Joint Contracts Tribunal) mostly used in the UK

"It isn't easy to plan and programme from the early stages without the knowledge that we have got now. There have been few problems because the complexity of the job was not considered much more".

This respondent emphasises on knowledge and appreciation of complexity of the project, which complements the findings in chapter 8 (project and PM constraints). Many interviews including CS-02-SSR4, CS-02-SSR1 and CS-02-SSR2 discussed above agree that the lack of appreciating the complexity of the project leads to the unrealistic planning. CS-02-SS6, the site manager, says *"planning is great and is good in a lot of respects but something should go wrong during the build-up time…".* This respondent as many others admits that planning could not be perfect in construction but it should be as realistic as possible to be developed further during the delivery stage. Respondent CS-02-SSR4 maintains *"the job is quite under planned really because there is a lot of stuff missing here and that is why we are struggling a bit, financially and on programme".* From this respondent's view, the unrealistic deliverables and missing deliverables, which is a result of unrealistic planning is causing delays and financial problems to the case study. The former will be discussed in detail later in this chapter and subsequent chapter ten but the argument remains that it could be an unrealistic duration proposed.

9.3.1.7 Task Duration

In chapter 5 of this thesis, scientific management theory was discussed among other prevailing theories for PM. Scientific management seeks to standardise productivity therefore suggesting the duration of a project is 'effort driven'. This means the more people on a project the lesser the duration for completion. In as much as this could be true in some sense, it is unsuitable for real world construction projects as respondents suggest. E.g. interviewee CS-02-SSR4 says

"A man in our head office was given hundreds of drawings and was told to produce a programme the following day or the following week so probably based on mathematical formulae. For example, he tried to quantify the amount of steel works, some very basic method of planning, the job has got 1000tonnes of steel works and he knows that you can fit forty tonnes of steel a day with a tower crane so he will generate the programme from that".

This respondent suggests that using the mathematical formulae do not consider the risks, and complexity of a project. Again, construction projects are executed in uncontrolled area as compared to the scientific mathematical formulae. Equally, interviewee CS-02-SSR3 admitted this by stating:

"You know there are ***a lot of empirical data in our head office****, like the average joiner can fix six doors a day so if you have 20 doors pro-rata. I meet the planners and that is how he does it. He uses the floor plate area say 1000m^2 per day for floor so three floors, therefore 9 floors".*

When the researcher questioned 'why they were far behind on the groundwork', the reply, was inadequate allowance of duration and other management factors. This respondent stated:

"We didn't have contingency for it other than doing it. That is one of the things Ian is very good at spotting everything that is needed to finish the job. It was a very complex job at the start. I do also believe interference with higher management has also caused problems".

It is a common agreement among interviewees that solely 'effort driven' calculation is unsuitable for construction projects. The Contracts Manager of case study one, says

It is very easy to say 5000 square meters wall to paint, one man can paint 50m^2 in one day so 100 men. This is a mathematical project plan and that is the usual method. But you can't get 100men a day, you may have 5 men for 20days what will other people be doing within those 20 days so it is the question of getting the right information from all the participants and this comes from experience and what the complete job requires and not a particular task, OK (CS-01-SSR1).

These interviewees suggest that a construction project and its tasks are constrained by many things, which do not allow 'effort driven' calculation to be suitable for estimating task durations. Figure 9.2 below presents the relationships and performance curves resulting from the observation of trades, painters.

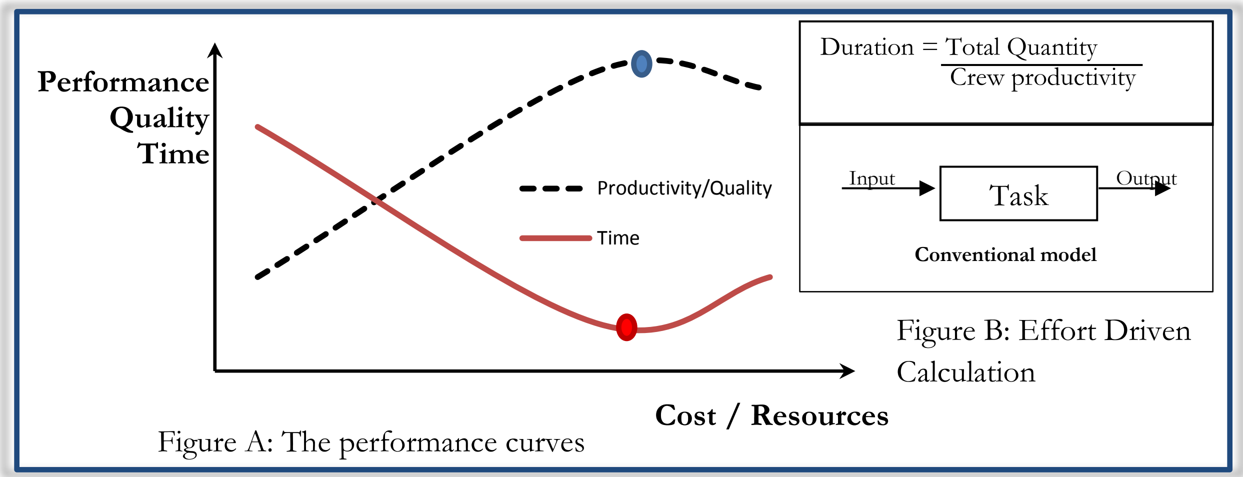

Figure 9. 2: The relationship and Performance Curves

Figure B of figure 9.2 illustrates the 'effort driven' calculation for duration used for tasks duration. The total quantity of the task is calculated by the cost manager (Quantity Surveyor) normally presented in the bill of quantities. The contractor, the planner or the individual responsible for preparing the PDP uses this mathematical formula to determine the duration of a task. Figure A presents the results of performance, quality, and time against cost or resources. The 'red curve', which denotes time, shows that increasing resources will reduce time to certain point, where this point is the optimum resource required. Therefore, increasing the resources after this point actually increases time that causes delay, increase cost and sub-optimal performance. Another, major problem derived is health and safety problems. This stance has been validated by statement by interviewee CS-02-SSR9, who is the Construction Manager in-charge of Health and Safety. This respondent asserts

"2013 people have been inducted with the first induction on the 15/11/2010 and the last up to date [05/10/2012, date of interview]; say 20 minor injuries and one of 3 days injuries is 1 person. The last 3 months accident and injuries has really increased but I think the more people on site the higher the risk"

This respondent seconded the results that more people above the optimum point also causes accidents and other health and safety issues. Equally, many respondents such as the senior project manager cited that effort driven calculation is not feasible in construction due to the other constraints as said earlier.

"…sometimes it is not possible to increase the labour, for example, you can't put more than two decorators in this room there will be in each other's way. So it will take certain amount of time to paint this room so increasing the labour will not necessarily reduce the duration". (CS-02-SSR2)

The above statement set the basis to discuss the productivity curve shown on graph with black curve. This graph shows that, increasing cost or resources will increase the productivity to an optimum point then any further increase will reduce productivity and quality of the delivery. However, this will increase the cost of the task, and the project in general. It is, therefore, concluded that using the conventional production model and the 'effort driven' calculation is unrealistic in terms of a construction task due to the many constraints and the uncontrolled environment. Again, interviewee, CS-04-USR1, suggested that productivity varies in different levels and floors of the projects as well as the weather are a major factor in construction project.

As suggested in chapter 8, construction may be some form of production but certainly not a linear production and where productivity remains constant with controlled environment. Finally, the documentary evidence, observation and interviews add to the call for innovative and holistic project planning technique. This was clearly expressed by respondents, for example, interviewee CS-02-SSR4, a project manager who has a master degree with many years of experience, explicitly stated:

"there is no alternative, what is the alternative? It is cheap to produce and faster. I have been to university and studied, yeah, but they seem to be no alternative. We can also say that depending on the information put in if it is poor information in then you will have crap programme"

This interviewee's comment concluded this section, which confirms, the literature, the insufficiency of the current planning techniques available to the general practitioner. Appendix 11 presents samples of planning techniques used in the case studies.

9.4 PROJECT CONTROL AS PRACTISED

This section is concerned with the discussion and analysis of how a project is controlled[47] as in practice. There are many procedures involved in project control, site monitoring including health and safety management, cost management, risk management (include Risk Assessment and Method statement prepared during the planning stage) and quality control and site control which include meetings, variation management, Risks control, and review. Both documentary and observation data collected verify the project control system used by all the case studies which is common among them. However, this study focuses on the control associated with a project delivery plan (programme). In the opinion of interviewee CS-02-USR, project control is enabling an efficient working process and environment, which intends achieve an optimum value, hence asserted that:

"… in managing project what you've to make sure is how you can allow those guys to work efficiently. We are working efficiently, you know you are getting best value for money you can get out of them and that to me is the most effective way of controlling your cost and maximising your value" (CS-02-USR1)

Accordingly, to enable effective and efficient process, there is a project meeting, which summarises the control process. This review process is part of the 'Evaluation process', as established in chapter 8 (CPMMP- Planning, Control and Evaluation). These meetings were normally scheduled on a monthly or fortnightly basis for all the case studies except CS-03. This case study had their meeting weekly as interviewees also confirmed it. CS-03-USR1 said, *"…one of my tasks is coordinating the production planning meeting, the one that we have on every Friday afternoon. This involves the production of that report there..."*. The main purpose of the meeting is to

[47] As discussed earlier in this thesis, project control in this thesis denotes traditional monitoring and control.

review progress. In CS-01, because the subcontractor's PDP is unwritten, they take note for their lookahead programme. In the other cases, a demarcation is made on the contract programme (PDP), usually with 'red thick line' as shown in the appendix 11 (project control). The project meeting covers other related issues, which its details may be outside the scope of this study such as cost management. However, the main focus of the project main is on progress report.

9.4.1 Progress Assessment

The progress is only concerned with 'activities that have been completed at the time of assessments'. This is therefore shown with a vertical straight line down the 'bars', which show the duration of the activities, but some activities are not completed on the date of the assessment. CS-01-SSR1, who is the director of subcontracting company, believes

"project monitoring and control is not seen as important task. It is on the other side, the focus is to get the work done, meeting day to day problems normally involving men and materials and if the results are not vindicated then monitoring and control comes in".

This interviewee believes that monitoring and control becomes a major issue when a task is not completed as scheduled. As shown in figure 9.3, activities such as item 18, 19, 20, 25, 26 and 27 were shown to be far behind scheduled. There is a column that also shows the targeted percentage and actual percentage of completion. In the minutes, similar report was given for the progress. There are other activities that were shown to have been completed or nearly completed such as item 21 and 22. However, what is not clear here is, when were these activities actually started and when were they completed.

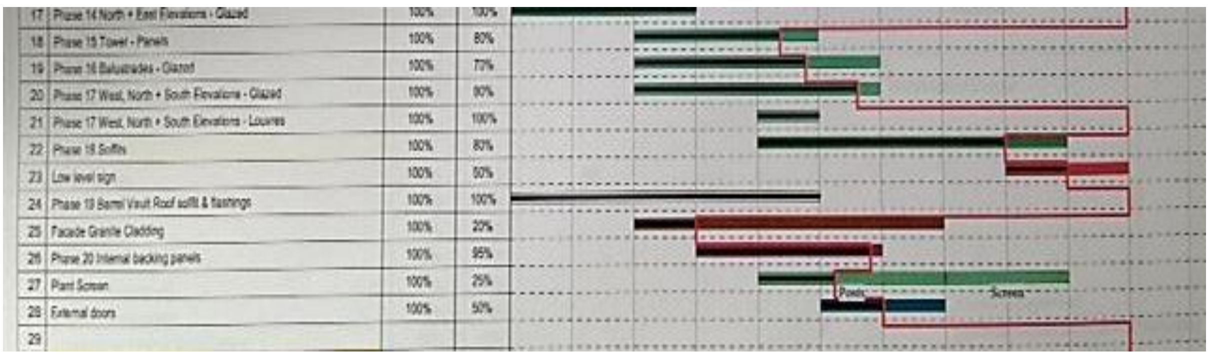

Figure 9. 3: Section of Progress Review

This method of assessing progress is common among all the case studies and many other companies where the researcher had interviews for research stage 10, thus it is established that progress assessment only focuses on the activities progress. This was clearly asserted in the statement below

I think a lot of the time you produce a programme, and it happened on this job, people keep monitoring progress against the programme but do nothing about it. For example, on 3rd week we are a week behind programme and nothing is done, on the 6th week we are 3weeks behind and still nothing significant is done and it get to the end where we have three weeks to go and then we are rushing (CS-O2-SSR8)

This statement is from the manager in-charge of planning (specialist subcontractor). This illustrates that a project is completed without any paper trail or reference on a particular task for data storage and lesson learnt. The control process lacks review and feedback, and this does not promote continuous improvement in the construction industry.

9.4.2 Managing Progress

Interviewee CS-02-SSR8 as discussed above, disagrees with this system of progress assessment solely based on whether the task is complete or not, thus believes why and when should be explored in the progress assessment.

"Controlling is similar to monitoring, like I said we produce a weekly and fortnight report and then we also do a monthly report which goes into a lot more detail that where we go into "whys" and "whens" implications of things. ...This is the method we use to flag up any issues".

A similar view is also shared by CS-02-USR1, who is a director, was describing a project he monitored and controlled as a project manager.

And the subcontractor will start to think that actually, this guy has not just got us in here to beat us with a big stick that we are behind programme and we've to go and sort it out, but he actually want to know what our problems are and how he can help solve them. That is your root and it is finding the root.

It could be concluded that planning techniques available do not allow the suitable assessment of progress, which intends do not allow appropriate review and lesson learnt of deliverables for continuous improvement in future projects. Additionally, this will ensure that planning and control will be realistic as possible which also advocated by respondents CS-02-SSR8:

"Many people produce a plan that is not realistic or achievable so if it is not achievable why produce it. You got to understand what you are planning, understand the detail about the project to enable you to produce a realistic and workable plan".

9.5 THE INDUSTRIAL PROBLEMS ASSOCIATED WITH PM, AND PLANNING AND CONTROL

This section explores the main and common industrial problems associated with PM and more specifically, planning and control. This could be done appropriately in isolation from exploring the success factors and possible improvement required. Therefore, similar to the interview questions, success factors are first to be analysed, followed with the main problems and finally the possible improvements. The data analysed in this section is mainly from the case studies. These factors and problems are closely related thus some are discussed more on a particular section than the others. This saves time, repetitions and ensures other themes are discussed in details.

9.5.1 Success Factors

The data used for this section runs through the 26 interviews conducted within the four case studies. In this section, the factors to a successful project and PM as well as planning and control are explored. The first part is factors to successful project, following with a discussion of the factors to successful PM and then finally is the analysis of factors to successful project planning and control.

9.5.1.1 Factors to a Successful Construction Project

Interviewees stressed on many factors which contribute to a successful construction project, although literature mainly focuses on the iron triangle (Time, Cost and Quality- TCQ). For example, interviewee CS-02-SSR1, suggests that beside project planning, factors to successful project are completing as quickly as it can be completed, to best value for money (VfM)

"To me a project is successful when it is completed, put programme at one side, put the planned programme at one side, put planned cost to one side, planned quality to one side. To me a job is successful when is completed quickly as it can be completed, to the best value for money that can be completed and to the best quality for that value for money" asserted by CS-02-SSR1

According to this interviewee, a project should be completed as *"…quickly as it can be completed"*. This means it is not necessary to rush and complete just on time, rather the project should be delivered 'effectively', which will result in completing on time. Again, this respondent suggests that projects should be completed *"…to the best value for money"*, which means project should be 'efficient' to achieve the required quality and time (This is developed further in chapter 11 as 4Es management model). This interviewee stresses that PM is core to project success, which is consistent with literature and also the finding in chapter 10. Similarly, the construction director, CS-02-USR1 suggests

"yes, if I am the client, am looking for my advisers to give me the best advice to do with who I place the contract with. So I will be expecting him to be looking at the cost and at the programme. I will be expecting him to look at the track record of all the contractors; I will be expecting him to interview all the contractors…"

Although this interviewee implicitly acknowledged that the project managers, in which he refers to the advisers or consultants, are core to a successful project, he stresses on project planning but in terms of cost and quality. Equally, other interviewees stressed on components of PM, these include, project planning, control, risk management, communication, co-ordination, and experience and competence.

CS-01-SSR2, who is the commercial manager, asserts that factors to successful project are *"…programme management and delivering the project on time"*. This interviewee, notwithstanding being responsible for commercial and cost issues, believes planning and delivering the project on schedule are the main factors to successful project. In a similar view, the senior project manager, CS-04-USR1 asserts that success of a project and its management centres mainly on planning.

"…there is no point to have 20 contractors and none of them can do nothing because there will be in each other's way that cost a lot more money than not do it. So you got to look at the bigger picture before you even start and the planning side of it at the early stages is very difficult especially on a scheme".

In addition, this interviewee makes another profound point in the statement above; he indicates that sufficient project planning provides to cost certainty as well as providing the bigger picture of the project to stakeholders, usually contractors. This view is shared by many other interviewees such as CS-02-SSR6 stated *"It is all down to thinking and Planning, and making sure that you cover every obstacle that there is [and]...you got to think about the bigger picture all the time, sorry it works"*. This respondent believes planning is key to project success; notwithstanding, the planning should cover the bigger picture of the project.

Within the same context of PM, CS-01-SSR1 suggests that good coordination is a core factor to a successful project. This respondent says *"…a good coordination between the client, the contractor and the consultants, and general management principle like having material on time and right quantity and at the right place"*. This respondent implicitly admitted that logistics planning is equally an important factor to a successful project, although the main weight was on coordination. This view is similarly asserted by the site manager, CS-02-SSR7, who says *"…how time and resources are being managed. Management of the project; how materials are being used. You can also talk about motivation, how the workforce is motivated"*. In as much as this respondent advocates on project management as the core factor to successful project, he singled out time, material and resource management. This implicitly suggested that project planning is again an important part in a success of project as well as communication.

Equally, the senior project manager of CS-04 believes project and its management success are largely based on planning and communication. This respondent emphasises on communication by stating *"the idea was we want to build a local communication for the offices, so we position our office central that is where we are sitting now, we've got access to both sides of the site. We run both sites in this office"*. In this respondent view, planning, coordination and communication are the core factors, arguably which is to say project management. Interview CS-01-SSR1, director, believes it is the quality of the team on the project and effective coordination between the stake holders. Therefore asserting *"…having a good team and a good coordination..."*. Interviewees CS-03-SSR1, CS-03-SSR3 and CS-01-SSR2 contend that it is more to do with site control therefore asserting "good site management and having clear project objectives". Arguably, these respondents argument may be driven by the fact that they do ad hoc planning and therefore the success of their project is solely dependent on site control or management. CS-03-SSR1, who is the project manager, again believes *"…having access to the right technical support"*. This interviewee took the argument to another level by introducing another theme, experience and competence.

This theme of experience and competence was largely reinforced by many interviewees. CS-03-SSR4, who is the operation manager with many years of experience, emphasises that *"…experience of an individual is important. It is one thing to do a project, which is similar to what you have done before and another thing to do a project, which is completely different"*.

This respondent argues that a construction project maybe unique but they are not necessarily different, thus, experience and competence is important to a successful project. Similarly, CS-01-SSR1 argues that *"…the parameters to understand the different tasks that makes up the project, if you have no understanding, you should have access to people with understanding"*. According to this respondent the understanding of the individual tasks involved in the project is equally important to a successful project.

However, CS-02-SSR3 suggests that *"Experience breeds contentment and resistance to change. You have got somebody inexperience that is not always a bad thing, it depends on the nature of the project.* In the view of this respondent, competence is the key to successful project rather than competence. Yet, this same respondent argues further that an experienced person is necessary for project planning by stating "…*someone like Ian, he is experienced and he will just have at the back of his mind where the pitfalls and the problems were".* Here, he believes an experienced person, such as his project manager, could identify the pitfalls in planning and control due to his experience.

The common theme asserted by interviewees as a factor to successful project is when the project is profitable. Interviewees such as CS-01 –SSR2, CS-04-USR1, CS-03-SSR3 and CS-02-SSR4 clearly stated "profitability" as the main factor to successful project, whilst CS-02-SSR1 described it as value for money. This is where the client gets his/her value and they make their profits. CS-02-SSR4 emphasised that *"there are broader barometers of measuring success; our company value profitability as its number one motivation in terms of success, then repeat work of the client, and no accidents".* This respondent explicitly stated their company barometer of success to project as profitability, repeat work from the client and low accident rate on the project. This view of repeated work was also clearly stated in all the case studies. It could be argued that from contractors' perspective among other factors, profitability, repeat work, low accident rate and site management are part of the core factors to successful project. However, all these could be achieved through effective project management. From this analysis, it could be concluded that factors to successful project is fundamental to effective project management as figure 9.4 below illustrates the main themes and relationship to project management.

"A continuous relationship with the client is a good barometer to determine the success of a project. If a client never uses you again then it is assumed that the job wasn't a success in the client's perception. I think you don't get many second chances in the building (construction) industry so continued relationship with a client is a good indicator". This is the response from CS-02-SSR4 which suggests other parameters to successful project. This interviewee made an intriguing statement that in construction there are not many second chances therefore client retention is vital.

It has been noticed in this analysis and across the case studies that factors to successful project is beyond the TCQ as stressed in literature. Therefore, this study establishes other parameters that have not been explored in literature. This also confirms assertion in literature that managing project based on TCQ is obsolete and therefore this study presents 4Es model for managing projects which is discussed in chapter 11.

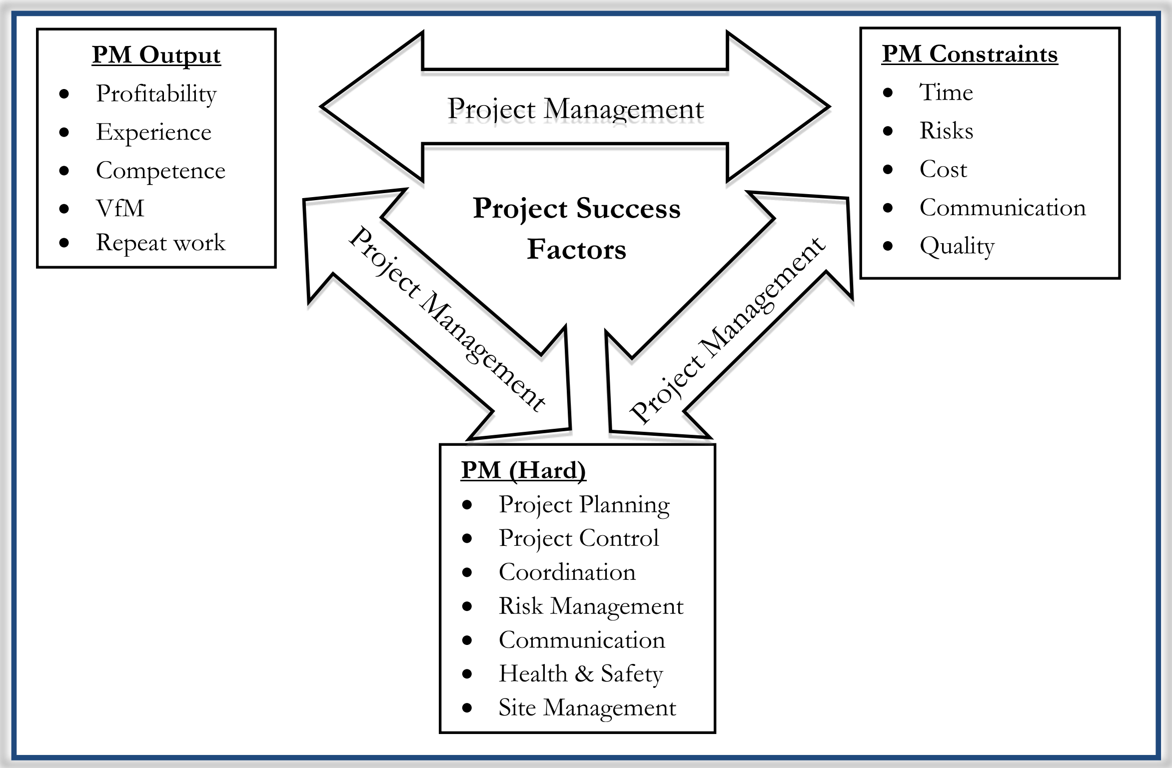

Figure 9. 4: Project Success Factors – Contractors' Perspective

Figure 9.4 presents the categorisation of the themes for the success factors to project as discussed earlier. There are three categorisations of success factors, i.e. PM output, PM constraints and hard PM. This illustrates that the success of a project is largely based on its management, hence project management. One may argue that this is only contractors' perspective; however, this is consistent with the findings in chapter 10, which considered other stake holders in construction such as clients, consultants and developers. Furthermore, it is parallel to the study of Hubbard (1990) and Wit (1995). The next section focuses on the factors to successful project management as it plays a major role in the success of project.

9.5.1.2 Factors to Successful Project Management

Success factors in literature has concentrated on using statistical biased strategy to study success factors, which has abound in numerous repetition of themes. However, to understand a real world issue, this study considers alternative strategy, qualitative.

This section of analysis commences with fascinating statement from CS-02-SSR4 which covers some main themes believed to be success factors for PM. The project manager, CS-02-SSR4, reviewing the success factors of the project stated

"Generally, it has been quite well executed; the only failure is the programme failure. The project duration is also too tight. There was no appreciation about how the job was to be constructed at the tender stage. Of course

we have few issues with people, where one of the big firms went bankrupt which had an impact on the job and another firm finished four months late. We have been having regular meetings…"

This interviewee explicitly stated the following themes, execution, PDP (programme), unrealistic completion duration, project complexity, team work, financial management, competence and resource management, and project review meetings. Again, this response also directly indicates some problems associated with PM, which is part of the core aim for this chapter (discussed later). Other interviewees, such as CS-02-SSR5 and CS-01-USR1, stressed communication and team work.

"Some people don't get on well for various reasons; Communication is key to everything. You've got to have effective communication all the way through. There must be an understanding through communication. Communication is paramount" (CS-02-SSR5)

CS-02-SSR5 believes although people don't get on for other reasons, he maintained that communication is the solution factor. Therefore, the analysis success factors to PM identified these themes headings as shown in figure 9.5 below.

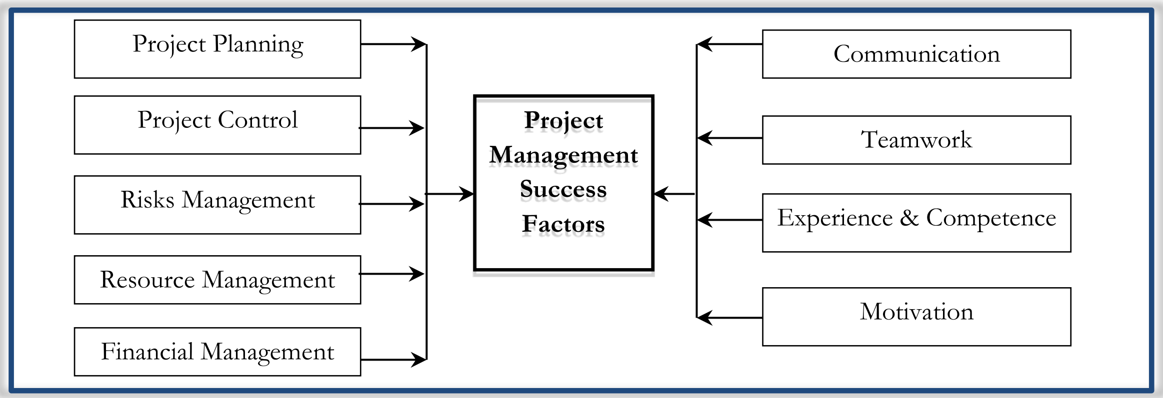

Figure 9. 5: Success Factors for Construction Project Management

Project Delivery Planning (PDP)

Interviewees suggest that PDP is the core factor to PM that many related functions are built from. CS-01-SSR2 simply stated "…*programme management*" and CS-03-SSR2 also asserts obviously planning as the main factor for successful PM. Similarly, CS-02-SSR2 and CS-04-USR1, who are both the senior project managers, suggest that *"…planning is key"*. CS-02-SSR8 asserted:

"Many people produce a plan that is not realistic or achievable so if it is not achievable why produce it. You got to understand what you are planning, understand the details about the project to enable you to produce a realistic and workable plan"

Project Control – Site Management

CS-02-SSR4 and CS-02-SSR1 asserted the importance of project monitoring and control in the success of PM. CS-02-SSR4 added that *"…Quality of supervision as well is important*", whilst CS-02-SSR1 asserted:

"it is monitoring that programme. You need to monitor that programme very closely, identifying any areas that you fall behind, yeah, monitoring and controlling. We have subcontractors, you find out that something is not right, you find out why is not right and what can be done like I said earlier. It is so so simple"

Again, the construction director, CS-02-USR1, seconded this view by explicitly asserting:

"Everything is controlled by the project programme. If something is falling behind, you need to know why and for you to know, you need to ***monitor the programme****. You have to religiously meet every sub-contractor weekly or fortnightly depending, I mean to say on a regular basis".*

This validate the CPMMP established in chapter 8 and stresses on the importance of the review process by suggesting that it should be on a regular basis to bridge the PDP and the control process. The next section is concerned with the discussion of the project review meeting.

Evaluation - Project Review Meeting

Project review meeting is recognised as one of the vital processes in PM and unsurprisingly it is one of the main tri-process of CPMMP established in chapter 8. However, it worth stating again that literature is quiet on this process and its contribution to PM success.

There was unanimous agreement among interviewees about the importance of review process to PM. In CS-01 and CS-02 project review meeting are monthly; whilst CS-03 is every week and CS-04 every fortnight. CS-02-SSR3 argued that,

"If he [Contracts Manager]hold it weekly it takes an hour and we all massively benefit from it by understanding where the priorities are. I don't think we do things differently, generally we don't. If you understand what the priorities are, the problem of tomorrow will be different".

Communication

Respondents deemed communication as one of the main factors to successful PM. This was stressed by CS-02-SSR5 and CS-04-USR1

"…communication is a key to everything. You got to have effective communication all the way through. There must be an understanding through communication, communication is paramount" (CS-02-SSR5)

"the idea was we want to build a local communication for the offices, so we position our office central that is where we are sitting now, we've got access to both sides of the site..." (CS-04-USR1).

Equally, CS-01-SSR1, who is the director of a subcontractor, stressed communication as key to successful PM

Coordination and Teamwork

"When there is spirit of antagonism, the client is at one side, the contractor on the other and the subcontractor here and people are trying to point figures, when there is a culture of blame. When there is a culture of blame and so on, it is very difficult for project management to proceed. When there is spirit of corporation, and good communication then it is much easier for project management to succeed" (CS-01-SSR1)

This interviewee believes PM will succeed with coordination and communication. As the latter has been discussed, the former is equally stressed by other interviewees, such as CS-02-SSR8, who claimed:

"There are a lot of facets to a successful project management. Keeping your team motivated is a big factor. Making sure you have the right people doing the right jobs; obviously managing relationships with people working for you or client or others; communicating with people both upstream and downstream. Man management is also a big part of it as much as anything"

This respondent elaborates on motivating the team as a good coordinating approach but believes team work and managing relationships is an obvious choice for a successful PM. Furthermore, this respondent advocates that coordination and teamwork is a big part of PM as well as anything. CS-02-SSR7, a site manager, also admits that motivation plays a major part in coordination and PM in general. This respondent indicated:

"how time and resources are being managed, management of the project; how materials are being used. You can also talk about motivation, how the workforce is motivated; when it comes to managing the project, I think it is about cultivation of good habits, by making sure you are on time, and everything is well planned"

CS-04-USR1 suggested that the location of the office is important for effective communication, which was seconded by the principal planner, CS-02-SSR8 who argues that:

"Now and again, George, you get a better team approach, for instance, the main contractor sat down stairs and we sitting up here. Everybody is kept away from their own little bits. Whiles on some jobs the main contractors said, right, everyone let sit in the same room, I am not bordered about what one says, let us all work together. I think that is a better way of working rather than every sitting in their little corner".

Experience and Competence

Another theme that was common among the respondents was experience and competence of the individuals as well as the team. These themes have been discussed in much detail earlier in this chapter (under factors to a successful project). CS-01-SSR1, who is a director, is concerned about the competence of the individual. He claimed that *"…the parameters to understand the different tasks that made up the project if you have no understanding you should have access to people with understanding"*. CS-02-SSR3, the senior cost manager, also stressed the quality of the individuals and the time allowed the task. CS-02-SSR3 claimed:

"I don't think it is solely the number of people and the money spent, I think it is the quality of the individuals and the amount of time that the individual is allowed to concentrate. So exclusively on this site I look after it 100%".

Resources, Financial & Risks Managements

There were other themes that were not common among respondents but worth mentioning include **resource management, financial management and risk management**.

CS-01-SSR3 and CS-04-SSR2, who are both project leads with many years of experience, argued that PM is all about *"…risks management"*. Their argument could originate from the complexity of construction project, which was also echoed by CS-02-SSR2 and CS-02-SSR4 who believe that, normally, people underestimate the complexity of construction projects (as discussed earlier). CS-02-SSR4 and CS-01-SSR2 advocate for resources management as core to PM. CS-01-SSR2, being the commercial manager for subcontractor, believes PM's success is solely based on resource management; therefore suggested factors to successful PM are *"…labour, plant and material management"*.

Additionally, CS-03-SSR5, who is a site manager and has a direct connection with the subcontractors, believes finances plays a major role in a successful PM. *"we need to have a lot of people, we don't have because the preliminaries on this job has been chopped so we have very few site managers available"*.

Motivation

"You come across to somebody and if you know what they are capable of and even better you ask them what they are capable of and you take their opinion on board. Yeah, you will get so much respect and you will get them so much more motivated, ***a better motivated workforce****. You will get a people who want to work".*
This is a quotation from CS-02-USR1

Motivation was described as one of the main factors to a successful PM. As stated above, this interviewee, who is project lead, suggests motivation through collaboration. Equally, CS-04-USR1 seconded this by saying *"…beside everything, it is about motivation"* and CS-01-SSR3, who is also project lead for subcontractors, suggests that *"…motivation through the management chain"*

This interviewee, CS-01-USR1, who is a director with many years of experience, elaborates that motivation is also done by give the people ownership; this intends give them pride to work for themselves. Respondents suggest that motivation is one of the factors to a successful PM, therefore affirmed:

" I am getting off the subject here. In terms of motivating people; people who work for me, they won't but people who work for themselves. They will work for their own pride in what they are doing. What we've got to do as managers is to try and agenda that pride. Give them a sense of ownership, make them feel that they are important, make them feel like he is not just coming out here to see how the job is going but he is coming out here to see what am doing. Ownership is 100% the key to people been motivated. Sorry, if I went off".

9.5.1.3 Factors to a Successful Project Planning

This section presents the analysis and discussions of what interviewees believe to be the main factors to a successful planning and control[48]. The above analysis has established that PDP and control are both important factors in PM success and project success factors. This is consistent with literature and findings from chapter 10. However, the factors to successful PDP and Control are sparse in literature.

"What happens is that the planners, estimators and the directors will say, look this is how much the job will cost. If we really want this job, slice hundred thousand pounds on preliminaries; slash 100K here and there. Then they will say we are going with that price. Then we come to the site to realise it will not work" (CS-02-US1). This comment suggests that PDP and project based mainly on cost is unreliable. Another interviewee, CS-02-SSR2 cited *"…the accuracy of it [PDP]; that somebody have really given it a thought and therefore it is useful; has covered everything that needs to be done"*

Nine themes were identified as the main factors to a successful PDP and figure 9.6 presents these themes, which is followed with the analysis and discussion of these themes.

[48] As said before control in this thesis denotes traditional monitoring and control.

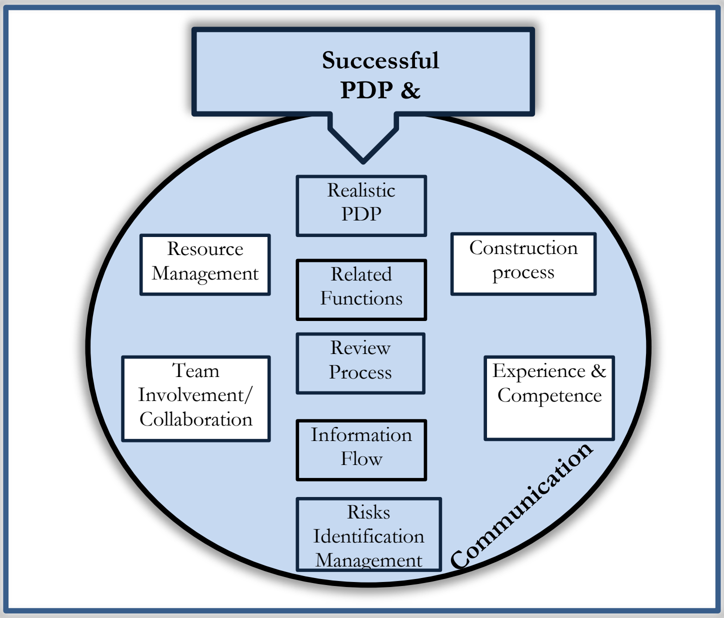

Figure 9. 6: Factors to successful Planning and control – Case Studies Perspective

From the analysis and figure 9.6 above all the themes, except information flow and risks management, have been discussed enough in the previous section of this chapter, thus it does not worth repeating.

Risks Identifications

CS-02-SSR1, who is a project lead, believes that choosing a subcontractor is part of risk management. Therefore, this respondent suggests that one of the core factors to a successful PDP and control is risk identification. This interviewee asserted:

"…we take risk on board as the main contractor but we then have to manage those risks, so which of our specialist is the best to take risk on board. Who knows digging holes on Nottingham best, who knows how much it will cost and the right amount of time to do it; therefore, choosing this type of subcontractor to do that work is risk management".

In this interviewee's perspective, risks identification will also give cost and time certainty. Again, this interviewee takes the argument further by asserting that inappropriate risks identification can result in financial crises and delays. Furthermore, this interviewee made an interesting commercial highlight that inappropriate risk identifications may have commercial effect on the stakeholders as well as the project, thus emphasised:

"Contractually, it is his responsibility but when he comes up with a problem, particularly, in the current climate where price is being very very tightened, money is tight and it might bust him. Then that problem that

contractually was his becomes mine and my client. Again that is an example of poor risk management. Good risk management is making sure that right people are doing the right jobs".

The emphasis placed on risks illustrates its importance to both project and its management. This is in keeping with the findings in chapter 8 that established risks as main constraints to both project and PM. CS-02-SSR3 also argues in favour of this theme from both PDP and control perspectives by asserting:

"…risk identification is one thing I will say Ian is exceptionally good at on the construction stage. At the tender stage we have planners go through the job with fine tooth comb and they identify the problems the job will have".

This interviewee, who was part of the tender process and development of PDP (first plan), argues risks identification was done because it is one of the factors to a successful PDP and control. Risk identification is household theme as CS-04-USR1 also seconded by stating:

"what we need to do is to highlight the risks of the job; we do that in two ways, we do the generic risk of the job, which is covered by the client and covered by us and covered by what we intend to do, and then we do risk for construction a separate risk register, which covers the risks we could encounter on the project and the ones that will have effect on the delivery of the project"

Information Flow

Again, respondents suggested that PDP, which is solely based on time, is distorted. This is well articulated as:

"Cost will be what it will be. If the job is priced correctly in the first place, provided you manage programme, safety and quality to the best of your ability and you make sure the job is efficient as possible you will get a good results in terms of cost and financial results." (CS-02-SSR1)

The respondent stresses a cordial link between the programme and control as well as information flow. He asserted suitable information will results with realistic programme, which benefits from TCQ. Furthermore, this interviewee believes PM on site depends on managing programme, safety and quality as he suggests cost will be what it will be (This idea will be discussed further in chapter 11).

Some respondents suggest that a PDP should consider the complexity of a project, whilst others argue that the risks identified should be transferred to the PDP. CS-02-SSR2 claimed, *"…for you to be able to plan, you need to discuss the complexity of it"* whilst, CS-02-SSR3 argues that their latter programme is better because of appropriate risks identification and information flow. This respondent asserts, *"the job is now being programmed better because tomorrow's problem is considered today"*.

The PDP is better because of information flow and arguably the experience and competence of the individuals responsible for it development. One may also argue that it is better owing to the collaboration at the site when the PDP was developed. Whatever be the case, it is established that information flow is core to a successful PDP and control. Some interviewees argue that planning should have relationship with other functions as discussed in the literature. CS-02-USR1 emphasised this with one of his projects that he doubled as the planner, how he planned the project.

"I did that with every subcontractor and I got series of individual programme for each subcontractor. Then put all those programmes together and I promised them and I spend another week looking at it. I was looking at where there were crashes and where one guy is interfaced, he couldn't carry out unless the other guy has done his little bit so there was a little bit of juggling on the programme".

Again, this interviewee, CS-02-USR1, stressed the other aspects of information by asserting:

"What you should also bear in mind is this and is similar in other industries, you have got degree and doing a PhD, brilliant, I have got a degree, and we are intelligent guys. A lot of the guys are intelligent but not educated, and lot of the guys out there are not intelligent and not educated".

This expresses the importance of information flow and collaboration, and again suggests the importance of understanding cultural and intellectual relationships with the team and the subcontractors.

9.6 THE PROBLEMS

The section presents the analysis and discussion of what practitioners suggest to be the main problems associated with construction project planning and control. The analysis of the problem is structurally divided into three. The first part presents the problems associated with construction PM, the second focuses on the general problems associated PDP and control and the specific problems of why tasks are behind schedule, which is compared to the third part, which is concerned with the causes of delays. It is acknowledged that many of the themes overlap with the success factors, thus limiting the commentary to avoid repetition, which is obviously one of the drawbacks in qualitative analysis.

9.6.1 Problems associated with Construction PM

Respondents presented twelve themes for the problems associated with PM. CS-02-SSR3, the senior cost manager and chartered surveyor, argued that,

"The biggest issue is allocating responsibilities to somebody to do it and that person having the capability to do it. I think so long as somebody is given adequate time, that is an important thing. I think at the start of the job we look at it as a generic job and as the job progress we define the workload as they become important in themselves".

This respondent identified responsibility allocation, competence, allowing adequate time and having defined deliverables as the problems associated with PM. CS-01-SSR3 simply stressed on *'communication',* whilst CS-01-USR2 believes it is all about *'project planning'*. CS-02-SSR4, the project manager, said:

"I describe it overall as a bit of pressure; clearly, the client must be struggling on cost because he has made a lot of hoops and variations. To some extent, it is the client's project manager to deliver the job of that size and we are struggling on programme and on cost".

This practitioner also stressed on inadequate time, excessive variations to work, cost and project planning. Scope creep, excessive variations as the interviewee may describe it, was lamented as one of the issues in PM. CS-04-SSR2, who is the planner, suggested that

"When they are on site many things change; variation to the drawings, additional works and change of client's ideas. This has add-on effect on the programme regardless they want the end date to remain same. This variation may also affect cost I think the QS will tell you same"

From this interviewee, scope creep is the main problem, which has add-on effective PDP. Equally, CS-02-SSR3 seconded by stating "*the other problem is the client at the start instructed a lot of very expensive variations…*" This was confirmed by CS-04-USR1, who is the project lead, by stating:

"yeah, you don't change the completion date obviously, but update the programme. You do so by identifying the deficiencies and positives of the programme, sometimes changing the sequence of working depending, including what has been omitted from the programme, I mean updating the programme"

This interviewee suggests that their PDP is updated regularly to suite their actual task. Arguably, this could be the management decision and the type of contract[49] used rather than practice because the project lead, CS-02-SSR1, disagrees with this system as stated:

"What is dangerous is, programming to suit events. So if you are behind then you move programme bar. No, No, No, because that then stops people from following programme. It is important to note that particular tasks are behind and need to focus on them".

CS-04-USR1 further suggested that inadequate time allowance and information flow as other problems to PM; therefore affirming:

"…you see in here when we first came, we say it seem January we have to start at this stage here, we didn't start that we actually started somewhere later, over here". CS-04-USR1

Although they didn't start the project as planned for some reasons that is beyond the scope of this study, they were expected to complete the project as scheduled. In another stance, this respondent stresses on lack of risk identification as well as information flow.

"At tender we get a lot of information about everything, that information is not always spot on it is more like a guide..." CS-04-USR1

From the subcontractors' perspective, i.e. CS-01 and CS-03, the problems are integration of technique and teams, and no allowance for project control (site management). CS-02-SSR3, who is the project manager, argued that,

"In our case, site managers having to take hands on role in the construction element, not leaving enough time to manage items, such as programming, labour and material requisitions".

According to this respondent, there is inadequate time to manage programme and resources. Therefore this respondent is implicitly emphasising on programme and resource management. CS-02-SS3 suggested inappropriate commercial decision is also a problem to PM, especially on site and from directors with less knowledge on site.

"I do also believe interference with higher management has also cause problems. When we had a problem with subcontractors at the start the higher management got involved and not 100% input into the job and lack of

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[49] It is understand that NEC contract allow programme update regularly.

full knowledge and as result granting subcontractor extension of time, which has cost us financially and time. This has given Ian further headache to catch the job up because of the delays and stuff.

This respondent emphasises on leadership and competence as part of the problems. He also suggests that although management involvement is a good thing, they should do so in collaboration with the project team. CS-02-SSR6 stressed that communication and meetings thus stating *"Don't let people think they are thinking on the same level as you are thinking. It is important to have meetings to discuss the way that you think or the manager thinks to make the work happen"* whilst CS-02-SSR7 argues from teamwork stance, thus suggested *"…if the team is not working to what it is planned or you have planned then that is going to be a problem because you are not going to achieve your aim"*.

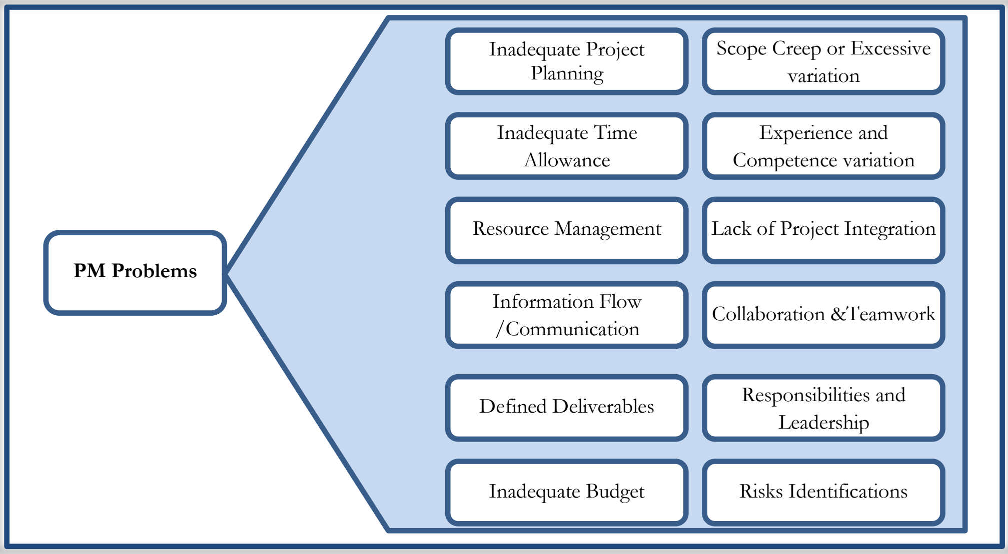

Figure 9. 7: Problems Associated with Construction PM

9.6.2 Problems Associated with PDP and Control

This section is concerned with practitioners' views on the problems associated with PDP and control, and the themes are discussed under separate headings. Practitioners explicitly confirmed the insufficiency of the exiting PDP techniques available to them. Below is a comment from CS-02-SSR5, who is a site manager (engineering), who asserts that PDP is unrealistic, whilst CS-01-SSR3 simply said *"…bad system of implementation"*

"…you get your programme to do a job; it is sometimes not realistic, governing factors that are beyond your control, maybe. There are lots of things like, design problems, which is one of the main things…" (CS-02-SSR5)

9.6.2.1 Unwritten PDP

Earlier in this chapter, it was presented that CS-01 (sub) and CS-03 PDPs are unwritten which is a problem to them. CS-03-SSR1 says *"…the whole really, on a big job on site we struggle"*. This is a problem to both CS-02 and CS-04; perhaps due to the size of their organisation and project. CS-02-USR1 and CS-04-USR1, who are construction director and senior project manager respectively, suggest that unwritten PDP is out-dated technique. CS-02-USR1 advocates

"I will tell you what I have learnt, one and the main thing is never try to remember everything because you never will. The guy who wrote the programme two days later could not understand where he got various things from, that was me. Trying to remember it, I just confuse myself. Don't try to remember everything, don't be frightened to say I don't know but I will find out. Don't be frightened to use bit of paper, don't be frightened to use bar chart".

This practitioner suggests that, in whatever way, a PDP should be written, although he emphasised on using Gantt chart, arguably this is the main technique available to general practitioners. This interviewee made an interesting point that 'the individual who prepared the PDP could not understand various things just after two day'. This raised the issue of either lack information storage or lack of collaboration in planning, and that assumptions are not written. The question that one may ask is how can others understand this particular programme? Others may also question the rationale of sequence since it is one of the main problems when using Gantt chart. CS-02-SRR3, who was part of the first plan, explained:

What they identified was through linked bar chart; if they didn't work backward to get the atrium finish on time. Using the bar chart, if one activity has not finished the other cant progress, which means the completion of anything in the atrium would have affected the total delivery of the contract.

Equally, CS-04-USR1 questioned:

"There is no point to have 20 contractors and none of them can do nothing; because they will be in each other's way and that cost a lot more money than not do it. So you got to look at the bigger picture before you even start and the planning side of it at the early stages is very difficult especially on a scheme"

CS-04-USR1 emphasised the problem of using unwritten PDP; however, he introduces two important themes. First is the sequence and interfaces of the tasks and second, looking at the bigger picture in planning. These two themes are discussed in the subsequent sections but the next section focuses on the latter, bigger picture planning.

9.6.2.2 Inappropriate Work breakdown - Task oriented Planning

As introduced in previous section, CS-04-USR1 suggested that planning should be concerned with the bigger picture of the project rather than task oriented. Arguably, this problem is more to do with the technique available to general practitioners, Gantt chart. This type of technique focuses on activities rather than the bigger picture. Yet, one may suggest that the sum total of the activities becomes the bigger picture project. Indeed, but CS-04-USR1 suggested the break down should be 'deliverables' focused due to the use of subcontractors. This was seconded by CS-02-SSR6 who argued:

"My view is the younger generation that comes into the management tends to be very blinkered in the way of not thinking far enough to make the job happen; you got to look at the end date programme, and got to think about the site, and got to think where we are going to be in five days' time".

Similarly, CS-02-USR1 suggested that the inappropriate breakdown of the project is a problem hence stating:

"Don't be frightened to break it down into small manageable chunks. If you do that it is not difficult, it is easy and makes it look easy. People normally ask how he manages [do I manage] that, I don't manage it any different way to how a housewife runs a home. What does she do, she knows every day to do x, y, z tasks. She doesn't try to do all together. She breaks them down into small manageable chunks".

This interviewee suggests that breaking the project down to manageable chunks is key. This respondent compares project breakdown to 'house wife'. The focal point of this argument is that a 'housewife' breaks her project down into manageable chunks, which are deliverable within her available time. One may debate that 'housewife's project is less complex as compared to construction and her available time has no clinch ends.

9.6.2.3 Unrealistic Programme Duration

Respondents suggest that the programme duration allowed for planning are unrealistic, which is one of the main problems associated with planning. This view was justified by planners' respondents as well as the other respondents. CS-02-SSR1, who is the project lead and with many years of experience in this position, spills the beans as he admitted that in competition contractors want to be cheaper and quicker, which is a problem, thus stated:

"The end product does not always tie up with what was planned because of the procurement process, and because of people. Contractors try to be cute when pricing a job to make themselves look cheaper and quicker than their competitors. In the competition, they need to be cheaper and quicker"

Other interviewees claimed that project completion duration is fixed by the client, which is unchangeable although not necessarily realistic. This was echoed by CS-02-SSR2, the senior project manager, who stated:

"We have struggled all the way through because the programme is very very tight. One of the tightest programmes I have worked on. So it has been difficult to achieve it. Sometimes you don't foresee everything; sometimes things go better than what you foresee".

This statement suggested that programme duration is unrealistic and it is one of the tightest he has worked on. A similar statement was made by CS-04-SSR1. This may be due to tight budget as suggested by respondents.

9.6.2.4 Tight Budget

Respondents recommended that due to tight budget, it does not allow individuals time for developing the PDP as well as project control on site. CS-02-SSR1 explained:

"What happens is that the planners, estimators and the directors will say look this is how much the job will cost. If we really want this job, slice hundred thousand pounds on preliminaries; slash 100K here and there. Then they will say we are going with that price. Then we come to the site to realise it will not work"

This interviewee believes tight budget makes both PDP and control very difficult to manage, although he stressed on project control. However, CS-02-SS8, who is a planner, argued that they are mandated by the client to give discount and reduce duration. This interviewee stressed, "*No, I think they are forced into it. The way the market is people are forced into taking discounting projects to some extent that, they then operate with such a tight budget"*

9.6.2.5 Inappropriate Risks Identifications

Some respondents suggest that improper risks are identified because of many reasons, which CS-02-SSR6 deemed it is due to the manager or the planner knowing the bigger picture. This interviewee stated *"I found out that knowing the bigger picture works. You just say I want you (a trade) to do something, he will go why? You need to explain it to them, let them understand*"

It was identified that weather is a big problem in managing project on site. Although, weather cannot be estimated in the programme, it must be identified and allowance should be made. CS-04-USR1 advocated that,

"One of the biggest on here is the weather, something you can't plan, you can't plan the weather and the biggest issue again is that a lot of programme and contracts don't take weather into account".

According to this respondent, weather should be allowed in a PDP as there are some statistics on local weather available currently. Arguably, using the mathematical calculations suggest that construction process to be linear; obviously do not allow factors, such as weather. For example, duration for plastering remains per m^2 the same throughout a project of 2 years. This is what these respondents argued to be inappropriate risk identification. The site engineer, CS-02-SSR5, argued that programme fails to identify the link with the design. Obviously, site engineer's risk on site is mainly design, thus explained:

"This is design and build contract so you come to site knowing you should have all the design information but it doesn't not work like that. If you know when something will start then you can ask for it, for example, if you need four weeks before this start so that I could check all the drawings. I think it is a good way that it is done by using a programme because it lists everything out".

This interviewee suggests that the PDP should indicate the required items, which control each particular task. This is factored into the development of TPC presented in chapter 11. TPC identified all the task flows which include designs and introduces input duration.

9.6.2.6 Poor Resource Allocation Decision

Practitioners argue that allocation of resources for the activities is poor. Usually activities are created without anyone in mind; they are created based on the planner's experience and assumptions. Regarding the subcontractors, they also resource task based on the quantities provided in the 'bill of quantity or cost plan'. CS-02-SSR3, the senior cost manager, who is in charge of procuring subcontractors admitted to the resource allocation problem. This interviewee stated:

"…this put serious strain on everything because surveyors needing to do procurement of subcontractors were concentrated in pricing variation for the job can progress but the procurement need to happen"

The surveyors who are in charge of procuring subcontractors will be attending to other issues, which strain everything. This is owing to poor resource allocation. CS-02-USR1 explained one poor resource allocation:

"This particular individual came on site and said, whilst they are knocking that building down there, why don't you start digging the foundation here for the basement. I said no don't because we have got only one access in, one egress out. He [demolisher] has got huge machine sat here [in the main access]. When he brings the stuff down, the steel, the concrete, and the bricks he will be putting in here [where the plant is sitting now]. The guys we have employed to do the excavation basement have never yet hit a programme for us, not once. He is always

over optimistic and then he hit for a claim. Saying, you have delayed him here and there, to get more money of you".

This interviewee discusses the inappropriate resources allocation decision made on the substructure. This decision was fuelled by top management above, which demonstrates the lack of collaboration as discussed earlier in this section. This interviewee stresses that the subcontractor is over optimistic in programme, which means his programme is unrealistic. This unrealistic programme results in delays and additional cost. This respondent opened up a new theme, unrealistic sequencing of activities, which is discussed in the next chapter.

9.6.2.7 Unrealistic sequencing

Respondents, such as CS-05-SSR5 clearly stated that PDP is unrealistic as discussed lengthy in this chapter. This section only considers the unrealistic sequencing of the activities. This problem is arguable due to the dominant use of Gantt chart, which has this inherent problem. CS-02-SSR7 stated *"…the sequence of activities, priority list deciding on what is important and knowing the activities that could be done simultaneously"*. CS-02-SSR6 stressed on many problems that include sequencing,

"The initial programme, I don't think enough effort was put in it, things like weather conditions, the amount of time they actually do a job, I think some of it was through the lack of experience of knowing how to visualise an item. A planner should look into that and what the finish article will be, not just the general things like I got to build a curtain wall, you got to think of how it can be run on site and internals, react to how the place is being built".

This respondent identified weather conditions as not catered for in the PDP and suggests that inadequate time is allowed for preparing PDP. Again, emphasising on the understanding of the process and the experience of individuals to understand the process and what is required.

9.6.2.8 Lack of experience and Competence

The problems of experience and competence have been discussed extensively in this chapter as both a problem and success factor, thus this section focuses on some few quotations to avoid repetitions. CS-02-SSR6 acknowledges the importance of planning and control but emphasises on the experience of the individual on site and the understanding of the construction process, thus asserts:

"planning and control are very good and important, but to have a planner just sitting there as non-productive person really is not right because you need somebody who can go out on site, you see the site is run on plan not from the office".

Again, this respondent advocates that experience is important in planning and control by stating: "*…a lot of people here are very good at what they do and I have got a lot of time for them and they got my respect".* CS-02-SSR2 also emphasised the knowledge and experience by stating:

Yeah, the more knowledge and experience you have the better. Definitely, the more experienced the person is, the more accurate they are going to produce that plan or programme.

It was clear in this study that competence and experience play major role in success factors as well as being a problem. Therefore, the researcher questioned respondent since project planning is a major part of project manager's work, should it be led by them? Most respondents agreed to some extent. CS-04-USR1 argued that planning should be collaboration but CS-02-SSR2 stated:

"It will be an ideal but I don't know how many site managers or project managers will go down that root. Also the salaries have to be very similar, very attractive. A site manager will not become a planner if he can't earn same amount of money. That should have to be structured right within an organisation. It will be an ideal situation, yeah".

Although respondents agree that it will be ideal, they believe the industry should be structured in this way to reflect the salaries. Another point raised is site manager and project managers see planner as down root.

9.6.2.9 Lack of Planning Review

Planning review meeting was stressed by CS-02-SSR2. This respondent, who is senior project manager with many years of experience, stressing this issue worth discussing. Although CS-04-USR1 agreed that he was involved in the planning, he admitted that the planning review meeting is vital. CS-02-SSR2 elaborated this as:

"It [Planning review] would be a very good idea but maybe it a time thing [time availability]. Yeah, that would be good because like we are here and doing problem shooting it would have been better to sit down and review things and give some feedback. The problem is tender programme is often quite optimistic trying to impress someone [client] how quickly you can do it but forgotten that is the programme that they are going to monitor you against and assess your performance.

This interviewee touched on many themes of problems discussed earlier, such as inappropriate time allocation, unrealistic PDP and unrealistic programme duration. The intriguing part is people forget they are assessed on site based on their PDP (first plan).

9.6.2.10 Communication & Information Flow

Similar to previous theme, communication and information flow has been discussed in detail earlier this chapter, thus avoiding repetitions, the following stances worth mentioning and discussing under this section. CS-02-SSR6 claimed people should talk to each other and stated:

"You've got to make people do the work to make you achieve that target. Basically planning is the whole part of it. You tend to find that if you don't talk to people that work with you, the whole emphasis is to liaise and talking to people".

In as much this respondent acknowledges that core role of PDP; he suggests that people need to talk to each other. In broader terms liaise with others to allow information flow. CS-02-USR1 suggested that communication is a problem, especially when all the subcontractors are put together in a planning review meeting. This interviewee recommended that since a project is broken down into manageable chunks, subcontractors' review should be in sections or individually, thus asserted that:

"…if I try to put all of them together, too many people, too many ideas, too many conflicts and too much, nothing gets done. Individually each subcontractor, right, where are you on your programme?

However, CS-02-SSR3 argued from information flow stance by suggesting:

"The trouble is that, it is done at the start of the job, really busy for everybody and don't worry there is plenty of time to get it right. We are very good at knowing a lot passing it over, forgetting the lots and needing to reinvent it later on".

This interviewee claims information is not transferred from the pre-contract to the construction stage, thus ending up 'reinventing the wheel' later. This statement complements the importance of proper information storage and the essential need for holistic technique, which is obviously the main aim of this study.

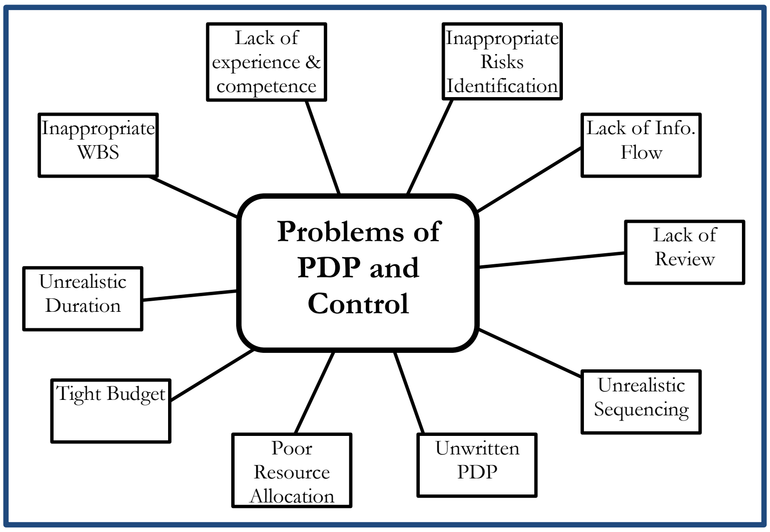

Figure 9. 8: Problems associated with PDP and Control

9.6.3 Causes of Tasks behind Schedule and Causes of Delay

Delay is a general problem associated with PDP and control. Although delays and task being behind schedule may be similar in meaning, in practice they are seen differently. Delay is seen as time overrun to the entire project, whilst tasks getting behind schedule are specific to PDP. To understand the problems associated with project planning and control in much detail, the causes of tasks getting behind schedule[50] and the causes of delays were investigated besides the general problems as discussed above. The importance of cross-examination in qualitative research is stressed in methodology chapter, 7. In this respect and ethics of qualitative questioning, the factors why tasks are on and ahead schedule were examined together with tasks 'behind schedule'.

Individuals react to tasks being 'behind schedule' differently, for example, the project manager, whose responsibility is to deliver the project on schedule, is suggested to 'panic', whilst the cost manager is interested in 'blame game'. This is clearly expressed by CS-02-SSR3, who is a chartered surveyor with many years of experience,

"Again, looking at our interest so that we can pass on blame if it is a better term. If a client is causing [the problem], we believe the client should recompense us for that. That might be an extension of time it might be acceleration or it might be anything".

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[50] It is obvious from the documentary evidence that Percentage Plan Completion (PPC) is low but the scope of this study is not to calculate the PPC rather to understand the problem associated with it.

This respondent further admits that the main problem that causes task to be behind schedule is late procurement of subcontractors. However, he was quick to add that if there are weekly meetings these would be eliminated, perhaps. Therefore, he explains:

"I have to admit that as a surveyor I don't panic as Ian panics. I accept as a surveyor there will be areas that we can affect. If we are late in procuring subcontractors that will have significant effect. The weekly progress meeting are essential because that allows Ian to say I need somebody in the next two weeks to do something

This interviewee emphasises that weekly review meetings are essential to indicate when a subcontractor is needed on site. This problem is shared with the designers, who argued that they did not know when some drawings are needed on site. This problem of 'blame game' led this interviewee to suggest a Liquidated and Ascertained Damages (LAD) should be levied against Designers as it is done with subcontractors. CS-02-SSR4, the project manager said:

"On this job we had the design and procurement programme and it is probably six months behind. It has never been tracked therefore there was no need to put effort in to do it in the first place. I think we have in the back of our mind knowing what we need to concentrate on and doing it that way".

Yet, the question is should this be the case if the planning technique could incorporate this issue? This issue is addressed in the novel technique, the TPC system, as it is presented in chapter 11. CS-02-SSR3 later in the interview admitted that there should be an effective way to address this problem, although he does not know how. He admitted that "…*the problem is normally our records are inadequate to go back to understand after the event, what the true cause of the issue or what sometime was".*

In his view, the causes of delays should be recorded for analysis and continuous improvements on future projects. This is incorporated in the novel and holistic technic, TPC system. This system introduces a 'comparator' that allows the review of a deliverable as well as the project. The common response to both delays and programme being behind schedule is unrealistic PDP. CS-03-SSR3 clearly stated: *"There was an* ***unrealistic programme****, I think so! There were some activities which were on the contract programme which was massively behind. Whatever happens,* ***client satisfaction is essential****…"*

Respondents argued that knowledge is key which was stressed as: cease

"The biggest thing to delay is knowledge, if you understand what you are doing and you understand the complexity of it and understand where the problems are likely to be, you can prevent them because you are aware of them. I think lack of knowledge is the biggest problem" (CS-02-SSR3).

Another intriguing issue is that practitioners believe they are too polite to say the project duration suggested by the client is unrealistic. The project manager, CS-04-SSR1 argued:

I think another problem we have in reality is that we sign up to programme that is too tight so we have very less capacity in our programme therefore any matter becomes delay rather than becomes an issue they get resolved and of course the end results is delay. I think we are too polite, too soft or whatever with a client to say NO we need more time.

In this respect, table 9.1 and 9.2 present the analysis of the causes of delays and causes of tasks behind schedule. The themes stated are the common amongst the interviewees.

Obviously, tasks being behind schedule are delays; however the causes of these two are slightly different. The peculiar ones include, 'the poor performance', and 'information flow and communication', which were identified as causes to tasks being behind schedule but not in causes of delay. This suggests that although there are problems, they are mitigated in process through other mechanisms, thus they do not cause delays to a project as a whole. One may also argue that since the participants are contractors they don't want to be seen as their poor performance and lack of information flow causes delays to projects. This seems to be the case since the findings in chapter 10 include these two issues.

On the flip side, 'poor commercial decisions' and 'poor space and logistics management' were suggested to be causes of delays. However, they were not mentioned as causes of tasks being behind schedule. This could be that these two issues are way above a particular task. In broader terms, it is a project level problem rather than tasks level problem.

The most intriguing problem established in both parts is the issue of Health & Safety. Some interviewees, especially from the subcontractors deemed Health and Safety as a problem to PM. However, it was interesting to note that this view was shared by a site manager, who has a masters degree with significant experience. This interviewee explained and later cited examples as:

"…unnecessary Health and Safety, even though it is good for people, it can also cause delay to the project, in such a way that even though there are no short cut to achieve our goals there are some things that could have been done in an easier way but following the health and safety regs it is assumed to be safe but it turns to delay the project" (CS-07-SSR7)

The Project Lead, CS-02-SSR1 disagrees and argued that *"…lack of maintenance of that environment out there so guys are not working efficiently*". This interviewee believes maintaining clean environment on site, allow subcontractors to work more efficiently. However, it does not refute the site manager's claim that unnecessary health and safety causes delays. In as much as the senior project manager stressed that Health and Safety is a good thing for the project, He makes an additional point on planning by stating: "…*Scaffolding takes time. Scaffolding is not normally built to programme. On this job it takes a long time to put scaffolding up"* (CS-02-SSR2). In this response, the TPC system have addressed these issues by introducing input and output duration which caters for activities, such as scaffolding and concrete curing time (see chapter 11 for details).

Table 9. 1: The Causes of Delays

Attributes	Themes
Game playing for more money	Poor Commercial Decisions
Underestimating the complexity of the project	
Professional Unassertive	
Insufficient Design details	Design Problems
Buildability	
Insufficient Planning	Insufficient Project Planning
Addition of items from the planning.	
Tight Programme	
Missing activities during planning	
Lack of contingency in duration	
Lack of management of the tasks interface	Poor Monitoring and Control
Poor management of labour Logistic Problems	
Variations or Changes	Scope Creep & Unclear project Requirements
Scope creep	
Unclear project requirements	
Financial problems	Financial Problems
Cost Cutting (Less resources, smaller site office and less site management)	
Improper risks transfer	Inappropriate Risks Transfer & Mitigation, and Unforeseen Circumstance
Improper risk mitigation	
Unexpected problem (inc. weather, winds, asbestos and ground problems)	
Unexpected problems are encountered (e.g. discovering services when excavating)	
Inexperience and incompetence	Knowledge, Experience and Competence
Lack of Knowledge	
Knowledge of alternative construction methodologies	
The quality of the individuals	
Health and Safety	Health & Safety
Late procurement of materials Lack of Resources	Poor Resource Management
Lack of Space Logistic Problems	Poor Space and Logistic Management

Table 9. 2: Causes of Tasks being behind schedule

Attributes	Themes
Poor planning	Insufficient Project Planning
Unrealistic programme	
Interface problem with is shown on programme	
Poor sequencing of activities	
Tight Programme	
Programme is too critical	
Lack of education and training	Knowledge, Experience and Competence
Underestimating of a task	
Lack of Knowledge	
Knowledge, Experience and Competence	
Less education	
Information Flow	Information Flow and Communication
Communication	
Not knowing the bigger picture	
Late order of materials	Procurement Problems
Late delivery of materials	
Availability of materials	
Late procurement of subcontractors	
Poor Management	Poor Management
Areas not available	
Delays by other trades	
Lack of maintaining the environment (work place)	Health & Safety Issues
Unnecessary Health and Safety	
Underestimate the complexity of the task	Underestimate Task Complexity
The job is complicated	
Changes	Scope creep & Changes
Scope creep	
Lack of resources	Lack of Resources
Insufficient resources for designers	Designs Problems
Design Problems	
Poor performance of subcontractors	Poor Performance
Inefficient people	
Mistake and Redo	
Subcontractor's cash flow problems	Financial Problems
Money matters	
Weather	Unforeseen Circumstances

9.7 IMPROVEMENTS

This first two sections presented success factors and the problems, thus this section, areas for improvement, complement these questions. The analysis and discussion in this section focuses on PM and PDP. As stated earlier, the subcontractors PDP are unwritten; however, they recommend written PDP. CS-01-SSR3, who is the contacts manager, suggested, *"making sure subcontractors are updated regularly on programming"*; whilst CS-01-SSR2 stressed *"…programming* *to be carried out before every project starts; Organising labour and materials in accordance with the construction programme"* This suggests that written PDP is an acceptable way of managing projects; however, he recommends that labour and materials should have relationship with the PDP. This is laudable and has been considered in TPC.

PDP plays an essential part in PM, as practitioners recommended that there should be a planner on site or alternatively, another person who will be site focused to allow the project manager spend time on planning. This was stressed by CS-02-SSR3,

"Ideally, this site needed one more person on site and somebody looking after the planning. I think Ian was doing the planning probably more actual time input than if we would have an extra person less capable of planning than Ian is but more site orientated…"

CS-02-SSR4, the project manager, recommend by asserting *"I think it is planning, but also if the person is educated and trained enough he can produce a realistic programme in the first place*". In as much as this interviewee recommends planning, he suggests that the individual should be educated and trained to produce realistic PDP. Table 9.3 and 9.4 present practitioners' recommendations for improvement for PM and PDP respectively.

Table 9. 3: Improvement recommend by Practitioners

Attributes	Themes
Effective Management	Effective Project Management
Sufficient time for management	
Effective Control or site management	
Realistic Project Cost from the start	
Proper planning	Sufficient Planning
Sufficient time for Planning	
Realistic project duration	
Subcontractor Update on programme	
Planner on site	Planning time site
Time for planning on site	
Education and training	Knowledge, Experience and Competence
Investment in People	
Knowledge and Understanding	
Project Review Meeting	Project Review Meeting
Good Corporation and Communication	Good Corporation and Communication
Dedicated Team and Individuals	Dedicated Team and Individuals
Clear project requirements	Clear project requirements
New techniques and methodologies	New techniques and methodologies

Practitioners clearly requested for improvement in the current PDP and they are interested to improve the PM system. Literature has clearly established that managing project based on TCQ is outdated, which is in keeping with this request. Again, practitioners are endeavoring for new techniques and methodologies. Other peculiar themes were 'experience, knowledge and competence' which practitioners recommended for their improvement, yet literature is sparse of these themes in PM.

Table 9.4 presents practitioners requirements for a PDP. It is established in this analysis that the conventional planning techniques available to practitioners are not suitable, thus proposing a new technique is ideal for them. The recommendation of new PDP techniques have been discussed in literature in recent few decades as presented in chapter 3 which is consistent with these findings.

Table 9. 4: Practitioners Requirements for PDP

Attributes	Themes
Realistic Planning	Sufficient Project Delivery Planning
Written programme	
Visual programme	
Sufficient time for planning	
Understand the planning in critical	
Realistic duration estimates	
Contingency in project duration	
Related function (weather, logistic and procurement)	
Collaborative Planning	
Involvement of subcontractors	
Realistic Deliverable	
Right Information	Information Flow and Communication
Information Flow	
Communication	
Relations between resources and programme	Bases for Related Function
Related function (designs)	
Feedback	Feedback
Right People	Knowledge, Experience and Competence
Knowledge and Understanding	
Understanding of construction process	
Education and training Experience and Competence	

9.8 TASK FLOWS (REQUIREMENTS)

This section is concerned with the main tasks requirements for planning and control. The requirements, also denote the flows, are the main requirements before and/or for the actual commencement of a task. In essence, PDP is a guide for the task and the project delivery.

This section draws from the above analysis, observations and the documentary reviews, which established twelve task flows. The flows are the preconditions for the execution of a construction task. This finding is a development on Koskela's assertion of seven flows, which is discussed in chapter 3. Koskela's did not capture internal conditions, the duration (the start and finishing time), interferences, review, experience, knowledge and competence. Practitioners suggested that these flows are equally important preconditions for execution and control of construction tasks. The most interesting flows that are sparse in literature, however, they have run through all the data analyses are experience, knowledge and competence, and common understanding. This type of flow is called soft flow (Agyekum-Mensah *et al.*, 2012a). The lack of understanding of task flows has been hindered due to lack of appropriate planning techniques to support. However, the understanding of the task flow is the basis of establishing related functions from a PDP. Therefore, this study uses these flows to develop a novel and holistic PDP system, TPC, which is presented in chapter 11.

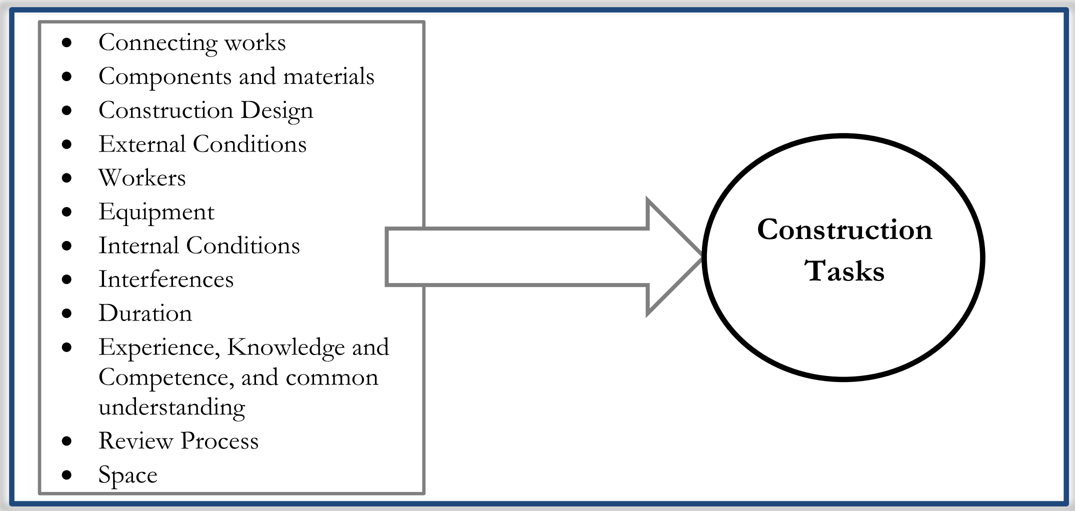

Figure 9. 9: Construction Task Requirements

9.9 CONCLUSIONS

This chapter addressed objectives three and four, which are to investigate the industrial problems associated with project management, and planning and control; and identify the requirements and task flow for delivery planning and control respectively.

In this chapter, project planning as practised was presented which established that the subcontractors PDP is unwritten, although later in the analysis it was recommended for a change. The literature stresses the use of WBS and CPM; yet, the dominant PDP technique is Gantt chart which is implicitly underpinned by WBS and CPM concepts. Practitioners refer to this PDP as a programme, which is also a schedule. This is not peculiar since in reality it is only concerned with time. This PDP is prepared by a single person, normally a planner from the main contractors with limited time to do so. Respondents disagree with this approach and suggest collaborative planning and allowance of significant time, since PDP is core to both project and PM success. It is established in this chapter that the conventional PDP techniques assume a relationship between activities which suggests the relationship is linear which is consistent with the literature. Again, PDP is done in isolation from other functions, such as cost, logistics planning and procurement.

It is also established that project control is mainly over time and cost where interviewees suggest that is a core problem. One interviewee even suggested that practitioners are too polite to be professionally assertive to clients. This is due to the fact that the client drives the time and cost, thus construction project are also managed based on time and cost. This led to the analysis of the problems associated with construction PM and PDP. For a deeper understanding of the problems the success factors, problems and improvements were examined and discussed. It is established that many of the themes are related and overlap.

It was evident that the core to a successful construction project is PM, where three main groups of PM were established, including PM output, Hard PM and Soft PM. The output of PM is the results of PM with themes including profitability and repeated work. From contractors' perspective, these two themes are among others factors which determine the success of a project. Nine themes were established as the success factors to PM which is a development to the literature. Themes such as communication, teamwork, experience and motivation, which are classified under soft management, are sparse in construction literature. However, interviewees suggest their importance to PM. Equally, nine success factors to PDP were established, which include realistic PDP, review process, flow in the process, and experience and competence. In as much as realistic PDP have been discussed in the literature, the other themes mentioned are sparse in the literature. The understanding of the flow has only been championed by lean constructionists, although some scholars argue that the work flow in construction is common sense. But regardless of this, flow was suggested as a success factor as well as a problem associated with planning and control. Numerous themes were identified as problems associated with PM and PDP. Insufficient planning and unrealistic planning were the most common in the problems in PM and PDP respectively. These illustrate and confirm that the conventional techniques are insufficient in management construction projects, while on the improvement side it suggests practitioners' desire for a new and holistic PDP system.

The analysis of the causes of delays and causes of tasks being behind schedule were also presented. Although these two problems are very similar, practitioners suggested some slightly new themes in each. For example, practitioners suggest poor performance leads to tasks being behind schedule, whilst they suggested poor commercial decisions and health and safety causes delays. Practitioners do not see the current health and safety regulations as a necessarily good thing. Some believe it takes away the common sense responsibilities from people, whilst others suggest it causes delays to projects. In regards to PDP, the technique should flag up this health and safety issue so that subcontractors will allow for it in their planning. The common themes among them are insufficient planning, which is in keeping with the literature.

The chapter concluded with the precondition task requirements for construction tasks. Twelve requirements were identified, which is an extension to Koskela's seven flows. Practitioners emphasise the importance of experience, knowledge and competence of the individual and the team responsible for the preparation of the PDP and well as review process in project control.

These flows are the basis of the development of the novel and holistic PDP system, TPC, which is presented in chapter 11 of this thesis.

CHAPTER TEN: ANALYSIS OF STAGE 4 – SEMI STRUCTURED INTERVIEWS

10.1 INTRODUCTION

Stage four of this research process is concerned with addressing the 3rd objective of this thesis. The participants of this data collection are outside the four case studies. As discussed in chapter 9, stage two also addresses these questions but only from and within the case studies. However, this stage examines other experts' views aside the case studies interviews in order to establish a deeper understanding of the subject area. Also, it ensures a broader perspective of the subject is covered. In total, 15 interviews were conducted with senior members working in prominent construction organisations and projects in the UK.

The chapter is divided into three main sections, that is, the success factors, problems and possible improvements. Conclusions are drawn with the summary of the main findings, which are further discussed together with other analysis chapters in the next chapter, 11.

10.2 OVERVIEW OF INTERVIEWEES INFORMATION

All the respondents were leading managers on the UK construction projects, including the London 2012 Olympic project, with significant experience and, both academic and professional qualifications as shown in table 10.1 below.

Table 10. 1: Interviewees Information

Code	Position	Academic qualification	Professional qualification	Organisation Type	Experience (years)
GK1	Project Engineer	MSc	IStructE, MICE	Consultant	13 Years
GK2	Senior Project Manager	MSc	MRICS, MCIOB, CCC	Consultants	15 years
GK3	Senior Project Engineer	MBA, BSc	MICE, MAPM	Consultants	12 years
GK4	Manager (Planning and Scheduling)	MSc	MAPM	Consultants	25+ Years
GK5	Programme Director	PhD, MSc,BSc	NONE	Consultants	20 Years
GK6	Infrastructure Engineer	MSc BEng	NONE	Consultants	12 Years
GC1	Projects Director	BEng (Hons)	MCIOB	Contractor	25 years
GC2	Project Engineer	BEng	NONE	Contractor	12 years
GC3	Managing Director	MSc, BSc	MCIBSE	Contractor	22 Years
GC4	Cost Manager	MSc, BSc	ICIOB	Contractor	12 Years
GD1	Director	MSc, BSc, LLM	MCIArb, MRICS, MCIOB	Developer	17 Years
GCL1	Senior Cost Specialist	BSc	MRICS	Client	25 Years
GCL2	Senior Manager	BSc, HNC	NONE	Client	16 years
GCL3	Consultant	BSc	MICE, MIHT	Client	53 Years
GCL4	Lead Civil Engineer	MPhil, BSc	CEng, MICE	Client	14 Years

The interviewees are divided into four different organisational frameworks. A total of fifteen participants, comprising six were consultants, four contractors, four clients and a developer as discussed in chapter 7 together with the research process. This analysis chapter is independent from the previous chapter 9, although they tend to address a specific research objective.

10.3 SUCCESS FACTORS

Many studies on success factors adopt a questionnaire approach, which does not allow the researcher(s) to explore and/or understand a 'real world' issue, rather recycle the old attributes within the literature. Cross-examination questions were developed, which comprises success factors of: 1) construction project, 2) construction PM, 3) and project planning. These questions ensured that success factors for all these groups were examined differently. Therefore, each group is discussed separately and conclusion drawn for each section.

10.3.1 Q - What are the Factors to a Successful Construction Project?

This question seeks to understand what practitioners believe to be factors to a successful construction project. Respondent GD1, who is currently a developer but has many years of experience as a client and a consultant, believes that success factors of a construction project depend not only on Time, Cost and Quality (TCQ) but safety and compliance to environmental issues. Therefore, this respondent GD1 clearly states:

"The success factors of a project are various and largely depend upon the needs/expectations of the client. However, these generally [are] considered as cost, time and quality but with the increasing awareness of safety and environmental issues, compliance to these are now considered as part of the project success factors".

Again, this respondent argues that factors to a successful project are largely based on the expectation of the client. In order words, a successful project is when the clients' expectations are achieved. Similarly, respondents GK2 stated:

"this depends upon the perspective of the individual looking at or involved in the project. Those involved in the project may see the success as achieving some pre-determined project goals such as time, cost and quality. Having said this, success factors could be components to the management system, which could either lead to direct or indirect success of a project. A client could determine that the success factors aside time, cost and quality as: external environment – political, technology, economy, culture, etc. weather, the government legislation, and work accidents could [also] affect the entire project phases…"

However, some respondents, mainly consultant interviewees who normally work closely with the clients, argue that clients even knowing what they want and their experience are also core factors to a successful project. Respondent GL1, who works for the client with many years of experience, states: *"the client must know what they want… all the needs of the project stakeholders must be known, understood and accessed"* and, interviewee GK1 believes the client *"…must have a clear brief with defined objective"*. Also, interviewee GK3 stresses on the experience of a client, therefore affirming *"…a comprehensive design brief, identifying clients' priorities…client's level of experience and management expertise"*.

Despite the argument that the predetermined goals of project are mainly TCQ in the literature, the respondents argue from other standpoints including management principles and external environment as additional factors to a successful construction project. Respondents argue that the management systems include, planning, monitoring and control, experience, procurement, excellent leadership and clear brief or scope. Most of the contractor respondents stress the importance of effective planning and supervision. For example, respondent GC1, who is the project director for a notable construction firm, stated: *"the main factors are experienced, supervision, thorough planning, experienced sub-contractors, sufficient time on the programme etc."* Also, respondent GC3, who is a director of another construction company stressed that *"planning is the major factor, then monitoring and experience"*. Unsurprisingly, respondent GK4, the manager in charge of planning and scheduling, believes factors to a successful project is dependent on ability to plan the project successfully by stating: *"…the time and ability to plan the activities successfully"* In spite this respondent stressing on the importance of planning, he implicitly stresses on the importance of the experience of the person(s) responsible for the planning. Equally, GCL4 and GC1 suggest that effective project planning is core; however, GC1 believes that sufficient time should be allowed for planning.

Chan *et al.* (2004) and Hubbard (1990) argue that PM is key to project success, and this arguably includes managing the construction project constraints (discussed in chapter 8), planning, monitoring and control. Another sharp contrast between respondents and the literature is that most respondents stressed on the importance of communication. Respondents GK2 and GK4 emphasise by stating *"clear and effective communication channels should be available to project team…"* and *"…good communication…"* respectively. Respondent GC2 also believes communication is core to successful project; however, this respondent believes "*…as-built information…"* is equally important to a successful project. This is what GCL2 also suggests to be *"…adequate research"*. Arguably, this is what has been in chapter 8 as the evaluation stage of PM, and has not been discussed properly in the construction PM literature.

This could be established that factors to a successful construction project mainly depend on effective PM, as shown in table 10.2. The main attributes are grouped into three, i.e. construction PM constraints discussed in chapter 8, Hard[51] PM which focuses on the effective principles and procedures of PM (that are tangible); and Soft[50] PM is concerned with the skills and intangible parts of PM. This finding is consistent with that in chapter 9 and, Hubbard (1990) and Wit (1995) conclusion that PM is key to a successful project.

Table 10. 2: Categorisation of Factors to Successful Construction Project

Theme	Factors
Construction Project Management constraints	Time Cost Quality Environment Communication Project Scope Safety Risks (external environment)
Project Management (Hard)	Planning Monitoring and Control Supervision Procurement Project co-ordinating Minimal post contract changes As-built information Communication Governance
Project Management (Soft)	Experience Communication Clear Brief/Scope Leadership Key performance indicators Team work Collaboration

10.3.2 Q – What are the Factors to a Successful Project Management?

Obviously, this question clearly presents its purpose as an investigation of the factors to a successful PM as it has not been fully explored, especially from a qualitative strategy stance, where the researcher aims to understand the issues rather than statistical findings of themes.

One of the most common factors to successful PM observed in the data was communication of the ideas through the team, to deliver a project for its purpose of use. For example, GC1, GCL2, GCL4, GK5 and GK6 all stressed the importance of communication in the success of

[51] Hard PM is the process or evidential part of PM, whilst the Soft PM is the non-evidential or non-tangible parts such as skills and knowledge

PM. Respondent GC1 trusts the success is dependent on supervision, which includes communication. This interviewee stated: *"the success of the project management on a contract depends on the level of supervision i.e. sufficient resources to manage the scheme, a good communication system, good communication and proper meetings"*

Some respondents suggest leadership, vision and team building are also core to a successful PM. This view is strongly advocated by respondents GK4 and GK5, perhaps, based on their professions (being responsible for planning and scheduling). Therefore, they suggest that the success of PM is mainly due to the skills and leadership of the project manager. Although both GK4 and GK5 agreed on this, GK5 believes *"…risks, change and schedule management"* equally play major role to a successful PM. This view is supported by respondents GK1, GK2, GK3, GC3 and GCL1. Respondent GK2 being a project manager, stated: *"…effectively managing change that is associated with the project brings about successful project management"*. In the view of this respondent, it is managing risks and change, and this is shared by respondent GCL4. According to respondent GCL1, *"…having the ability to plan out the project risk, …technical expertise, the ability to match the appropriate skills of the team to tasks and the ability to set realistic goals along the way"*.

GCL1 argues that risk should be considered in planning and the individual responsible should have both the technical expertise and skills to do so appropriately. Interviewee GK1 argues by suggesting "*…the act of doing [sic] planning, organising, monitoring and controlling the project"*. This interviewee suggesting that factors to successful PM is all about planning, organising, monitoring and controlling, which are core to the construction project management managerial process (CPMMP) discussed in chapter 8. Other respondents, such as GK2, GK3, GC1, GK5 and GCL1 shared this view. Respondent GC3 stresses on planning, coordination and experience, therefore states:

"…having a good team, having access to right technical support, a good coordination between the client, the contractor and the consultants, and general management principle like having materials on time and right quantity and at the right place. This is by planning; the hard part is knowing what is needed and when you need it. It varies on having the plan on paper but if you don't have the practical experience on site, to know the right sequence of the tasks, the paper plan means nothing"

According to respondents GK2 and GCL1, planning should be realistic, thus stating *"…create a realistic implementation plan"* and, *"the ability to set realistic goals along the way"* respectively. Respondent GK3 deems the individual responsible for planning, either the project manager or planner, should be *"…experienced with good understanding of construction process",* while GK2, GCL4 and GCL1 claim the team should be competent to deliver the project. Respondent GCL3 considers *"…experience gained over many projects"* is core to a successful PM but the question is: how could these experiences be useful without proper documentations?

Respondent GK4 stated: *"the other factors are staffing; staffing, a team with appropriate skilled people, clearly defining the expected benefits of the project".* This argument of resource management has been advocated by other respondents, such as GK3 and GCL3. According to respondent GD1,

"Fundamental to the usual management of the gateways within the project cycle, a successful management of a project will be determined by how well stakeholders' expectations were managed and of course to ensure value for money for the stakeholders

Although this respondent believes the essence of PM is to manage the stakeholders' expectations, he emphasises on the fact that the success of PM is when the stakeholders have achieved 'Value for Money' (VfM). This view is consistent with one of the factors identified in the chapter 9 which equally established that the very essence of operational client is to achieve VfM. This VfM concept is discussed in detail in chapter 11, where the researcher conduct a cross discussion of all the analysis chapters.

Table 10. 3: Analysis of Factors to Successful Project Management

Factors	Level
Effective Communication	Most Common
Realistic Planning	Most Common
Experience and competence	Very common
Monitoring and Control (supervision)	Very common
Coordinating and collaboration	Very common
Defined scope of works	Very common
Clear and realistic goals/objectives	Very common
Leadership and team work	Common
Resource management	Common
Risk and Change Management	Common
Organisation and meetings	Fairly common

Table 10.3 presents the summary of the factors to a successful PM, and effective communication and realistic planning were ranked the most common themes, followed by experience and competence, and monitoring and control (others refer to as supervision). Although most literature have acknowledged that planning is core factor to a successful PM, themes such as **communication, experience and competence, and monitoring,** which are part of soft PM, are sparse in the success factors literature. The scarcity of these themes in

literature could be due to the fact that themes are recycled, generated from the existing literature, rather than to seeking an understanding from experts in a 'real world'.

If planning is one of the most common themes among respondents, the question asked is: what are the factors to a successful project planning? The next chapter discusses the interviewees' response to this question.

10.3.3 Q – What are the Factors to Successful Project Planning?

The previous questions discussed set the foundation for this question, as the main aim of this study is to develop a holistic planning and control system to enhance construction PM. Therefore, this question aims to examine what respondents believe to influence a successful planning. Again, literature is sparse on factors to a successful project planning. Many themes were identified from the interviews, e.g., according to respondent GD1,

"Successful project planning will be based upon the scope of the project and incorporating any foreseeable risks and the employers thought process (i.e. when parts of the project should be completed etc.). Scheduling for the scope to set out a baseline (based upon the WBS) is important but most importantly is updating it to ensure compliance to the live project. To achieve this, the relevant teams on the project need to critically discuss and agree on the inputs of a compliant programme (e.g. productivity outputs expectation etc.) which the team shall review periodically"

Ten main themes were identified as the core factors to a successful project planning, which are illustrated in figure 10. 1 and are briefly discussed below.

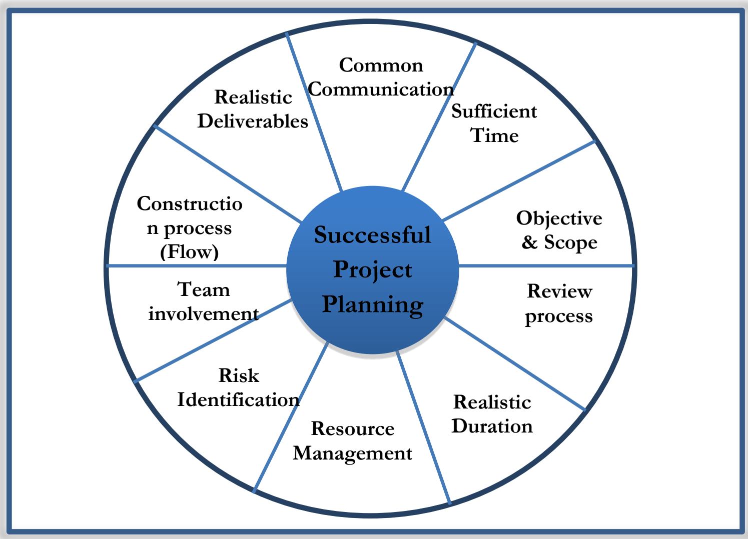

Figure 10. 1: Factors to Successful Project Planning

10.3.3.1 Clear Objectives and Defined Scope of Work

Respondents believe clear objectives and defined scope of a project are part of the main factors to a successful project planning. According to respondent GD1, as quoted above, the defined scope of a project is fundamental to a realistic planning. This respondent added that this is done using the WBS (discussed in chapter 3), and arguably, WBS is the conventional technique for scope management. Respondent GC2 argues that *"…clearly defined goals that should not change"*, meaning the objectives and the scope of the project should be clear from the onset of a project. Respondent GCL1 believes the success factors include, the *"ability to set realistic goals along the way*", while respondent GK2 states *"…clear business objective – proper documentation of primary purpose and goals for embarking upon the project"*. Equally, most of the respondents, especially, from consultants background, support this theme. Respondents GK3 and GK6 respectively stated: *"clear scope definition…"* and *"…understanding the project requirements and briefing…"*.

Although respondents believe that clear objectives and defined scope of a project are part of the factors to a successful project planning, realistic deliverables is equally essential.

10.3.3.2 Realistic Deliverables

In practice, and as discussed in the case studies in previous chapter 9, WBS is used to breakdown the project into activities, which is assumed to be deliverables. Respondents argue that realistic deliverables is one of the important factors to successful project planning. Respondents such as GK2, GC2, GC3 and GCL4 clearly emphasise the importance of realistic deliverables, whilst respondents such as GD1 and GC4 implicitly agreed. Respondents GD1 and GC4 believe the project should be broken down into realistic tasks that can be delivered by the resources available. Respondent GK2 stated, *"…clearly documented project milestone and deliverables"*. Again, this respondent stated: *"…define and build the project work breakdown structure"*. Respondent GC2 also stressed on the need to *"…develop a list of deliverables and schedule the outlying the project activities achieve targets"*. Respondent GK6 believes *"…having realistic workloads and deadline"*. Respondent GC3 equally stresses on this theme, realistic deliverable; however, he argues that understanding of the process or sequence is equally important, thus asserting: *"…in planning; the hard part is knowing what is needed and when you need it…to know the right sequence of the tasks the paper plan means nothing"*.

Other respondents equally share this view; the next section presents the analysis the theme construction process, which is also referred as 'flow of task'.

10.3.3.3 Flow of tasks – (Construction Process)

A project plan is literally the representation of construction process; therefore, the person(s) responsible for planning should understand the implementation process (this is what is discussed as 'execution process' in chapter 8). Normally, sequence of activities are perceived as sequential or linear in the conventional planning techniques; however, this section, which is consistent with some studies, such as Ballard (2000), Koskela (2000), and Koskela and Howell (2002b) , have established that seeing construction tasks process as linear only, does not reflect the 'real world' construction project. In this same respect, respondents stressed the importance of flow of tasks to a successful project planning. Respondent GC3 clearly indicated the importance of this theme, although he concluded with another theme, communication and team involvement, which will be discussed later.

"the parameters to understand the different tasks that made up the project, if you have no understanding you should have access to people with understanding. Very often, the consultants have good understanding of the design and the specification document but they don't understand the execution and the people who have the understanding of the execution don't have such a good understanding of the design and specification document…" (Respondent GC3)

This respondent stresses the importance of this theme and argues that collaborative planning is the solution to understanding the flow of tasks in project planning. Similarly, interviewee GK3 stated: *"…identifications of most important items that must be achieved for the project to be successful and a good understanding of the construction process"*. This respondent again stated *"…accurate estimation of project activities, sequencing, duration and schedule requirements"*. Although this respondent acknowledged the importance of realistic deliverables and the sequence of tasks, he emphasises also on another theme, which is duration and schedule requirements. The next section analyses this theme, realistic estimation of duration for tasks.

10.3.3.4 Realistic Duration (estimation of task duration)

The duration of a task is either a guess estimation by the planner or a mathematical calculation using the linear conventional approach, which is contrary to an applied construction. This is discussed in the case studies findings in chapter, 9. Respondents suggest that a realistic estimation of duration is also core factor to a successful project planning. Respondent GK2 suggests that there should be *"…valid and realistic time-scale"* and respondent GK6 asserts it is about have *"…realistic deadline*". Respondent GK4, who is the manager responsible for planning and scheduling, clearly stated *"…realistic duration estimation"* is core to a successfully project planning. This is equally advocated by respondents GC4 and GK5. Respondent GK5, who is also a programme director, described this approach of realistic duration as *"…scheduling management"*. One may argue that 'scheduling management' encompasses the sequence of activities (discussed above), a realistic estimation of duration and, time and experience to produce a schedule. Indeed, the next section looks at the themes sufficient time and experience as factors to a successful project planning.

10.3.3.5 Sufficient Time for Planning and Experience

Respondents again claimed that there is insufficient time allowed for project planning, which is also discussed in chapter 9. Similar to the case studies, respondents from contractor background argue that allowing sufficient time for project planning is one of the major factors to a successful project planning. Respondents GC1 and GC4 clearly stressed this point. GC1 stated *"time is the major factor. If enough time is spent planning the job prior to starting on site it will be successful*".

However, respondents from clients background argue, it is not limited to the time allowed only, rather, the experience of the individual responsible for the project planning. All the clients respondents stressed on this theme, experience, except GCL1. This respondent argues that besides experience, the individual should have *'technical expertise'*. Hence, he stated *"…technical expertise and the ability to match the appropriate skills of team members to tasks*". This respondent argues that technical expertise should include resources allocation or management.

10.3.3.6 Resource Management

Further to respondent GCL1 suggestion of this theme, other respondents shared this view that resource management is a factor to a successful project planning. Normally, the UK construction projects are executed using a specialist trades or individuals (Johansen and Porter 2003), thus planning resource alongside the activities are essential. Respondent GCL4 clearly suggests: *"…resource and material planning/management"* is part of the factors to a successful project planning. Respondent GK2 stated, *"…detailed resource requirements"*. Equally, respondents such as GK5, the programme director, stressed the importance of this theme by stating *"…resource and materials management*". This is in keeping with chapter 9, which identified resource management as core to planning. The resource management exposes the importance of team involvement as advocated by respondents, thus discussed in the next section.

10.3.3.7 Team Involvement

Conventionally, project planning is prepared by an individual, usually a planner, as confirmed in chapter 9. However, respondents claim team involvement (and subcontractors) in planning leads to a successful planning. Respondent GK2, who is a senior project manager, started by saying *"…keeping the project team focused and aware of the progress"*. Respondent GK6 shared this stance. These respondents argue that if even the actual project planning is done by an individual, the team should be aware. However, respondent GK4, who is the manager of planning, slightly disagrees. According to GK4, the team should be involved fully and clearly stresses that *"…team involvement"* is one of the important factors to a successful project planning. It is evident from the planning manager and senior project manager the importance of team involvement in the success of planning. Other respondents argue that in as much as team involvement is important communication is the underlying factor.

10.3.3.8 Communications

In chapter 8, communication was established as a main factor to successful PM as well as a constraint to construction PM. It is therefore not surprising when respondents identified it as one of the factor to a successful planning. The Director of planning, GK5 clearly stated, it about *"…communication ideas of building the project to other; communication"* but respondent GK2 believes in communication between the team as well and stated *"…setup project communication process"*. Clearly, respondent GCL4 states *"…effective communication"* is key to successful project planning. Respondent GCL2 also emphasises on communication and, also leadership. Respondent GC3 added by stating:

"…good understanding of what is required; I mean you can only plan something only if you know how to do it. It doesn't mean that you have to know how to paint the wall but you have to know how to paint a wall, what are the difficulties, what are the things that can make it go wrong, what are the things that can make plump; to plan something you should know how to do it or understand it. The individual experience is also important not necessarily the academic knowledge but both".

This respondent discusses the issues discussed above except the issue of "…*what are the things that can make it [to] go wrong, what are the things that can make plump…"*. This is what respondent GD1 described as *"…foreseeable risks"*

10.3.3.9 Risks Identification

Respondents such as GD1 and GC3, as stated above, stressed on the importance of risks identification in project planning. Respondent GC2 stated *"…all risks to be identified*". In these respondents' view, identifying risks of tasks is one of the core factors to a successful project planning. However, in practice, the conventional planning techniques available do not support this factor as discussed in chapters 3 and 9. In chapter 3, it is established that the risks identification techniques have no actual connection to the project plan or the tasks. Respondent GK3 stated *"…a good understanding of project objectives, risks, constraints and client requirements"* This respondent stressed the importance of risks identification in planning. In addition, this respondent emphasises other themes that have been discussed above. One of these themes worth mentioning is the identification of 'task constraints'. This particular theme has been sparse in the project planning literature. This task constraint is discussed in chapter 11 and incorporated in the development of TPC.

10.3.3.10 Review Process

Respondents stressed on the review process as one of the essential factors to a successful project planning; for example, respondent GD1, whose statement has been discussed in the introduction of this chapter, concluded by stating:

"…to achieve this [successful planning], the relevant teams on the project need to critically discuss and agree on the inputs of a compliant programme (e.g. productivity outputs expectation etc.) which the team shall review periodically"

In this respondent's view, the review process must be a continuous process, whilst other respondents implicitly agreed to this theme. Respondent GK2 suggests that 'review process' should be emphasised by *"…setting up performance measurement process"*. One may argue that the review process is the monitoring and control process, but these respondents argue that whichever way review process is seen, it is an important part in both planning and control processes. Respondent GC1 states that *"…I think, doing it regularly, getting feedback and following up on the feedback"*. To this respondent the feedback and follow up of the feedback is key, thus it could be concluded that review process is one of the main factors to a successful project planning, which is completely absent from construction planning debate in the literature.

10.4 THE PROBLEMS

The previous section focused on the success factors; however, to develop a successful planning and control system, which is the core of this study, both problems and success factors should be examined, in addition to any suggestion for possible improvements. This section presents the analysis of problems associates with: 1) construction PM, 2) project planning and control, and 3) the causes of delay.

10.4.1 Q – What are the problems associated with construction PM?

This question is analysed in groups of developers, clients, consultants and contractors. This is because these groups may have different problems, which are prudent to this study; yet they are all in the same industry. However, a common conclusion is drawn from all the groups.

10.4.1.1 Clients Respondents

The clients respondents have varied views on this question. Respondent GCL1 believes the main problem is *"…often projects are started with unrealistic objectives due to lack of basic groundwork research"*. This could mean either the clients' objectives are unrealistic or there is no basic data for how the proposed objectives could be achieved. Respondent GCL4 argues that it is a lack of *"…managing the client expectations"*. This respondent believes that the issue of project objectives, which is not managed properly by other stakeholders. This respondent further elaborate on this issue by blaming it on *"…lack of comprehensive design"*, and concluded by saying lack of risk management is one of the biggest problem in construction PM, as he asserted *"…risk of unforeseen circumstance that leads to temporary site closures or abortive work"*. According to respondent GCL3, this risk could be due to lack of planning. This respondent suggests that the problem *is "…breaking down the project into its various facets and managing each"*. However, respondent GCL2 stressed *"…time delays"* as the main problem.

10.4.1.2 Consultants Respondents

The consultants work alongside clients and contractors, and usually referred to as designers, contract administrators, or project managers. As discussed above, the clients' respondents argue that the problem is 'lack of managing client objective'. However, respondent GK1 argues that it is due *"…lack of proper project brief and clients not knowing what they want from the start [inception]"*. In addition, respondent GK6 argues that the problem is *"…due to unrealistic expectations",* whilst respondent GK5 considers managing this expectations as one of biggest problems of construction PM. Respondent GK3 claims that it is due to the *"…failure to involve end-users at the onset and failure to consider the strategic objectives"*. This respondent stressed the need for collaborative planning by involving other stakeholders.

Other respondents argue that the problem is risks identification and management. Respondents GK4 and GK5 termed risks as *"unknowns"* and *"unforeseen"* respectively. Respondent GK5 stated, "…*predicting the unforeseen issues"* and respondent GK3 also stated, *"…failure to identify and manage project risks, issues and constraints"* These respondents claim failure to identify the constraints of a project is one the biggest problems. This respondent, GK3, among other things, argues that the problem is due to *"…lack of senior management support, [and]* *high human resource turnover".* From this perspective, the respondent again stressed the importance of collaboration.

Respondent GK6 argues that experience as well as training is important for the team. This view was seconded by GK3, who stated, *"…appointment of constructor with no relevant experience",* whilst GK6 believes in *"…training for people*". This is supported by respondent GK1, who concluded, "*lack of competent project team, lack of proper management skills, lack of communication and information sharing, lack of experienced contractors and skilled workers".* This respondent claims besides the experience and training, lack of communication and information sharing is a persistent problem in construction PM.

Respondents, such as GK3 and GK2, suggested it is lack of effective process. Respondent GK3 believes another problem is *"…failure to select an appropriate procurement route".* In this respondent stance, failure to select an appropriate process, such as procurement route, is a problem with construction PM. Respondent GK2, who is a chartered surveyor and builder with many years of experience, stated:

"Project management activities and functional concerns are intimately linked, yet the techniques used in many instances do not facilitate comprehensive or integrated consideration of project activities. For example, schedule information and cost accounts are usually kept separately".

In this stance, the interviewee, who is a senior project manager, emphasises on the importance of integrated processes that is sparse in construction; thus suggesting an immediate consideration of an integrated technique. This is in anyway the aim of this study. This respondent further draws attention on the project control by asserting:

"The limited objective of project control deserves emphasis. Project control procedures are basically intended to identify deviations from the project plan rather than to suggest possible areas for cost savings. This characteristic reflects the advanced stage at which project control becomes important".

Again, this respondent, GK2, after arguing the need for an alternative technique for PM, concluded with the lack of planning, which has been a major setback to construction PM; therefore, affirmed *"the time at which major cost savings can be achieved is during planning and design of a project". During the actual construction, changes are likely to delay the project and lead to inordinate cost increases".*

The respondent emphasises on the lack of planning leads to increase in project cost and causes delay, which are arguably a few parameters affected by lack of planning.

10.4.1.3 The Developer

Developer's role typically involves that of a client and a consultant; therefore their stance will arguably reflect both. The developer respondent GD1 asserted:

"Most construction project designs and employers' requirements are artificial. For whatever reasons, the pre-contract stages do not really deal with the common risks that re-occur on many similar projects. Lessons learnt are only recorded and kept in the shelves; they are not transferred unto other similar projects. Of course conditions may differ but there are mostly common grounds than there are differences –but we hear of the same mistakes every now and then".

This respondent has a master degree in both construction law and construction project management. He is a chartered member of three of the most reputable professional societies in the world (see table 10.1) with many years of experience. This preamble is just to inform the reader, of his influence and authority in the UK construction industry. This respondent claims the 'project requirements are artificial' literally meaning that project objectives are unrealistic as previously discussed by other respondents, albeit from different groups. The interviewee took the argument further by querying the lack of risk identification and/or management. This respondent believes there are some risks, which are foreseeable if there was data storage from other similar projects. Furthermore, the issue of common problems re-occurring is considered as a major problem. There are two arguments to these re-occurring problems; either it is due to the obvious fact of lack of data information storage, or there is not appropriate technique or methodology which allows appropriate data storage.

As stated previously, the role of developer is a combination of client and consultant, sometimes contractors as well, consequently, their themes seem similar. Respondent GD1 also concluded with experience and training which is consistent with the client respondents. This was exhibited in the statement below:

"Lack of requisite broader experience is to blame as well as lack of adequate training. Being on one project for a long time does not necessarily make one a good project manager. Having a broader and circumspective perspective is priceless, but these are mostly ignored".

This respondent argued that being on a single project may not necessarily make an individual a good project manager; however, he suggests that broader knowledge in the field is most important.

10.4.1.4 Contractor Respondents

These respondents' main problems centre on lack of project planning, lack of resources, financial problems, lack of risk identification and delays. Respondents GC1 and GC4 argue that the main problem is project planning. According to GC4, *"…project management's strength is about how well the project is planned and failure to do so is the main problem".* Respondent GC2 also stressed on this point of ineffective planning and insufficient allocation of time for planning, thus evidently stating:

"I think insufficient time is also allocated to planning and this have knock down effect on performance on site so the execution of the project is normally hindered by insufficient planning before project commences on site"

Respondent GC1, who is the construction director, argues that the planning is a problem because of insufficient time allowed for planning. This respondent asserted:

"in the current climate the main problems are lack of resources and insufficient planning time. Ultimately this is a function of the lack of money on contracts. The service provided by design teams has suffered because of reduced fees".

In this respondent's stance, lack of resources and insufficient planning time is due to the 'tight budget' due to the current economic downturn. Again, this respondent emphasises even on design team (also called consultants) are also experiencing this issues due to reduced fees. This interviewee asserts that reducing fees unrealistically will not only lead to poor planning but also cause unnecessary delay and suboptimal performance. Respondent GC2 stated:

"well, the most common problem is the time overrun. In my experience this begins from the start of the project, when I say the start of the project, I mean on site, the project start on site with insufficient information and with decisions yet to be taken so it starts with a built in delay and the delay keep carried over to the next person and to the next person to the next person and finally the delays keep accumulating".

From this respondent, the problem of time overrun is due to lack of planning and lack of information flow.

10.4.1.5 Summary - Problems associated with construction PM

Figure 10.2 presents the summary of individual group of respondents and the combined problems with their ranking. It is noted that each group stressed some particular theme(s); for example, the developer stresses on lack of evaluation process and application of lesson learnt to other projects, whilst the clients respondents emphasise on other stakeholders inability to manage their (clients) expectations. The consultants argue that the clients are unclear on their objectives.

Clients

- Ineffective Planning
- Unrealistic objectives
- Lack of managing client's objectives
- Incomprehensive design
- Lack of risks identification & management
- Delays

Developers

- Ineffective Planning
- Unrealistic objectives
- Lack of proper evaluation process
- Lack appropriate technique or methodology
- Experience (team) and Training

Contractors

- Ineffective Planning
- Lack of resources
- Tight Budget
- Risk identification & management
- Delays

Consultants

- Ineffective Planning
- Unrealistic objectives
- Unclear objectives
- Lack of communication
- Inappropriate procurement route
- Ineffective control
- Lack of experience (team and contractor) and training
- Lack of integrated technique
- Lack of collaboration (end-users and senior management)
- Lack of risks identification & management

General Problems	Status
Ineffective Planning	Most Common
Risk Identification and management	Very Common
Unrealistic objectives	Very Common
Delays	Fairly Common
Lack of integrated technique or methodology	Fairly Common
Lack of experience (team and contractor) and resource training	Common
Unclear objectives	Among consultants
Lack of collaboration (end-users and senior management)	Among consultants
Lack of communication	Among consultants
Lack of managing client's objectives	Among clients
Incomprehensive design	Among clients
Lack of proper evaluation process	Among developers
Lack of resources	Among contractors
Tight Budget	Among contractors

Figure 10. 2: Summary of Problems associated with Construction PM

10.4.2 Q – What are the Problems associated with Project Planning and Control?

This question examined what practitioners believe to be the problem with planning and control in construction PM. Planning and control are closely related function as discussed in previous sections, and chapters 3 and 9, thus this section discusses them together.

Respondents GK1 and GC4 started by saying it is all down to "…*lack of planning*". This view is shared by respondents such GK6 and GK4 (planning manager). Respondent GK6 branded this as "…*unrealistic plans*". According to respondent GK4, inadequate planning is one of the main problems; however, suggested other additional problems. This respondent asserted by itemising as follows: *"…unclear scope, lack of work packaging, scope creep, inadequate planning, and lack of understanding of contractual requirements."*

Besides the inadequate planning, which is acknowledged as one of the main problems, this respondent stressed on unclear scope, scope creep, lack of appropriate work packaging and lack of understanding of the contractual requirements. The unclear scope has also been identified as one of the problems associated with PM, and which usually leads to scope creep. Similarly, respondent GK3 asserted: *"…an unclear scope and frequent or regular scope creep"*. Furthermore, respondent GK 2 stated, *"…avoid scope creep as it is one of the most common reasons projects run over budget and deliver late"*. Respondent GCL1 advised, *"…it is always difficult to plan for unforeseen events which often occur in construction"*. These illustrate that the conventional project planning techniques that assume all activities known at the onset of the project could be misleading as suggested in the literature (see chapter 3); therefore, in chapter 11, the methodology of TPC system takes this into consideration.

Respondent GK4 suggested a lack of work packaging as another problem, which is also seconded by other respondents such as GK2 and GCL4. Respondent GK2 advised that *"…never promise anything you know you cannot deliver. Stick to your guns no matter how senior or important the person is, they will thank you for it later"*. This problem could be due to the fact that the conventional technique, WBS, ensures the work is broken-down into activities not necessarily realistic deliverables (as discussed in chapter 3). Traditionally, work breakdown is assumed to be generic, thus transferable, which again may result in this problem. In response to this problem, the TPC system discussed in detail in the next chapter, 11, adopts deliverable breakdown structure rather than task focused WBS.

This is what respondent GK3 asserted as the *"…failure to understand the complexity of the project"*. This respondent argues that seeing a project as a linear process, which is in keeping with the conventional planning techniques, is one of the problems associated with project planning. In spite of the above, respondent GK3 also believes *"…incomplete design information leading to wrong estimation of project resources"*. This stance is also asserted by respondents GC1 and GC4. Although incomplete design is one of the problems of project planning, the question is: how do you plan, when you don't know and understand what is required? Many respondents such as GC3, GK5, GK6, GCL3, GCL2 GCL4 and GD1 consider experience and communication as major problem in this response. Most of the clients' respondents stressed on *"…lack of experience"* and others suggested communication. Respondent GC3 argued:

"from the point of view of the client and the consultants, it is insufficient experience in the execution of the project; they may have experience in managing of the project but not execution. In order to plan a project properly, you need to have an experience in execution so the contractor [main subcontractor] has much more experience in execution than the client or the consultants. But the contractor is not involved in the planning and the contractor is not paid to be involved in the planning. From my experience project planning is not shared between interested parties but it comes from the client or the consultants and the contractor is expected to fit into this and for commercial reasons or for time reasons the contractor cannot fit into this then there is delay"

In this respondent's view, which is consistent with the findings discussed in earlier in this section and chapter 9, clients consider the problem as lack of experience. However, this respondent, GC3, believes it is beyond experience of a particular group (client or contractor). This respondent argues that all the group have different experience, but when it comes to project planning, collaboration is the key to bridge the knowledge and experience gap. Similarly, respondents GK5 and GK6 blamed *"…poor communication among team",* whilst GD1 deems poor communication that runs through the monitoring and control stage of the project; therefore, stated:

"Breakdown of communication is a major inhibiting factor for monitoring and controlling projects. Almost always, the monitoring team are in offices far away from the construction site. Their representative on the site do not have the vision and expectations required and the construction team do not want to report mistakes on site so it leaves a black hole which is detrimental to a successful monitoring and controlling".

Despite respondent GD1 acknowledging the problem of communication, he also believes it is due to other issues including reporting process. This respondent suggested that lack of proper reporting process leaves major problem unattended until the end of the project. This issue has also been highlighted by GK3, which is consistent with the case studies findings. Respondent GK3 affirmed *"…poor record keeping and lack of early warning*". Have identified this as one of the main problem, the TPC system (discuss in chapter 11) ensures there is an evaluation process for a deliverable which will enhance the record keeping, communication and give early warnings. Finally, respondents GK2 and GK3 asserted a lack of risks identification and performance success factors. According to GK3, *"…lack of appreciation of the critical success factors"* is one of the problems, whilst GK2 seconded by suggesting:

"…define with the owner the critical success factors that will make project a success. Project closure, all projects have finite life. A project that is not closed will continue to consume resources"

These respondents stressed the importance of critical success factors in planning, which is not appropriately documented in the existing literature. In contrast, respondent GK3 asserted that the lack of proper closure of a project is one of the problems associated with monitoring and control. Figure 10.3 presents the summary of the problems associated with project planning and control.

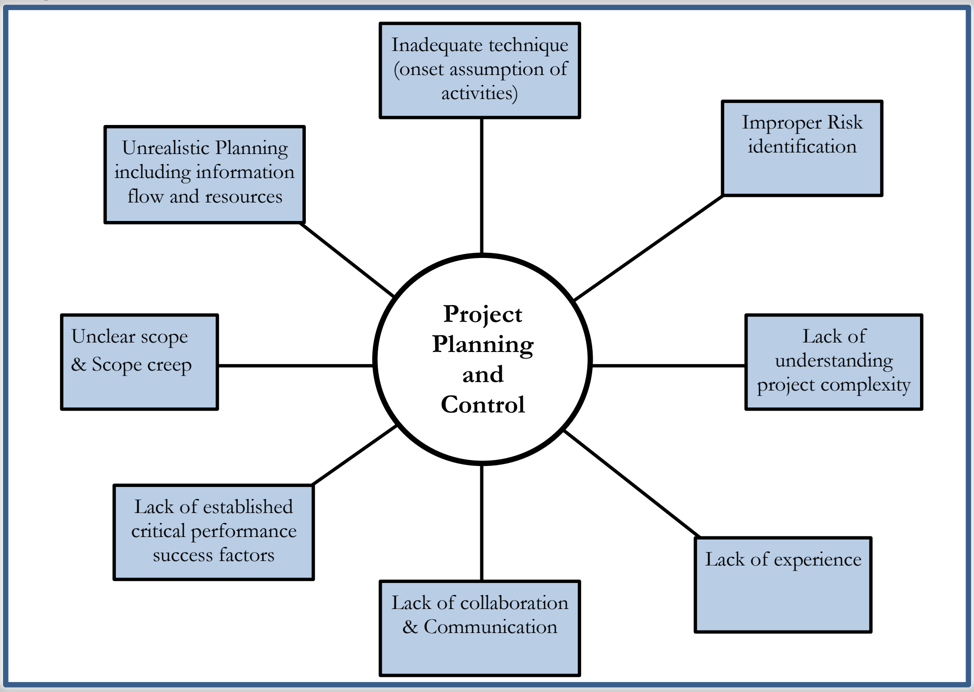

Figure 10. 3: Problems associated with Project Planning and Control

10.4.3 Q – What are the Causes of Delay?

Delays in construction literature have been largely associated with many factors, which include ineffective PM and planning as part of the main causes. Causes of delay have been examined in many other countries recently but not in the UK where the study is being conducted (see table 3.4). Again many of the study, if not all, adopted survey as discussed in chapter 3 but the question is, what is the appropriateness of using survey to understanding a 'real world' problem, which requires an attention? Besides, this study focuses on developing a holistic planning and control system to enhance the current practice, thus understanding the causes of delays will feed into the methodology of this system, the TPC system.

Delays in construction could be initiated by any of the stakeholders or project participants. Respondent GK2 described delays as a common problem in construction, which is consistent with the study of Sambasivan and Soon (2007); however, the effect of delays on project participants varies especially clients and contractors. This respondent argued that:

"project slipping over its planned schedule is considered as common problem in construction projects. To the owner, delay means loss of revenue through lack of production of facilities and rent-able space or a dependence on present facilities. In some cases, to the contractor, delay means higher overhead costs because of longer work period, higher material costs through inflation, and due to labour cost increases".

In this analysis the main causes of delays are discussed under 10 headings or themes identified from the data collected.

10.4.3.1 Insufficient Project Planning (unrealistic deadlines and deliverables)

Respondent GD1 argued: *"…we sometimes talk about 'delays' which are not delays per se but poor programming at the start of the project for not assessing the productivities realistically etc".* Respondent GK2 believes the *"…original contract duration [given by project owner] being too short".* Again, interviewee GC1 emphasised this by asserting "*I have already said that insufficient planning is the main cause…"* In this respondent's view, poor planning is a main contributor of delays, as it is believed that unrealistic assumptions are made and, it was expressed by respondent GL2 *"…agreeing to impractical requirements".* Respondent GK6 asserted that *"…deadlines and deliveries not being realistic"* and respondent GK2 stated *"…ineffective planning and scheduling of project".* Similarly, respondent GCL4 emphasised this issue by stating *"…unrealistic deadlines and deliverables"* and respondent GC1 concluded by stating *"causes of delays are poor planning…".*

These respondents stressed the unrealistic of the deadlines and deliverables discussed in the literature (Laufer and Tucker 1987, Koskela and Howell 2002, and Ballard 2000), which is arguably based in the conventional calculation of durations, using WBS and estimation based on only planners' assumptions. Respondent GCL1 emphasised the *"delays stem from bad planning…",* whilst respondent GCL3 believes the *"…optimistic programmes and lack of team support".* Yes, the programme could be over optimistic; however, it could be due the underpinning theory of calculating duration as discussed in chapter 3 (see figure 3.1), which assumes 'the more people the less duration'. This is peculiar to a 'real world' construction project. Respondent GCL3 raised another issue of 'lack of team support'. In this view, the respondent emphasised the importance of collaborate planning, which has been discussed throughout this chapter. A lack of collaboration opens up the issues of information flow and communication that is presented in the next section.

10.4.3.2 Poor Information Flow and Communication

Most of the respondents consider information flow and communication as major causes of delays. Respondent GK1, who is part of the design team (project engineer), established that

"…lack of information flow between the design team members". This respondent believes that delay start at the onset of the project, where there is lack of information flow between the team. This is equally transferred to the construction stage. This is clearly affirmed by respondents, such as GK2, who stated, *"poor communication and coordination at the construction stage"*. However, other respondents suggest that information flow or communication is a major problem throughout the project phases. Respondents, such as GK3, GK5, GK6, GCL2 and GC1, simply suggest delays are also due to *"poor communication and information flow"* except respondent GK3 who stated *"…poor communication and coordination among the project team members"*. This respondent not only stressed communication, he also considers coordination among team members as a major cause of delays. This theme, coordination, is therefore discussed in the next section.

10.4.3.3 Poor Management (Co-ordination of team members)

The problem of co-ordination could be attributed to issues of management or organisation. This is because the synonyms for co-ordination are 'organisation and management'; therefore, respondents say poor co-ordination of team members to implicitly imply 'poor management'. Besides, respondent GK3, respondent GK2 stated *"…poor communication and co-ordination"*. Respondent GK6 commented delays are caused by *"…poor team coordination"*. In addition, respondent GK2 suggests that delays are also caused by *"…poor site management and supervision"*. In this respondent's stance, poor coordination between the entire project team; however, poor site management and supervision on the path of the contractor is a major cause of delays. Similarly, respondent GCL1 argued that it is *"…lack of control on site"* and GK1 deemed it to be *"…lack of monitoring and control"*. This is consistent with the conclusion of Sambasivan and Soon (2007), which attribute poor site management as major cause of delays. Respondent GK2 believes the poor management could be *"…conflict between contractor and other parties such as consultants, owner or subcontractors",* whilst respondent GCL4 argued that it is due to *"…continuous changing of leadership and staff"*. Respondent GK5 suggested that the management problem is *"…lack of motivation and poor project governance"*. This draws to the next theme, lack of experience.

10.4.3.4 Lack of Experience and Incompetence

Respondents suggest that lack of experience is among the causes of delays to construction projects. Respondent GK2 stressed that *"…inadequate experience of consultants, this could apply to contractor depending on the type of contract or procurement"*. According to respondent GK3, *"…inexperience of the team"* is a major cause of delays. To this respondent, experience of the team is paramount in all areas, which is seconded by respondent GD1, who stated

"…incompetence of parties to the contract". Respondent GCL4 stated *"…incompetence resources"* and GK5 argued *"…unqualified [and] unskilled staff"*. According to these respondents, although inexperience leads to delays, incompetence equally does so. The experience and competence is either individual or team but other respondents suggest delays are due to unclear project objectives from the onset.

10.4.3.5 Unclear Project Objectives/scope and Scope Creep

Respondents deemed unclear project objectives, usually leads to the scope creep. Equally, changes and scope creep becomes inevitable in projects with unclear objectives at the start of the project on site. This particular problem is associated with the client; nevertheless, the client respondent GCL4 agreed. This respondent established that *"…continuous changing of project scope"* is a major cause of delays. Also, respondent GD1, who also double as a client, clearly stressed that *"…client's changes are also to be blame"*. Mostly, consultants respondents stressed this theme. An example: respondent GK4 asserted, *"…causes of delays could be scope creep, changes, lack of clarity or unclear brief"*. To this respondent delays could be caused by the list, which emphasised both unclear project scope and scope creep. Interviewee GK6 also states *"client instigated changes…"* This issue is not peculiar because it has been discussed extensive in the literature (chapter 3). It could be argued that the unclear project objectives are associated with incomplete design as suggested by some respondents.

10.4.3.6 Lack of Detail Design and Design Changes

Arguably, if design is not detailed enough before the start of the project on site but there is proper information flow and communication, then delays could possibly be eliminated. In addition, lack of detailed design could arguably be due to the procurement route or the project size. This is contrary to what respondents believe about this theme.

Respondent GK3 claimed delays are due to *"…frequent design changes at construction stage"*. The question asked here is: do the clients or the consultants initiate changes? Consultants are normally client's representative on site, although it depends on the procurement route. Therefore, changes to design are arguably client-initiated changes. This was advocated by respondent GK6, who stated, *"client instigated change"* as a major cause of delays. However, respondent GK2 argued that the changes in design are not only client initiated rather *"…mistake and discrepancies in design documents"*. This respondent again argued that *"…delay in approving major changes in the scope of work, which could apply to the owner"*. In this respondent's view, changes to the design as well as late approval of changes are both major problems.

Some respondents suggested that the design changes could be due to lack of in-depth investigations, such as groundwork. GK3, GK4 and GK5 all agreed that unknown ground condition can cause delays. However, GK5 argued that it is a *"…failure to undertake a comprehensive assessment of the ground conditions"*. *"It could be insufficient detailing in design or specification; it could be technical specification"* was the response of GC3. Respondent GK1 advised that despite this lack of assessment there are *"…not enough contingency allowed to deal with delays easily"*.

10.4.3.7 Unforeseen Circumstances

Another pertinent cause of delays, which has also been discussed in the literature, is unforeseen circumstances (Sullivan and Harris 1986, and Fallahnejad 2013). Inevitably, construction projects are exposed to many site conditions and thus exposed to risks. It is not surprising that 'risks' is identified in chapter 8 as a major constraint to both construction project and PM. Interviewees in case studies, discussed in chapter 9, established that weather is currently not a major cause of delays as statistics are available to be considered during the planning stage. However, this is contrary to these respondents. Respondents such as GC3, GK5 and GD1 explained that extreme weather is unforeseen circumstances, thus could cause delays to construction project.

Interviewee GK4 argued that it is beyond weather, thus it is *"…unforeseen circumstance"*, whilst GD1 stated *"…site and environmental conditions and political influences"*. Respondent GD1 considers unforeseen circumstances as *"environmental condition and political influences, where political influences include administrative change, legislation and governmental influence"*.

10.4.3.8 Poor Performance

Some respondents attributed delays to poor performance. Poor performance could be associated with many factors, e.g. respondent GK5 advised *"…lack of incentives, using optimum productivity estimates, and improper resources allocation"*.

Respondent GC1, a construction director, pointed figure at subcontractors as he asserted: *"…poor sub-contractors performance",* whilst GD1 believes poor performance could be from any of the stakeholders, thus stating:

"some of the causes of project delays are low productivity; however we sometimes talk about delays which are not delays per se but poor programming, at the start of the project for not assessing the productivity realistically"

Respondent GC1 suggested that since subcontractors are those who normally execute the job on site, their performance is key to the completion of a project. In contrast, GD1 argued that delays are caused by "low productivity or unrealistic productivity assessment". GK5 claimed that poor performance is due to 'lack of incentives', which could be due to financial problems.

10.4.3.9 Financial Problems

In the current economic climates, finance is a major driver in the construction industry, hence, it is suggested that financial problems causes delays to projects. GK2 indicated that *"…difficulties in financing the projects; lack of cash flow"*, whilst GC1 responded *"…companies going bust"*. It is undisputed among respondents, which is in keeping with the literature that financial problems cause delays.

10.4.3.10 Resource Problems

Financial problems may restrict a stakeholder to procure appropriate resources for a project, thus termed as lack of resources. Respondents argued resource problem is not limited to financial problems. Respondent GK2 emphasised that "*shortage of labour*" causes delays; and also argued that *"…delays in performing inspection and testing; late in reviewing and approving design document from consultants"*. This respondent suggested that a lack of resource equally causes delays because it does not allow other work to be done on time. Respondent GC3 asserted:

"very often from the contractors' point of view, the contractors have more than one project going on so it could be internal difficulties having to allocate the same resources to different projects"

This respondent, who is a director, argued that delays are caused by inappropriate resources allocation to projects, which is arguably beyond financial problems or shortage of resources.

10.5 IMPROVEMENT

The first two questions examined the success factor and the problems. This question examines how respondents believe project management and planning be improved.

10.5.1 Q – How can PM and Project Planning be improved?

Respondents were asked for their opinion on any admirable improvements to construction PM and planning. Figure 10.4 presents the attributes from respondents and most of the attributes have been discussed previously. However, there are a few of the attributes that have not been discussed therefore require emphasis.

There are many common attributes under both headings, which arguably vindicate other respondents and studies suggesting that PM is hinged on project planning.

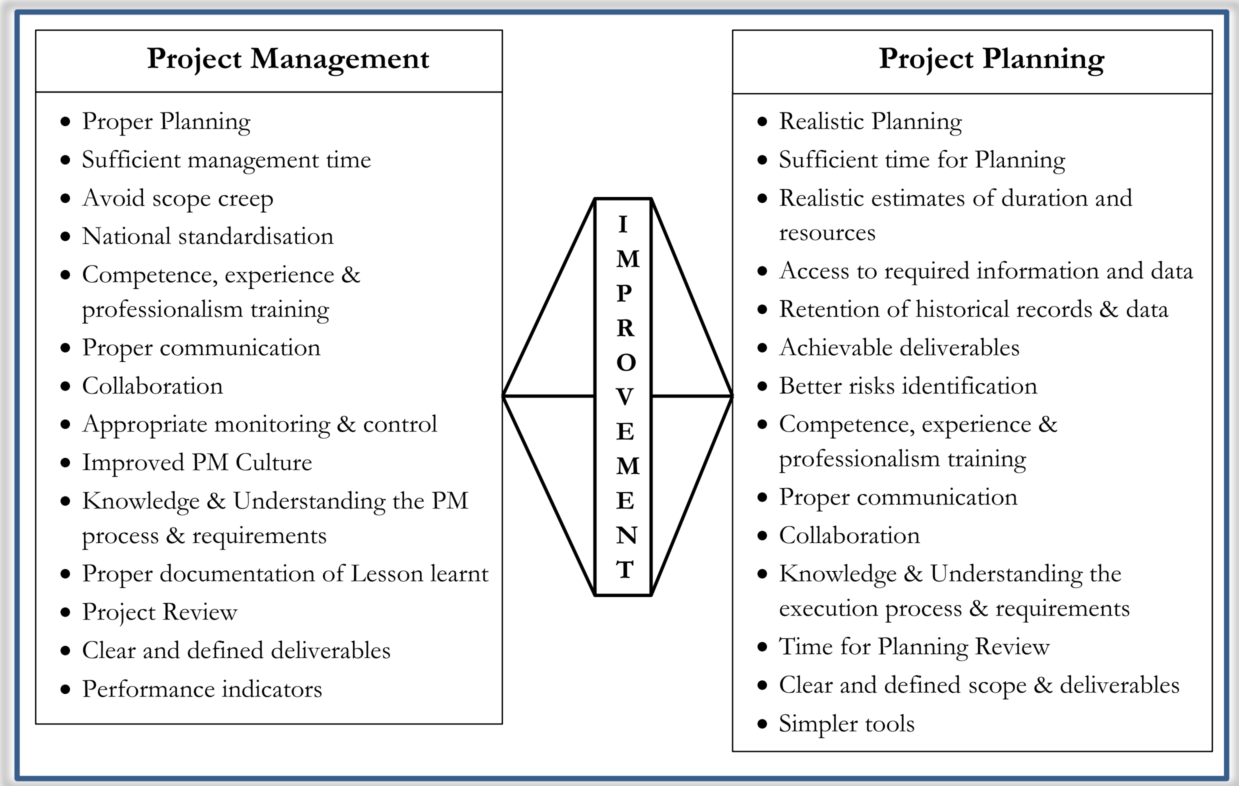

Figure 10. 4: Respondents possible improvement for Project Management & Planning

Under both improvement for PM and planning, suitable documentation on lesson learnt, data and/or information required were common. This confirms the need for continuous review and feedback or **evaluation process** as discussed in chapter 8. Respondent GK2 asserted:

"Lessons learnt report: a report which describes the lessons learned in undertaking a project and which includes statistics from the quality control of the project's management. This is approved by the Project Board and then held centrally for the benefit of future projects. If the project is one of a number attached to a programme this document will also be used as input to the programme review".

This respondent describing the importance of lesson learnt report but the question is: when should lessons learnt report be made? Normally at the end of the project but there should be review on each deliverable to improve the reliability and accuracy of the report. This is considered in the TPC system. (discussed in the chapter 11). Respondent GK4, who is the planning and schedule manager, states that *"better retention of historical records and use of data, if originally correctly recorded".* Again these respondents being senior project manager, and planning and schedule manager respectively, emphasised the essence of evaluation process required in PM as well as planning, which is sparse in literature. Respondent GD1 stressed on evaluation process among other attributes: *"Project management could be improved by project managers combining experience with knowledge and the ability to apply the wealth of lessons learnt from previous projects to subsequent similar projects".*

10.6 CONCLUSION

This chapter is the analysis of stage 4 of the research process which addresses research objective three. The analysis covers what practitioners believe to be success factors and their respective understanding of problems associated with construction PM and project planning together with how it can be improved.

This chapter establishes the success factors of construction projects are mainly pivoted on its project management, which is consistent with the study of Hubbard (1990). However, the factors in successful project management are mainly effective communication, project planning, experience and competence, project control and collaboration (Table 10.2 presents the full details), which is a development to the literature. Project planning was established as one of the main factors in successful PM but ten factors were established as factors in successful project planning, which include realistic deliverables, realistic duration, risk identification, construction process flow, collaboration and review process. The literature is sparse in factors to successful project planning, thus this study contributes to knowledge by identifying the ten factors to successful project planning. Again, this analysis distinguishes between construction project success and PM success.

The problems associated with construction PM, and planning and control were analysed as well as the causes of delays. It is concluded that the main problems associated with construction PM include ineffective project planning, improper risk identification and management, unrealistic objectives, delays and lack of integrated techniques (full details are presented in figure 10.2). In contrast, eight factors were established for problems associated with planning and control. These factors include inadequate techniques, improper risk identification, lack of understanding of project complexity and unrealistic planning including information flow and resources (full details are presented in figure 10.3). Ten causes of delays were also established which include similar factors identified as problems associated with PM and planning and control. These factors comprise insufficient project planning, poor information flow and communication, poor management (control) and unclear project scope.

This analysis established that the major problems associated with a construction project include insufficient planning, inadequate techniques available, lack of information flow and communication, and lack of understanding of project complexity which is set as the foundation for the development of the TPC system discussed in the next chapter.

Unsurprisingly, the analysis of possible improvements for project management and project planning established similar patterns as their problems. Obviously, these include realistic planning, realistic estimates of duration and resources; improved information flow and communication and collaboration. One of the most intriguing factors discussed under this section was the importance of the evaluation process which complements and validates the Construction PM managerial process discussed in chapter 8. The importance of a review process and evaluation throughout the project has further been strengthened, which is incorporated into the development of the TPC system in chapter 11.

CHAPTER ELEVEN: STAGE 5 & 6 – DEVELOPMENT OF THE TPC SYSTEM, ITS IMPLEMENTATION & EVALUATION

11.1 INTRODUCTION

This chapter is in two parts (i.e. research stages five and six) but they are closely related. The first part, stage five, presents the development of the innovative and holistic project planning and control system, Total Planning and Control (TPC) System. It is called 'total' because of its holisticity. Traditionally, theory informs practice; however, in developing a 'real world' system like TPC, practice informs theory. Therefore, the TPC is developed through the combination of the research stages one to four, although mainly stages two to four, which are the main data collection from practice. Then this is grounded in knowledge, which is stage one. This chapter is also a cross discussion and synthesis of all the analysis chapters (i.e. eight, nine and ten) together with literature to develop the TPC system.

The second part presents the research process stage 6, which focuses on the implementation and evaluation of the TPC system. TPC was implemented in the case studies. An expert evaluation group, which included the senior project managers and some academics with interest in the study, was formed. The group was mainly to give feedback on the TPC system and their feedback was very commending. However, some gave practical recommendations, which are discussed and incorporated in this thesis. Beside this evaluation group, an elite interview was conducted with Professor Glenn Ballard (the developer of LPS) whose comments were positive and encouraging.

11.2 ANALYSIS OVERVIEW – CROSS DISCUSSION

This section presents an overview and cross discussion of the analysis chapters, i.e. chapters 8, 9 and 10, which are research stages 2, 3 and 4 respectively. This section focuses on the empirical themes from the previous chapter, identifying their similarities and differences. The discussion covers a total of 88 interviewees and 8 participants (with documentary review and observations) for evaluation of the TPC system.

Figure 11.1, presents the research process for the development of the TPC system which is the focus of the study. This diagram illustrates the utilisation of the production model, IDEF0, (discussed in chapter 4), together with the adaptation of a bespoke PM theory, TFV theory (discussed in chapter 5) which are parts of the development of TPC System. The research stage two, which is discussed in chapter 8 discusses the PM and project constraints, and establishes CPMMP as planning, control and evaluation. The research stage 3 focused on PDP as practiced, and established the success factors, problems associated with PM and PDP, and their possible improvements. This is similar to research stage 4 but with different respondents across the industry. These led to the establishment of PDP requirements and task flows and development of 4Es management model. All these together set the foundations and environment for the development of the TPC system. Below are the empirical themes and findings which led to the development of the TPC system.

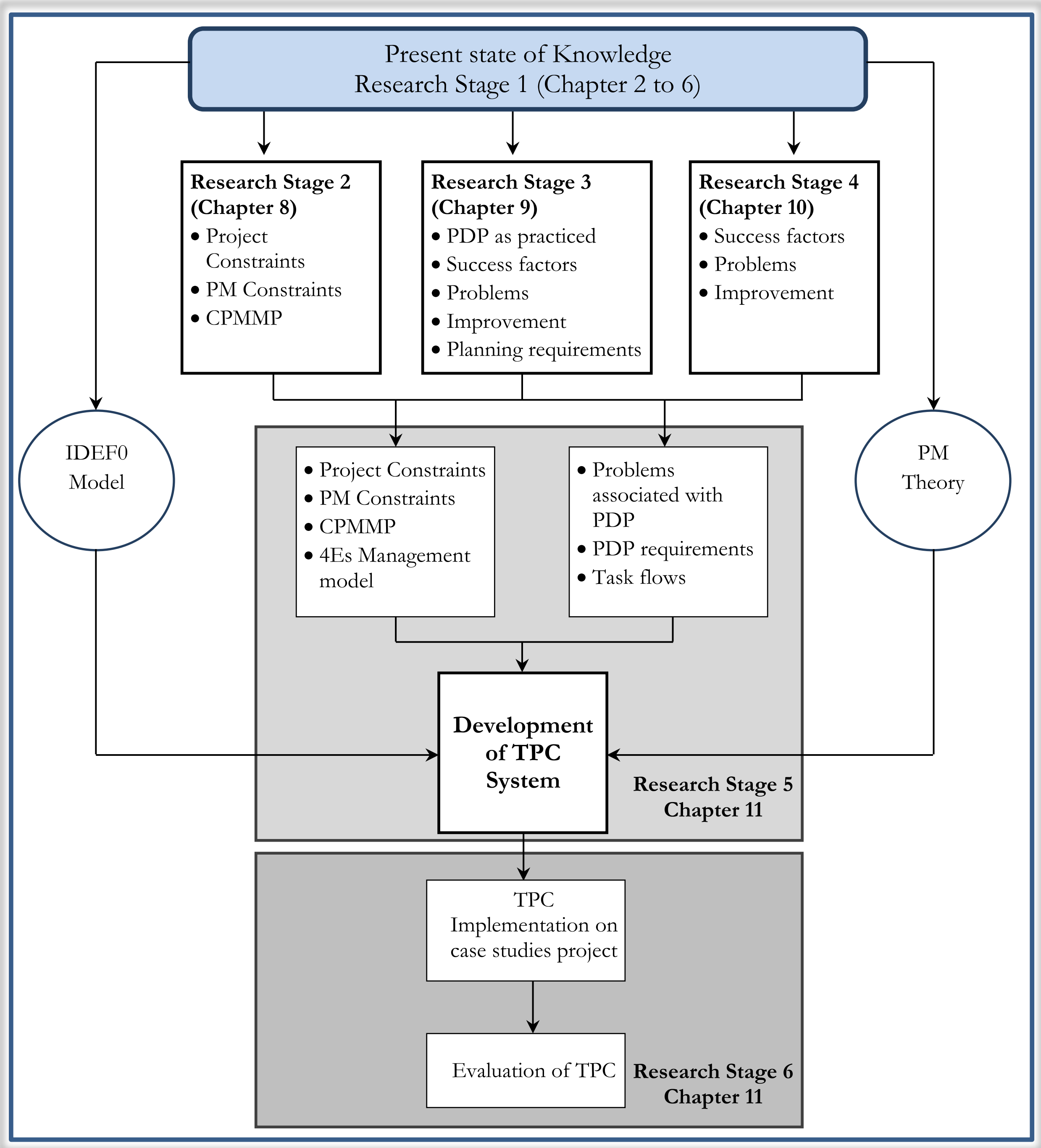

Figure 11. 1: The Research Process for the Development of TPC System

11.2.1 Construction Project Management Managerial Process (CPMMP)

It was established in chapter 8 that the construction project constraints are Complexity, Risks, Time, Cost and Quality whilst PM constraints are the same including Communication. This was represented with a star symbol, where the five constraints points are connected together with communication (see figure 8.5). In addition, a construction project was conceptualised as "reality out of imagination within an explicit period and boundaries for both specific and social benefits", or "concepts transformed through execution to purpose use with explicit period and boundaries". This was seconded by the findings in chapters 9 and 10 which show that construction projects commenced as concepts and finish in their purpose use. A site manager (CS-02-SSR6) with many years of experience clearly asserted this view by stating:

"Construction is somebody having an image of a building or an image of an idea and being able to create that idea. That is why you get structures like the hoover dam; they are people's ideas and image, and people's thoughts of being able to create something and then having the thought of a building"

Although this interviewee is in CS-02, which is excluded in the interviews in stage 2, the emphasis on the concept remains the same. This establishes that the concept is general to practitioners and as such it is applicable to all construction projects. This interviewee added:

"some people have got some good ideas and some people have got lousy ideas that is why some buildings are really, really, really terrible. Generally, there is somebody who has got a good idea and you can produce that model".

This further confirms the findings of the CPMMP as Planning, Control and Evaluation, where Construction PM is defined as "the planning, control and monitoring, and evaluation of every task and process to achieve the purpose use within explicit period and boundaries". This CPMMP has been re-echoed in other chapters. For example, the evaluation stage, which is relatively one of the new findings, is described in chapter 9 as the review process. Practitioners envisage the review process as success factors to PDP and PM. Notwithstanding, they admit that it is ineffective in current practice, which is a problem and requires improvement. Figure 11.2 presents the details of CPMMP.

The complexity of a construction project runs through all the analysis chapters but in chapter 8, a construction project was classified as 'complex production', thus establishing that construction is some sort of production and managing a construction project based on time cost and quality was insufficient and obsolete. Therefore, this study proposes a new management model, 4Es, which will be discussed later in this chapter. Before that, the success factors, industrial problems and improvements associated with PM and PDP are discussed.

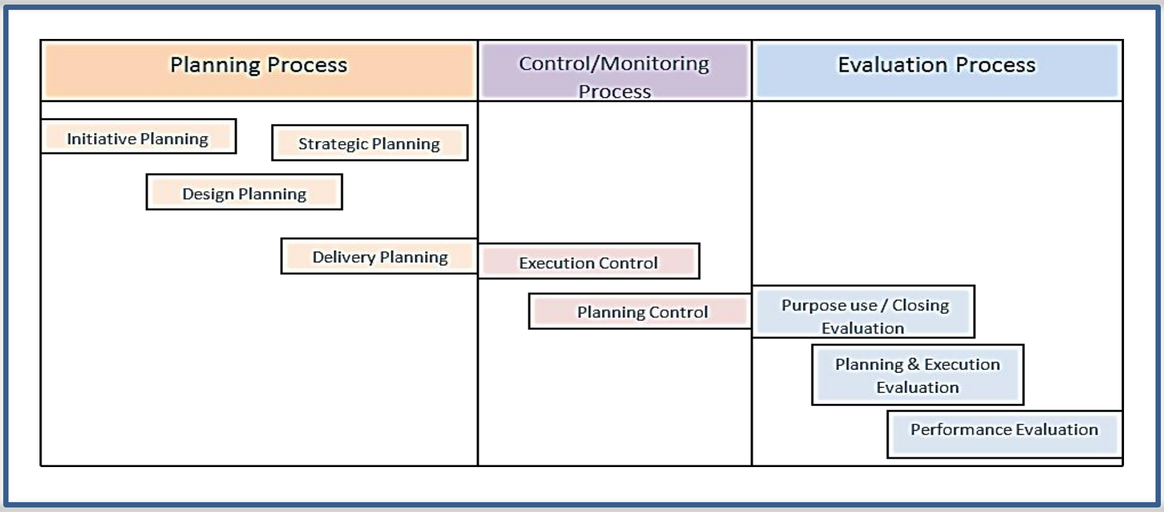

Figure 11. 2: The Details of CPMMP in relation to other established functions

11.2.2 Success Factors

Three success factors (project, PM and PDP) were empirically examined in both research stages (i.e. 3 and 4), where the sections were cross-discussed to identify their similarities and differences.

11.2.2.1 Success factors for construction projects

In chapters nine and ten, the industrial perspective for success factors, the problems and improvements requirements for construction PM and PDP were presented. The findings in both research stages were closely matched, although the respondents were different. While stage 3 presents respondents from the case studies, which are mainly contractors (main and sub-contractors), research stage 4 presents responses from practitioners from across the field. It is established in both chapters that the PM is a core factor to a successful project. Exclusively the contractors' perspective in chapter 9 draws on PM output, whilst the general perspective in research stage 4 (chapter 10) emphasises on PM constraints. The common themes between them both are PM (hard and soft). Much literature has been written on hard PM which is centred on the process of PM such as planning, procurement and control. However, the literature is sparse on soft PM. In both analyses of successful PM, themes such as PDP, communication, experience and competence, project control and review processes were common. Stage 3 stresses the 'review process' more than respondents in stage 4, as stage 4 presents general perspectives of the issue. On the contrary, respondents in stage 4 emphasise review meeting for PM more than that of stage 3 (See table 11.1 for general factors).

Table 11. 1: Project Success Factors – Practitioners Perspective

Themes	Attributes
Project Management Constraints	Time Cost Risks Quality Communication Project scope Safety Environment
PM Output	Profitability Experience Competence Value for Money Repeat work
PM (Soft)	Experience Communication Clear scope Leadership Team work Collaboration Key Performance Indicators Governance
PM (Hard)	Project Planning Project Monitoring & Control Risk Management Health and Safety Communication Procurement As Built Information Safety

11.2.2.2 Factors for Successful Project Management

Similarly, the findings in both research stages are consistent. The main difference is the assertion of 'motivation' as one of the core factors to successful PM by respondents in stage 3, whilst stage 4 claims clear and realistic project objectives and defined scope are parts of the factors to successful PM. Although interviewees in stage 3 do not disagree with these themes, it was not common. Figure 11.3 presents the general practitioners perspective.

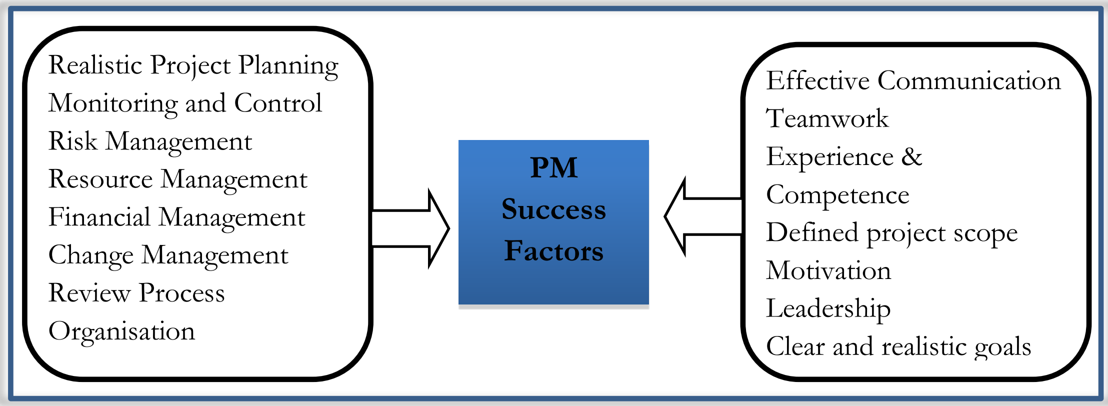

Figure 11. 3: Success Factors for Construction PM – Practitioners Perspective

11.2.2.3 Factors to successful PDP

Again, this analysis is not peculiar as both findings in chapters 9 and 10 were in keeping (for more details refer to figure 9.6 and 10.1). Therefore, the next section discusses the problems.

11.2.3 The Problems

The review of PDP as practised exposed the problems with the conventional PDP techniques in research stage 3. However, practitioners' responses were analysed and presented in chapters 9 and 10. This section focuses on the practitioners' responses.

11.2.3.1 Problems associated with PM

In stage 3, 12 themes were identified, whilst 14 themes of problems were identified for stage 4. Arguably, this illustrates the numerous problems in construction PM and also confirms the importance of PM, which is consistent with this study's findings on success factors for construction project. All the themes are common between the research stages except two of the themes identified in research stage 4 (chapter 10). In stage 4, incomprehensive design and lack of evaluation processes are the odd ones in the findings in stages. This shows that from contractors' perspective these are not main problems. This could be due to the fact that the case studies were designed and build thus designs were incorporated in the delivery stage of the projects. In chapter 10, these two issues were stressed by clients and developer respondents since these respondents are involved in many different projects with different procurement routes. Therefore figure 11.3 presents problems associated with PM.

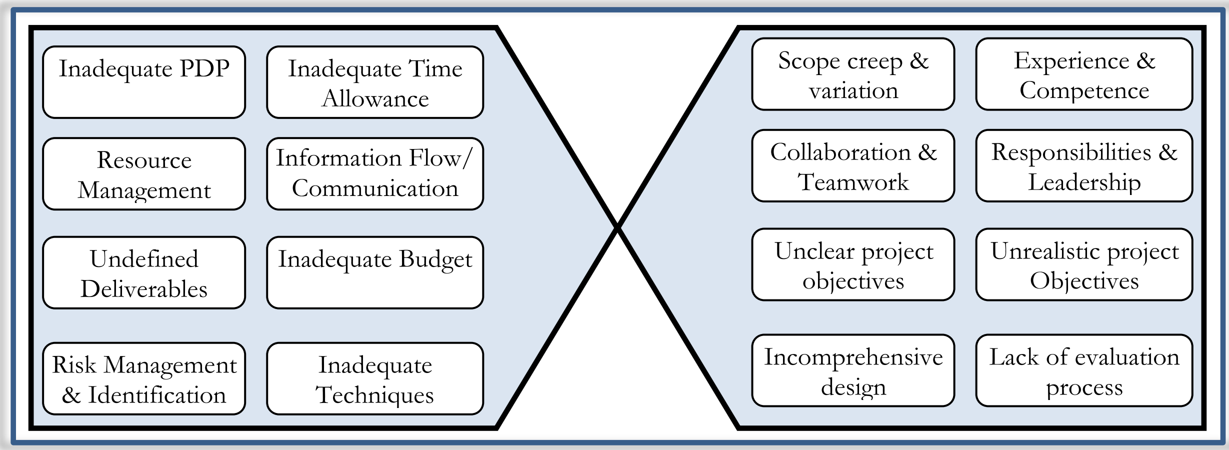

Figure 11. 4: Problems associated with Construction PM – Practitioners' Perspective

11.2.3.2 Problems associated with PDP and Control

The main problems established across the research stages are consistent with each other. This could be due to the fact that the construction industry is dominated by the use of Gantt chart which was developed in the earlier 20^{th} century. Thus, the problems have been with practitioners for many years. There are two problems that stand out in the findings of stage 4, which are tight budget and unwritten PDP. From the case studies, it was established that subcontractors' PDPs are unwritten, which could be owed to other factors discussed in chapter 10. However, respondents suggest that to be one of the main problems. Again, tight budget is established as a problem associated with PDP and Control. Respondents believe tight budget is the basis of poor planning due to insufficient time allocation and incompetent individuals involved in PDP. In this respect, the Lead Planner for CS-02 emphasises unrealistic planning by stating:

"Programme is seen as critical to the client as the contract sum. It might be just like the finance he who makes the biggest mistake wins it, he who does spot the real situation commit himself to something to win the job. No different to tendering, you put the price together; if we had to price the job properly we wouldn't win it. But we will make absolute fortune and it is the same with the programme. The client driving the programme down put pressure on us and there is no float, there is no spare time, we work all down to deliver it. The thing about this site is that is not taking as a low end of safety or increasing of the cost, we are managing to control both…"

This practitioner, who is also a lead Planner, suggests the planning should be given as much particular attention as cost or tendering. Again, this interviewee stresses that there should be a possible contingency in PDP; however, it is difficult due to client pressure to reduce the duration. Although PDP is recognised as core to PM and the conventional PDP techniques are insufficient, the industrial problems associated with PDP are sparsely discussed in the literature.

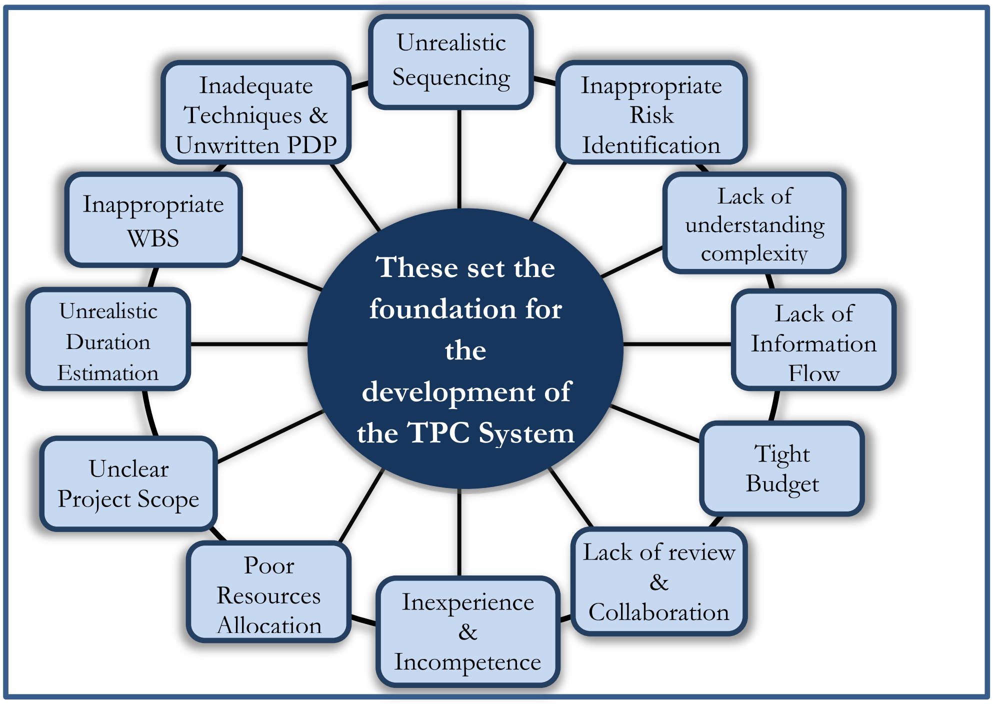

Figure 11. 5: Problems associated with Project Delivery Planning and Control

11.2.3.3 Causes of Task behind Schedule and Causes of Delay

For cross examination, the causes of tasks behind schedule and causes of delays were examined in research stage 3, whilst stage 4 focuses solely on the causes of delays. Delay is one of the main problems closely related to PDP in the literature; although this theme is not explicitly stressed by the interviewees in this study. However, insufficient or poor planning was ranked as most common for the causes of delays or tasks being behind schedule. The study established numerous causes of delays and tasks being behind schedule where many of the themes overlap. The findings are an extension to the literature as they establish 'the real world' causes of delays rather than the revolving themes gathered in literature. For example, poor commercial decisions, and health and safety are claimed to be major causes of delays to construction projects. In addition, practitioners suggest underestimating the complexity of tasks, and health and safety issue causes tasks to be behind schedule.

Another fascinating finding that has not been given much attention in PM literature is the experience, knowledge and competence of the individual and the team. Practitioners suggest they are part of the main causes of both delays and activity being behind schedule. Practitioners assert that information flow is equally a major cause to tasks being behind schedule (see chapter 9); however, they were silent in identifying information flow as a cause of delay. From the documentary review and the interviews, it was also established that tasks are behind schedule due to the non-relationship between the activities. This is obviously due to the dominant use of Gantt chart which is made easy for use in different software as established in chapter 8 (stage 2). Therefore, this study introduces the TPC system to mitigate most of the problems identified and make PDP as realistic as possible.

Tables 9.1 and 9.2 present the causes of delays and tasks being behind schedule respectively, which is accompanied by analysis and discussion. Equally, in chapter 9 the causes of delays are discussed. The findings complement each other, which is reflective of the industrial perspective of causes of delays. The next section is concerned with the improvement requirements from practitioners' perspective.

11.2.4 The Improvements

The details of practitioners' improvement requirements are presented in chapters 9 and 10 which are research stages 3 and 4 respectively. This analysis includes improvement for PM and PDP, which is cross discussed below.

11.2.4.1 Improvement for PDP

Practitioners further stressed their desire to have a realistic PDP, which arguably included all the themes presented in table 9.4 and Figure 10.4 in the previous chapters. Practitioners requested to see realistic estimates of durations and achievable deliverables in realistic sequences. Moreover, information flow and collaborating planning were suggested as improvements to PDP. The findings in both research stages were consistent with each other and also with the problems elaborated earlier. One of the improvements requested was that planning should be given adequate attention and time because it is critical to projects and PM. Equally, the knowledge, experience and competence of the construction process and delivery of the project was suggested as a very important improvement request. However, the next section presents the discussion of the improvement for construction PM.

11.2.4.2 Improvement for Construction PM

Again, PDP was a major force that practitioners requested to see improved. In stage 3, that is, in the case studies presented in chapter 9, respondents explicitly requested new techniques and methodology as the industry has changed over the years. This is arguably a fact, thus, the conventional techniques and methodologies become obsolete and insufficient. Practitioners argue that the management methodology is insufficient; therefore they request an effective PM. This is not peculiar as the literature has evidence that managing construction projects based on the TCQ is like juggling three balls, where you can only catch one (Reiss 2007). This suggests that the practitioners and academics are demanding a new managing model. Therefore, this study introduces an extended management model, 4Es, which is discussed in the next section.

11.3 4ES MANAGING MODEL

TCQ has become the *de facto* of managing projects, including construction projects and it is also used as a performance assessment model. However, numerous studies have emphasised the restrictions of adopting this TCQ model. Furthermore, this study has also affirmed that practitioners request a new model, which suggests the inefficiency of managing projects based on TCQ.

The scientific management theory is dominant in the management of projects. This theory led to several methods and studies, predominantly, work study and work scheduling. Taylor introduced time and motion study to determine the TCQ of work. Although scientific management is not wrong, it is limited.

The TCQ model is founded on the scientific management theory (discussed in chapter 5) which assumes production is on orderly or linear process. This is contrary to real world construction production. This does not also suggest that a construction project is solely based on chaos or complexity theory where management and planning are *ad hoc*. Construction draws from these two theories as discussed in chapter 5. Again, the findings of the study established from the analysis in chapter 8 suggest that construction is a 'complex production'. This means applying a 'linear production' management model, TCQ, to construction is unsuitable. Yet, this does not dismiss the importance of TCQ in projects, but it is not suitable for managing construction projects. Therefore, practitioners request a suitable model for construction projects.

Practitioners and academics have criticised TCQ as insufficient and 'two best guesses', which allows trade-offs between them. The study establishes that an operational client wants Value for Money (VfM) whilst the contractors believe profitability is a major factor to a successful project. In addition, a construction project is a 'location based project' which has an effect on the environment as well as a social responsibility.

VfM is not a recent term in the literature, although it must be acknowledged that the idea is widely used in many sectors currently. The VfM concept was first discussed in economists' literature in the early 20th Century. From the economist point of view, VfM is the exchange value of unit of legal tender, where legal tender in our current economic term means money (Pigou, 1917). This definition in relation to construction projects literally means the quality of work (value) is proportionate to the project cost.

In the recent few decades, economists have been discussing this term VfM in terms of buying goods. In the UK, where this study is being conducted, VfM is described by the UK Government as providing services that are of the right quality, level and cost that reflects the needs and priority of customers and the wider community (Communities and Local Government, 2007). The UK Government being one of the major clients in the construction industry now demands VfM from construction projects. It is not surprising that respondents from all the stages in this research suggest VfM as one of the success factors for operational clients. In broader terms, VfM is the ratio of quality and cost; however, in managing VfM, the economists suggest Economic, Efficiency and Effectiveness (3Es). This means from the economist stance to achieve VfM is not necessarily managing quality, cost and time, which allows trade-offs, but using 3Es. However, in the construction industry as discussed, projects are being managed based on the TCQ model; albeit, it is insufficient. In return practitioners want to achieve VfM as a requirement of operational clients. This was explained as having the right quality at its relative cost and within a specific period. However, achieving VfM is not necessarily managing TCQ separately but 3Es.

VfM is about obtaining the maximum benefit with the resources available, which is about achieving the right local balance between economy, efficiency and effectiveness. This 3Es concept is the main management model in all UK Governmental departments as part of their procurement and management of processes. (Communities and Local Government, 2007; HMS0 2006; HMSO 2005). This model results in achieving TCQ without trade-offs but not necessarily managing them separately. Again, this model is utilised in other industries but not in construction. The question one may ask is why is it not adopted for construction projects? One may argue that the construction industry setting is unique from other industries. In as much as this is a fact their purpose remains the same, which is to achieve TCQ.

This VfM concept, 3Es, is concerned with the delivery of a project or procuring goods, which is not labour or people driven. Again, construction projects have direct social responsibilities and thus add to environment problems. Furthermore, it could be argued that construction is a 'location based' and a 'complex production' as compared to other projects. This is the limitation with this VfM concept; it addresses the delivery of a product or project but does not factor in the involvement of people and the environment. This perhaps justifies its slow adoption into the construction industry. In this concern, this study introduces the fourth 'E', which is the 'Ethics'.

According to Kibert (2008), Ethics addresses the relationships between people by providing rules of conduct that are generally agreed to govern good behaviour. Ethical factors will ensure people and environment issues are under control since these two are major factors in the construction industry. In essence, ethics governs people's behaviour and control their environmental impact. Therefore, this study established four themes that are Economics, Efficiency, Effectiveness and Ethics (4Es), which are analysed with the research findings.

From table 11.1 above, 26 separate attributes were identified as success factors for a construction project, which actually established that managing construction projects based on TCQ is obsolete. It is noted that many other factors determine the success of a construction project and table 11.2 presents analysis of the 4Es model. It is evident from table 11.2 that in the use of 4Es many of the attributes overlap with other factors. Adopting the 4Es model, other attributes will be achieved including TCQ, which does not also allow trade-offs.

The contracts manager, who is the Project Lead, in case study two (CS-02) clearly stressed that cost will be what it will be if the project is managed effectively. This practitioner argues specifically that if programme, quality, production, and health and safety are managed equally then the project will be successful. This concluded that if safety, quality and production are managed effectively on site the project will be successful. He emphasised that programme will take into account time and cost automatically not necessarily managing them separately. He also claims that production will ensure other attributes will be achieved which will include quality. Arguably, the health and safety is addressed by ethical factors. This practitioner asserts:

*"Yeah, what we do do is we create the environment, both physical and financial environment to operate. The more efficient we can make that environment the better they will work. In Physical sense that means Safety, Quality and production. They all go together, you can't separate them. It has to be tidy and neat, you don't want people to be tripping on things and all the time searching for a tool here and there or a piece of material there. Everything should be in ordered" (*CS-02-SSR1)

Table 11. 2: The Analysis of 4Es

Themes	Attributes
Economic	Cost Risks Quality Profitability
Efficiency	Communication Experience Competence Value for Money Key Performance Indicators Clear scope Resources Repeat work
Ethics	Environment Experience Communication Leadership Team work Resource Collaboration Governance
Effectiveness	Time Project scope Project Planning Project Monitoring & Control Risk Management Health and Safety Communication Procurement As Built Information Repeat work

Table 11.2 presents the attributes of 4Es which illustrates that 4Es are formed with many attributes. The attributes are more and above only TCQ although TCQ are included. TCQ are an overlapping attributes with the main themes Economics, Effectiveness, Efficiency and Ethics (4Es). This is further presented in figure 11.6 below.

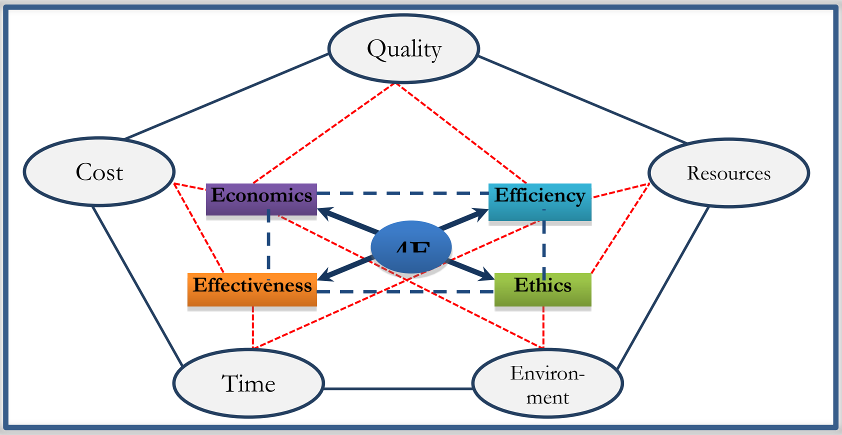

Figure 11. 6: 4Es Model and its relationships with TCQ and other factors

Figure 11.6 presents the 4Es model, which supplant the conventional TCQ model. The model shows the interconnectivity of the factors and the relationships between them. The complexity of the factors is evident in the model; for example, Effectiveness results in cost, time and resources management, as time is one of the measures of effectiveness. This established that the 4Es ensure TCQ, resources, and environment management is achieved simultaneously. This is in line with the concept of sustainability model which is discussed later in this chapter.

11.4 THE DEVELOPMENT OF THE TPC SYSTEM

This study identifies PDP as one of the major problems facing construction PM currently, which is not peculiar from the literature. The results of this study as well as the literature illustrate that both practitioners and academics desire for new and holistic planning technique.

Previously, in this chapter and in the analysis chapters, the PM constraints have been identified and the CPMMP is established. Also, the success factors, the problems and the improvement required for project planning from practitioners' perspective have been discussed. All these address the first research question, which is 'what are the industrial problems associated with construction project planning? From this, the requirement for planning and task flow has been established as discussed in chapter 9. Therefore, this section is particularly concerned with the presentation of the development of the TPC system, its implementation in the case studies and evaluation. Figure 11.1 (on p. 260) presented the diagrammatic view of how TPC system is developed.

11.4.1 TPC Concept

It is evident from this study that a construction project is some sort of production system, although practitioners describe construction as 'complex production'. As discussed in chapter 4, every production operation requires input to give an output (see figure 4.1). This production operation is conducted in every task in the production.

Similarly in construction, projects are made up of deliverables and activities within the deliverables. But a construction project is described as 'complex production' arguably because in construction, each activity possesses different constraints and requires different mechanisms to achieve the required output. Arguably, this is one of the fundamental problems with the conventional planning techniques. In this respect and as discussed in chapter 4 of this thesis, the appropriate modelling technique adopted for this study is IDEF0.

In this study, 12 requirements have been identified as task flows. The lack of identifying flows in the conventional techniques is one of the reasons for PDP's lack of being the foundation for related functions. This task flows are categorised into four parts, i.e. Input, Control, Outputs and Mechanisms, which are ICOMs mode adapted from IDEF0 model. These requirements and other empirical themes became the basis of the TPC concept in figure 11.7.

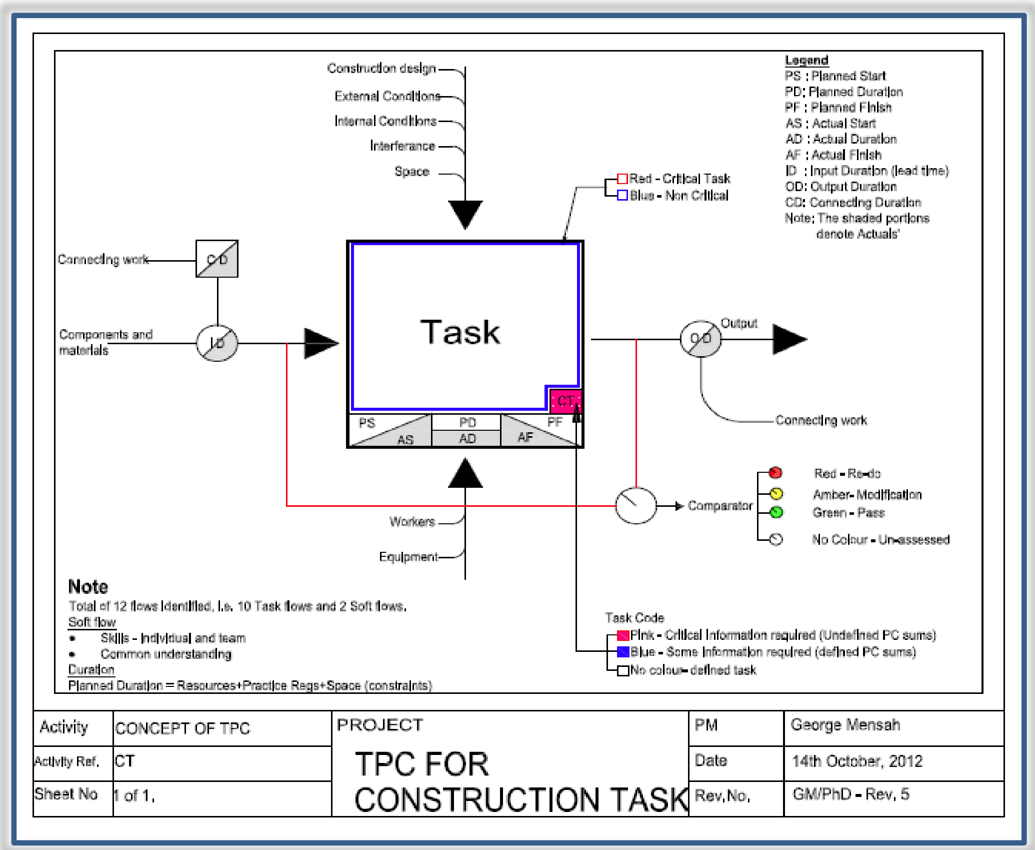

Figure 11. 7: TPC Concept for Construction Task

Below is the brief discussion of the components of the TPC concept, which encompasses thirteen different elements or components.

11.4.1.1 Connected works

Connecting works is identified as a requirement for PDP. This was first suggested by Koskela (2000), which was part of his assertion of seven flows. The connecting work is similarly referred to the conventional techniques as sequence. In the conventional PDP techniques, such as CPM and Gantt chart, the connecting works exist between two activities as discussed in chapter 4. This means the output of an activity becomes the input of the other activity. This is arguably because of their bases from scientific management, which suggest the construction process as linear and production is also done at a controlled environment with constant resources. Even in practice, there are no explicit connection works shown on the programme (it is assumed or unreadable) as discussed in chapter 9. However, practitioners stress the importance of connecting works in PDP. There are some activities that may not necessarily be connected to the task but interfere with the task. Thus, interference is identified as a requirement which is discussed below.

11.4.1.2 Interference

Interference is where an activity is constrained by other non-related activities or actions. As an example, noise for other activities may affect a particular task and if it is not identified may cause delays. In the CS-02, there is the testing of the lift which results in barricading some parts around the lift. This causes interference to other tasks in terms of the work obstruction and caution required around this lift areas and floors. Interferences are common to construction tasks; however, it is not discussed in the literature. Interference is the proposed effect from other related or non-related activities but a construction task is also controlled by internal conditions. This is discussed in the next section.

11.4.1.3 Internal Conditions

The construction industry has many types of organisational structures, protocols and organisation philosophies. In delivering a construction project, different organisations adopt different managing or organisation processes. Therefore, it is misleading for subcontractors to assume the same organisation philosophy for all projects. In this respect, internal condition is identified as a requirement for a construction task. A perfect example observed in the CS-02 was that the main contractor expects all the subcontractors to clean their working area daily. CS-02-SSR9 clearly stated *"our policy is to make sure the site is tidy at all times but some of them are given me problems concerning that"*. But the subcontractors insist that doing so is costing them money as well as delaying the task since their allocated productive hours is reduced by nearly an hour (time for cleaning) each day. The main contractor's health and safety officer advises that if that is not done it will be interference to other trades, the subcontractors say they did not allow for such activity in terms of time and money. In this response, CS-02-SSR9 further argues that:

"They can go to hell if they priced it or not, H&S [health and safety] is paramount. If they do that they will be out of site, not even CM [contracts manager] can bring them back. Our strict H&S policies have helped us as a company to achieve Gold medal and many awards. You should know trades by now, they always give excuses for not doing something".

This is just to emphasise the importance of internal conditions to task, which is not captured in Koskela's seven flows. Again, the internal conditions take into account the method statement and the risk assessment for tasks which is particular for an activity. Besides the internal conditions, a construction task is controlled by other external conditions which are discussed in the next section.

11.4.1.4 External Conditions

Koskela identified external conditions as one of the flows required for construction tasks; however, he described external conditions as mainly weather related (i.e. extreme temperature, rain, snow, and wind). This is partly consistent with this study's description of external conditions. In as much as practitioners acknowledge weather as one of the main requirements under external conditions, they also stress other external factors such as governmental regulations, economic and social factors, other associated legislations, and professional bodies' requirements. In the case studies, it was evident that environmental issues and CDM regulations were also part of the external conditions that control an activity. This is an extension to Koskela's description of external works.

11.4.1.5 Construction Design

Another flow that controls a construction task is the 'design'. It is evident in this study that design problems cause delay to construction projects. In addition, late design also causes problems to construction tasks. It is therefore clear that design is one of the major flows of a construction task which has been stressed in the literature, particularly Koskela's seven flows. The next flow to discuss in the next section is space availability.

11.4.1.6 Space

The importance of space in a construction project is not peculiar in both this study and the literature. As construction is a 'location based production'; space is an important requirement for a project and its activities as well. In planning for an activity, the space availability ought to be factored since space controls the activity. Practitioners have stressed this issue as discussed earlier in chapter 9. In CS-04, the director stresses due to lack of space availability, the resources could not be increased when they wanted to crash the programme. Again, it has been established in chapter 9, the productivity of construction project depends on other factors such as space (see figure 9.2). Thus space is a PDP requirement which is consistent with Koskela's study. The space availability also determines the flow of materials and components for an activity. This is presented in the next section.

11.4.1.7 Components and Materials

Components and materials are obvious requirements for construction activity, which does not require detailed discussion; however, the conventional PDP techniques fail to clearly incorporate it. Materials and components triggers the commencement of a task, thus, it is an input to a construction task. Identifying material and components flow in PDP sets a foundation for related functions such as procurements and logistic planning. After establishing the components and materials as a task flow, it definitely requires work. Therefore, the next section presents discussion on equipment and machinery.

11.4.1.8 Equipment and Machinery

The equipment and machinery required for a construction task varies from task to task. It is therefore necessary to identify the required equipment for effective delivery of that particular activity. Some people may argue that equipment may be generic for construction activities; notwithstanding, construction tasks are different at different settings, therefore equipment and machinery may be special for a particular task. For effectivity of a task delivery, equipment and machinery vary with tasks. Equipment and Machinery are part of the major PDP flows. This is asserted by Koskela in his seven flows and recent PDP software have made provision for this, although focusing on resources. This draws to the influence of technology in planning and delivery. This equipment and machinery requires workers to operate it as well as workers to execute the task. Therefore, there is the importance to draw the balance between equipment and machinery, and workers. The next section discusses 'worker' as a flow.

11.4.1.9 Workers

In IDEF0 model, workers are categorised under 'mechanism', which also includes the equipment and machinery discussed in the previous section. As discussed in the research process stage one (literature review), workers are an important part of a construction project in the delivery of tasks. Construction project is human driven, thus workers are a major flow to a construction task. Although human resource should be in balance with the equipment and machinery required, it is not surprising that the current PDP software allows for the incorporation of workers (as resources). Inappropriate allowance for workers in PDP has resulted in many disagreements on site. As discussed in chapter 9, a subcontractor prices an activity without indicating the number of resources, thus they turn up on site to realise the resources on site cannot do that particular activity. The subcontractor then requests additional money for additional labour, whilst the main contractor disagrees. This disagreement could be alleviated by reorganising the workers not only to execute the task but as a flow to the task. This brings up the issue of the experience, competence and knowledge of the workers as well. The next section discusses this type of flow.

11.4.1.10 Experience, Knowledge and Competence

Experience, knowledge and competence are a major flow for construction task that is scarcely discussed in the literature. This type of flow is described as a soft flow by Agyekum-Mensah *et al.* (2012). This is one of the publications of the author. These are referred to as a soft flow because it is not physically seen or expressed. This study establishes practitioners' stance on importance of experience, knowledge and competence to construction projects. This means for a task to be executed effectively, efficiently, economically and ethically (4Es), the individuals are required to have experience, knowledge, and competence. It must be acknowledged that the TPC concept does not explicitly manage this flow; however, it highlights it for further checks and control. This is done through the planning review process, but the next section is interested in task review process.

11.4.1.11 Task Review Process

Arguably, practitioners will maintain that the tasks review process is done on site as part of the control process. This recognises the importance of a task review process in project planning and control techniques, as well as being one of the important flows. However, the conventional techniques and their corresponding software only show the progress of the task at the time of review. The review process should indicate the progress as well as comments on the progress. This is because a particular task is a connecting work for another so if task is behind schedule or ahead of schedule the agreed reasons behind that should be known. This root cause type of analysis helps effective evaluation of the tasks and the project in general, which reduces disputes (while disputes cost the industry lots of money as discussed earlier).

In the TPC concept, a comparator is introduced which reviews the progress of the work as well as the quality of the delivery. The review is indicated with the 'traffic light system' where 'red' means the task is not satisfactory and requires 'redo'; amber means there is a modification required and green denotes it is satisfactory at the time of inspection i.e. pass (see figure 11.7). This is novel to the conventional PDP techniques. The review process draws up one major flow, duration which is presented in the next section.

11.4.1.12 Task Duration

Obviously, task duration is a major requirement for PDP which is acknowledged in the literature as well as the conventional techniques. However, this study extends the knowledge of task duration in construction.

As discussed in previous chapters, task duration is either mathematically calculated as effort driven or calculated based on the experience of the individual. The latter, although seen as subjective, its validity depends on the experience, competence and knowledge of the individuals involved in the PDP. But the former has been discussed as solely insufficient for construction tasks (refer to mainly chapters 3 and 9).

Besides the normal task duration, which has a start date and a finish date, a construction task has both the planned and the actual duration (See figure 11.7). This means the addition of the planned start date (PS) and the planned task duration (PD) results in the planned finish date (PF). This mathematically denotes PS + PD = PF. However, tasks do not start as planned which is evident in the case studies. Therefore, there is the need to introduce the actuals, which is AS + AD = AF (A denote 'Actual' see figure 1.7 for details). The actual will be known at the control stage of project (when executing the task). This is a novel approach to control project, which improves learning and reduces dispute as well as promoting collaboration to ensure the project is delivered with the 4Es.

In addition, connecting duration, input duration and output duration are identified from the case studies as a requirement to task duration. The connecting duration are for the activities that feed into (input) the particular task normally found at the start of a deliverable. A perfect example is the preliminary activities before site commencement such as site offices.

The input duration was established as the lead time for the components and materials. This facilitates procurement and logistic planning. There is a perfect example in CS-01 where the contractor assumed that the specified pavement material to match existing ones was to be purchased straight from on top of the shelf. They later realized that it takes over a week to procure. Although the task duration was right but the input duration was not considered.

To cap the task duration is the output duration, which is for non-quantified activities after the actual task. For example, curing, scaffolding erecting and dismantling time, and painting drying time. When walls are painted it requires drying time, which is normally not considered in task duration. Similarly, erecting of scaffolding for subsequent work and curing time for concrete, block work and some finishes are examples. Therefore, task duration is comprehensive to make the PDP realistic as possible which is the essence of PDP.

11.4.1.13 Deliverable Task Code

Similar to the conventional WBS code, which connects the secondary tasks to a particular primary task, so it is with TPC concept? In figure 11.7 the deliverable task code is denoted with 'CT'. This deliverable could be decomposed into detailed tasks similar to the conventional WBS but TPC adopts IDEF0 model approach, which includes relationship in the secondary and tertiary tasks. The codes are connected to primary deliverables. The next section presents discussion of TPC as a system for PDP. This is essential due to the fact that it is founded on slightly different theoretical assumptions and approaches, which are different although with some overlaps.

11.5 INTRODUCTION OF THE TPC SYSTEM

This section focuses on the discussion of the TPC system. The main parts of the system, which differ from the conventional techniques, are discussed.

11.5.1 Theoretical Assumptions

TPC is founded on a bespoke TFV theory, which is a combination of both scientific management and complexity theory as discussed in chapter 5 of this thesis. This theoretical assumption ensures that both task management (scientific management) and flow management (complexity theory) are achieved to the required value. The value is the sustainable value discussed later in this chapter. The conventional techniques are predominantly based on scientific management theory which is limited in terms of 'flow management' and to some extent the value management (since value is seen as the meeting client requirements).

In order terms, the TPC system appreciates the contribution of both technology and social perspectives in construction, although with opposing stances. Figure 11.8 illustrates that the TPC system keeps both scientific management and complexity theory in perfect balance. As TPC is primarily 'practice informing theory', it is thus a holistic representation of the industrial requirements.

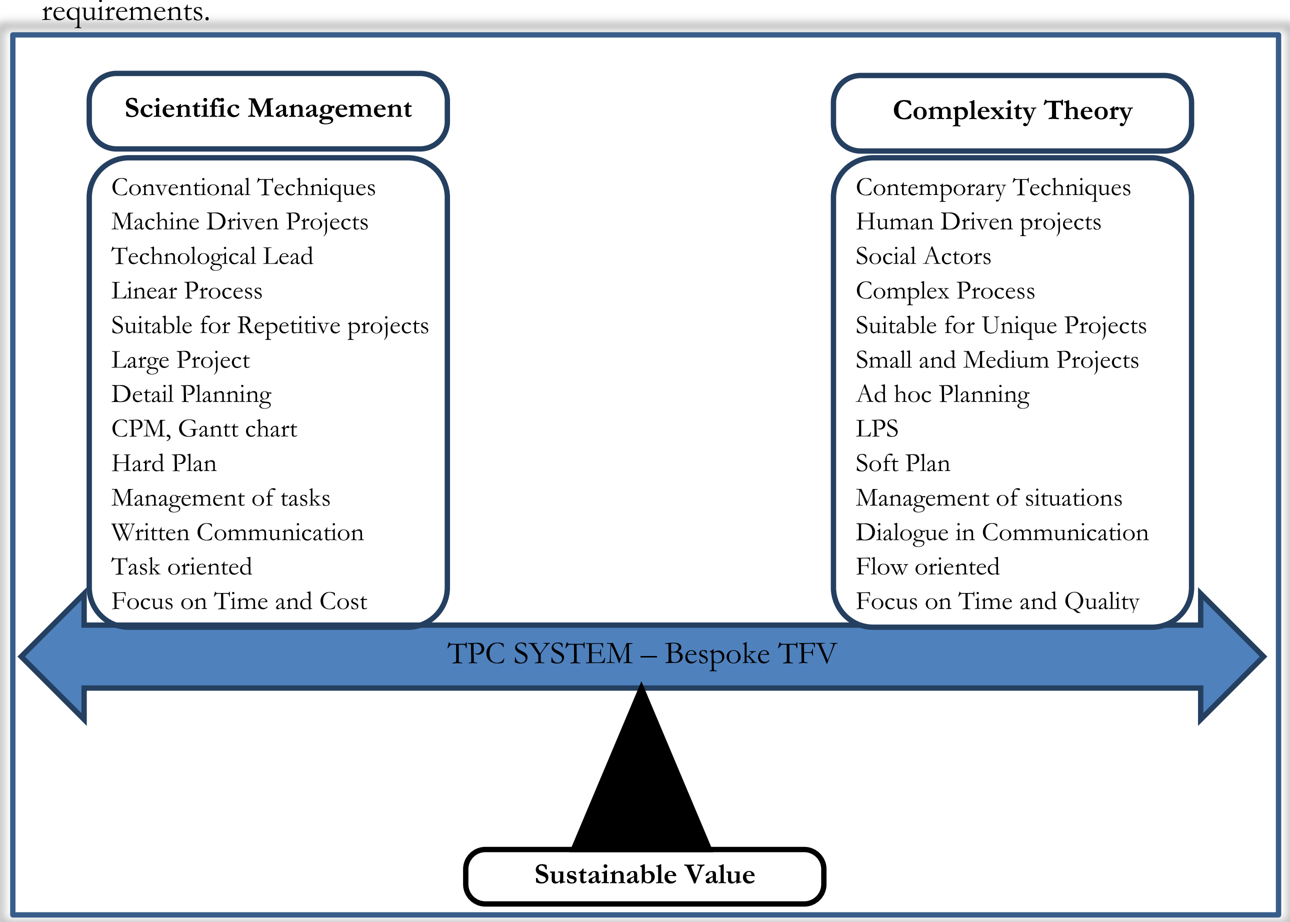

Figure 11. 8: Representation of the TPC System with comparison of conventional and contemporary techniques

Figure 11.8 presents the comparison of scientific management and complexity theory in relation to the TPC system. This suggests both the conventional and the so-called contemporary techniques are at the extreme end of construction management. This is not to disapprove their contribution to a particular type of project, but they are limited in addressing the real world construction management, thus creating a gap in the 'real world' of construction. This is a combination of both theories and their respective processes. Therefore, the TPC system bridges this gap and addresses the applied PDP problems.

As discussed throughout this study, especially in chapters 2, 8 and 10, both theories focus on TCQ as the management model. In addition, TCQ is also used as performance indicators although the literature has established the setbacks of using this TCQ model. In response to these limitations, this study introduces 4Es management model as discussed in the earlier chapters. The next section discusses the 4Es model and the concept of TPC.

11.5.2 4Es Management model in TPC concept

The limitation of using TCQ cannot be over emphasised as they are discussed in chapters 2 and 10 of this thesis. This has arguably led to the introduction of 4Es. This section is concerned with presenting 4Es as the management model for TPC System which supplants the traditional TCQ model. Figure 11.9 shows how 4Es could be achieved using TPC concept (using the ICOM representation).

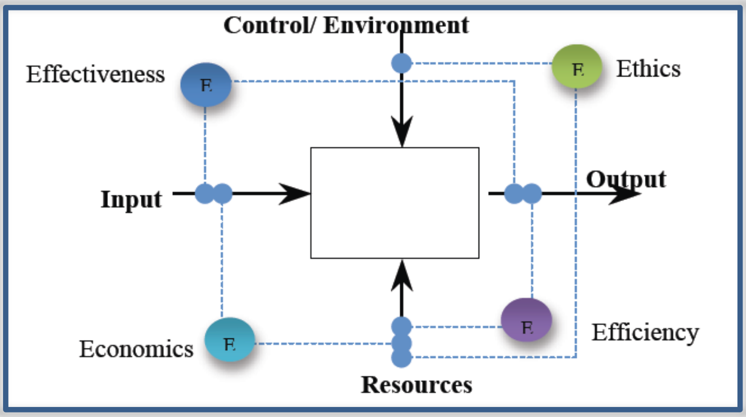

Figure 11. 9: Adopting 4Es in TPC Concept (source: Agyekum-Mensah *et al.* 2013)

Figure 11.9 illustrates that the ratio of output to input gives the effectiveness of the process; similarly, the ratio of output and resources determines the efficiency. Economics is assessed by the ratio of input and resources, while ethics focuses on control and resources usage. As discussed earlier in this chapter, adopting 4Es not only results in achieving TCQ, and effective resource and environmental management, it also ensures that the management process is sustainable. Therefore, the next section discusses the sustainability of TPC.

11.5.3 4Es and 4 Poles of sustainability

TPC system methodology ensures sustainability is achieved through the entire project process. Chapter 6 presents the review of sustainability in the construction industry. Sustainability has become a very important subject in the construction industry in recent decades due to the higher CO_2 emission and the social responsibility facing the industry.

'Triple bottom line', which is economic, social and environmental factors, is the assessing *de facto* of sustainability in many industries, if not all, and the construction industry is not exempted. However, this model has been criticised, as it allows trade-offs between economic, social and environmental dimensions of sustainability. Adams (2006) stressed that this conventional model of the understanding of sustainable development is flawed because of these trades-offs. Similar to the sustainable model, TCQ is flawed because it also allows trade-offs between time, cost and quality as discussed earlier.

This trade-off between the sustainable dimensions draws the argument of technology in the sustainability concept. In the UK, where this study is being conducted, the Government has ruled out the retrofitting[52] as a regulation in the Green Deal (RICS 2011). However, technology cannot be overruled in the concept of sustainability.

In today's world, which is usually referred to as the 'technological world', technology plays a major role in achieving sustainability. Therefore, the main dimensions of understanding sustainability are economic, social, environment and technology. These four dimensions of sustainability are termed '4poles of sustainability'. Technology, which is one of the keys to a project's delivery, is under control from the project management perspective because critical evaluation and assessment ensures that appropriate technologies are employed at the right time and place. This argument links up the 4poles to the 4Es model, meaning sustainability can be achieved when the 4 Poles are project managed 4Es.

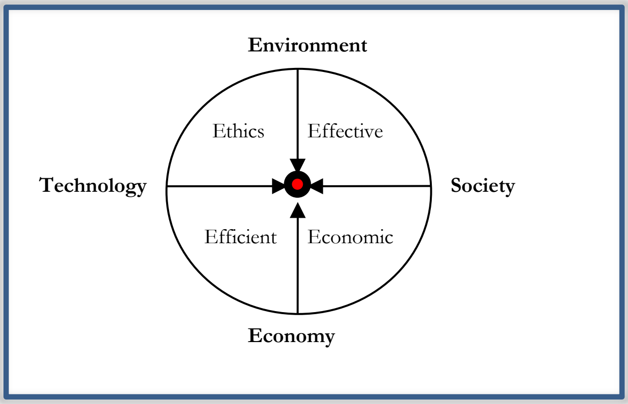

Figure 11. 10: 4Es and 4Poles Model of sustainability **(***Source: Agyekum-Mensah et al. 2012***)**

The 4 Poles of achieving sustainability are shown in figure 11.10 above and represent: Environment (north); Economic (south), Technology (west) and Society (east). These poles have assessing or managing quadrants, comprising: Effectiveness (north east), Economic (south east), Efficiency (south west) and Ethics (north west).

[52] Retrofitting is where new technology or features are added to older systems to improve efficiency, increase output and reduce carbon emissions. In the built environment, this will help in improving the energy efficiency of existing buildings including factories, universities and domestic properties.

The uniqueness of this model is the combination of project management (4Es) with the poles of sustainability (4 Poles) to achieve sustainable development as compared to the existing models. It is also an integrated and holistic approach to achieve sustainable development. Drawing from the above review, arguments and analysis, this study suggests that *sustainable development is the meeting point of social, technological, environmental and economic factors to maintain the present and the future.*

Achieving sustainability using 4Es and 4Poles is achieving sustainable 'value' in the TPC system. Value is where the small black and red circle (see figure 11.10) is achieved where all parameters are considered effective rather than focusing solely on the 'triple bottom line' without any management concept.

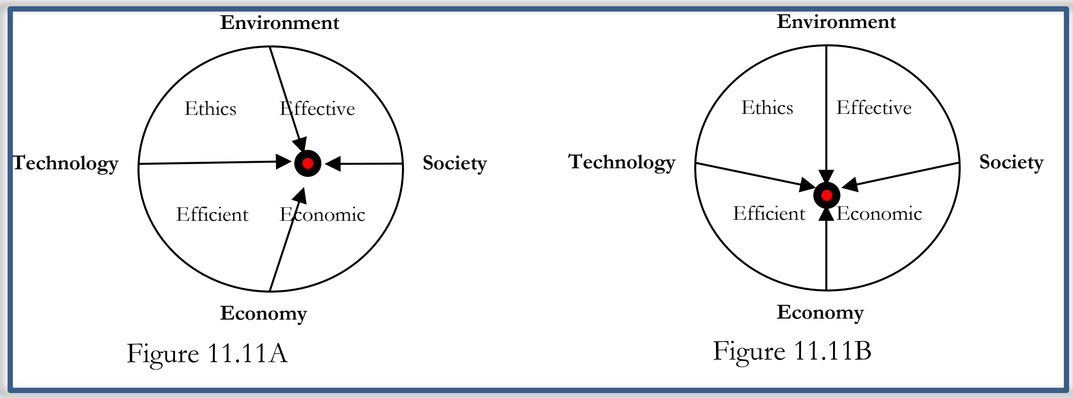

Figure 11. 11: Illustration of the principles of 4Poles

Figure 11.11 is a simple illustration of how the 4Es and 4Poles work in reality. Figure 11.11A demonstrates that where technology is dominant in a project, this reduces the need for social (human) input. On the flip side, if a project is labour intensive, this implies less technology is used. In project management terms, the former is where conventional techniques are utilised and the latter is for socially driven techniques such as LPS. The concept of sustainability is to maintain human beings and their environment; but not at the expense of the other poles (economy and technology). In figure 11.11B, the focus is on the environmental pole, thus affecting the economy. This means that when the focus shifts more towards the environmental pole, the economy may suffer implying that society cannot be maintained and vice versa. Figure 10.11 illustrates that in sustainability concept all the 4 poles must be managed using the 4Es.

Technology is identified as one of the main 4poles of sustainability, thus the TPC system adopts the use of technology. The TPC system will be considered as software which is beyond the scope of this research, and thus marked for further studies. However, it will maintain its collaborativeness (social edge) in planning and control. This next section presents the flows of the TPC system.

11.5.4 Representation of the flows

The TPC system's representation of flow are different as they are categorised using the ICOM mode. Therefore, the arrow on the left of the task node is the input flow (components and materials); on the bottom of the task node are the resources flow (workers, and equipment and machinery); the top arrow is the control flows and the arrow on the right side of the task node is the output flow. This ensures the all flows are placed in appropriate sections, which allows common understanding and communication.

Although the TPC concept adopts IDEF0 as the modelling technique, the arrows from the output denote the sequence of the task which is contrary to the arrows in IDEF0 model. The representation of the sequences is presented in appendix 9. Furthermore, contrary to the limitation of IDEF0 concept to represent parallel activities, TPC introduces the 'dummy flow' (which is represented by hiding lines) and task durations. This ensures all activities can be represented appropriately and the system is intuitive and dynamic rather than static as in IDEF0 model.

It is essential to note that the TPC is different from the accepted IDEF0 model both in function and representation. However, it is acknowledged that IDEF0's ICOM is still instrumental in the development of TPC. (See appendix 9 for more example of TPC implementation).

11.5.5 Deliverable Breakdown Structure (DBS)

A construction project is established to be 'reality produced out of imagination' in this thesis. This arguably means in PDP terms that the projects become really clearer as the project get closer to the delivery stage and more information become available for detail planning. Again, it has been established in chapter 3 and 9 that many of the construction projects are executed by subcontractor as opposing the task oriented breakdowns (WBS). Therefore, in the TPC System, the breaking down of the project is deliverable oriented as compared to the conventional task oriented, thus connecting both first and last plans which has been a debate in literature. The DBS allows the project to be broken down (decomposed) further if necessary which incorporates subcontractors PDP, thus ensuring the initial PDP is realistic as possible. (See appendix 8 for the illustration of the DBS concept).

11.5.6 Collaborative Planning

As the conventional PDP techniques are undertaken by individuals, the TPC system is contrary. Although the TPC could be undertaken by individuals, most projects with other subcontractors require information from them. Therefore, the TPC system promotes collaborative planning and collaborative project information flow. This improves trust and communication for effective delivery of the project. A TPC system requires a planning meeting at the conceptual stage of the project and equally requires collaborative control at the execution stage of the project. Therefore, the next section discusses the collaborative control of the TPC system.

11.5.7 Collaborative Control

In most cases in the real world construction project, the PDP is further developed at the execution stage of the project. Therefore, the TPC system allows for this development through the use of DBS decompositions. This ensures collaborative control and integration of the team. Again, the collaborative control is important for review of the task and control updates of the TPC system. This is an extension to the conventional techniques of just drawing the line on the PDP just to represent progress. It must be acknowledged that collaborative control is adopted in LPS, which is arguably one of its strengths.

11.5.7 Common Understanding - Experience, Knowledge & Competence

As stressed by practitioners, the TPC system requires the lead to have competency in methodology. Although, it is claimed to be simple to understand, knowledge in PDP and project delivery with the required experience depending on the size of the project and its complexity is equally important. The TPC system bridges the knowledge gap between the first plan and the last plan as well as the planners and the site managers (including subcontractors), thus providing common understanding for all parties.

11.5.8 The Comparator – Review process

The TPC system introduces a novel review process, the comparator, which connects the outflow and the input flow represented with a red line. The comparator adopts the traffic light system as discussed earlier in this chapter. This is updated after collaborative control meeting as discussed above. One notable benefit about the ‘review process’ is that it runs through the entire modelling or project, thus generating reports at the end of the project for lesson learnt, evaluation and performance assessment. The comparator also provides a better digital data storage for the project for future work as well as lessons learnt.

11.5.9 Related Functions

The TPC system is a foundation of related functions such as schedule, cost management, health and safety management, quality management, logistic planning, and resources procurement. Again, the TPC system is intended to integrate the project team such as designers, cost managers, project managers, planners, subcontractors, clients, consultants and of course the contractors. The next section focuses on the implementation of TPC

11.5.10 Information Required Tab

The TPC system integrated into the concept an information required tab based on the recommendation of the expert evaluation group. The purpose of this tab is to notify the parties of the information required for the task. This ensures that the designers as well as other information are highlighted. Similarly, it also adapt the traffic light system for easy identification and common understanding (the next section discusses the reason behind this).

11.6 IMPLEMENTATION OF TPC IN THE CASE STUDIES

The initial developed TPC system was introduced and implemented by the researcher in the case study projects to identify the practicability in its implementation and to get practical feedback for improvement where possible. The implementation was led by the researcher who used computer drawing aids and other computer techniques to present the concept and its implementation (mainly using Auto CAD and hyperlinks). The TPC was introduced to the case studies top managers for their comments and acceptance before its implementation in a particular part of the project. The implementation was on any agreed portion of the project except CS-01 where it was through the project. This is due to time limitations on the study, and the lack of software for TPC makes the modelling very hard and tedious, and the fact that the purpose was to pilot the TPC concept in different project settings to ensure practicality and feedback for improvement. Figure 11.12 presents the implementation methodology.

The first stage of using the TPC system in a practical situation is to identify the project and PM constraints using the ‘star wheel constraint’ as a guide. This is followed by a simultaneous process of determining how the project and PM constraints identified earlier could be managed and managing sustainability through the PM process. This is by using the 4Es managing model, and the 4Es and 4Poles sustainability model respectively. This then leads to the actual project planning brainstorming or collaborative meeting, where the project is breakdown into deliverables using the TPC DBS. Using the TPC information sheet and information from the collaborative meeting, deliverables, flows and durations estimates are conducted. One of the unique part of the process is after the initial TPC plan, there is a collaborative review meeting (although it depends on the size of the project) to assess its suitability; if there is acceptance or not. Figure 11.12 illustrates the methodology further.

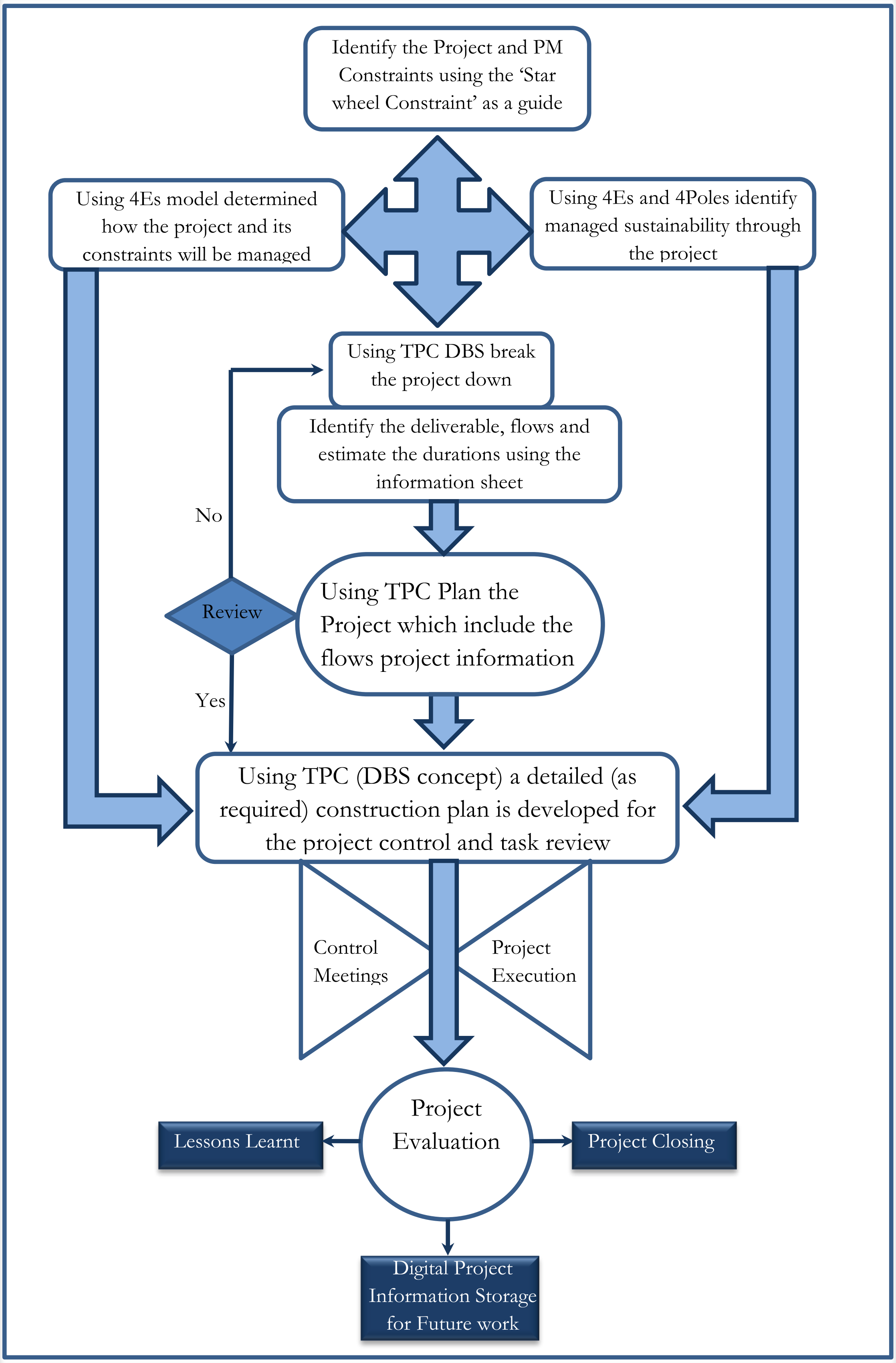

Figure 11. 12: The Implementation Methodology of the TPC system

The TPC system was first implemented in CS-01 from design to handing over of the project, which showed many positive potentials for the industry (See appendix 9 for a sample). It was then implemented in CS-02, which was a more complex project as compared to CS-01. Therefore, the detailed implementation was in the agreed portion as discussed above. However, the 'level one' deliverables were modelled to allow the detailed comparison of the TPC system with their adopted technique (the conventional techniques of course). The comparison indicates the effectivity of the TPC system over the conventional techniques as will be discussed later in this chapter. A detailed modelling was conducted with the subcontractors on deliverables such as demolition, steel work, concrete slabs and external walls. Implementing it in CS-02 resulted in some modification for improvement and clarity in the modelling process. This is discussed later in this chapter under evaluation of TPC system.

Similarly, it was introduced and implemented in CS-03 and CS-04. In CS-03, a repeated project was modelled as well as a one-off engineering project. After successful implementation of the TPC system in CS-03, the researcher was requested to model as many as twenty-five projects that are being executed by the company. This is basically mixed production management. But the researcher turned down the offer to do so, due to the constraints available to the study as discussed. This is one of the further studies suggested for this research so that the TPC system could be adopted in other industries apart from the construction and engineering industry. After successful implementation, the TPC System was evaluated and the next section presents discussion on its evaluation.

11.7 EVALUATION OF THE TPC SYSTEM

An evaluation group, people with expertise, from each case study was established, which mainly included senior managers and external senior academics with interest in the study. The primary task for this group was to offer feedback on the TPC systems for necessary improvement. Positive feedback was received and they commended the study. They gave some practical recommendations for improvement, which were incorporated into the final TPC system. The evaluation was conducted using focus interviews and checklist administered questions. The implementation was successful and the attitudes of the experts were positive and the TPC system was greatly appreciated; however, there were some reservations which are recommended for future work as they were beyond the scope of this thesis.

11.7.1 Check list Questions

In total, seven experts' responses were received from the senior managers of the case studies organisation after the implementation and a senior academic with interest. All these are professional and academically qualified with many years of experience in the industry as project managers. In addition, these people supervise over forty thousand people all together, thus their feedback could be arguably a representative sample. Therefore, their feedback was important for the improvement of the TPC System.

The experts were requested to complete the check lists by ranking, which is 1 to 5, where 1 is the least and 5 is the highest. The lowest ranking given is 3 which denotes 'good'. This is a positive sign due to the constraints associated with the implementation. Typically, respondents recommended the TPC System to be very good by all standards. Awarding 5 out of 5 means the concept is perfect; yet, these respondents gave the TPC system excellent for being holistic, suitable for planning, promoting collaborativeness, being systematic and for its uniqueness. Another interesting aspect of the feedback is about its simplicity as it does not require a lot of training. Figure 11.12 presents the analysis of the feedback.

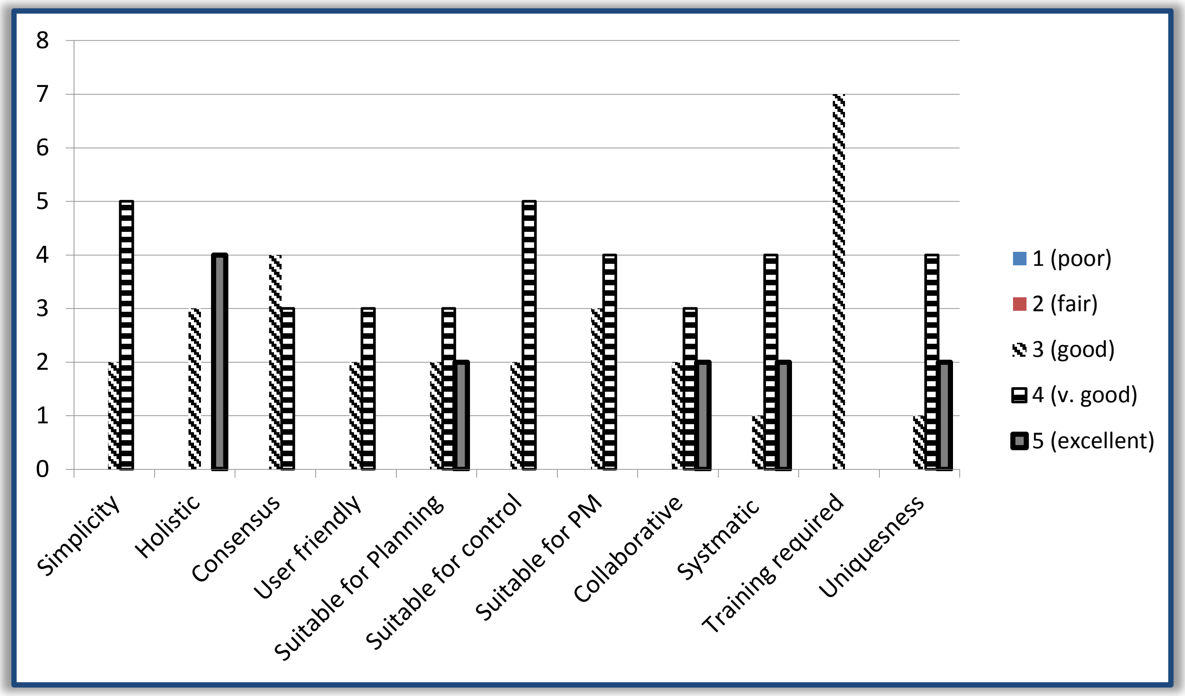

Figure 11. 13: Representation of Expert Evaluation Group for the TPC System

Notwithstanding the positive feedback, respondents gave comments such as *"although simple to understand, training is needed for those who need to operate"*. This respondent also thinks it is simple because *"it is similar to network diagram"*. This view is shared by the construction director of CS-01 who asserts that *"it is taken from best practice but unique"*. The academic respondent claims *"it can change the industry if people put effort in"*. This respondent further asserts that *"this approach requires honesty, trust and commitment from all parties"*; this is because *"information is required early"*.

This information requirement was stressed by the senior project manager of CS-02. This respondent advises that *"keep the system simple and easy to use"*. These constructive feedbacks have been incorporated into the TPC system and further studies for its development as software to keep it simple and easy to use.

11.7.2 Expert Group

The TPC System was introduced to a focus group within each case who are mainly the senior managers. Participants gave positive feedbacks and greatly recommended the TPC system to be successful in the industry. However, constructive suggestions were made which led to improvements. For example, in CS-01, participants suggest that TPC system is "useful for reducing disputes and for final account and closing of the project".

In CS-02, a participant questioned how one would know if the task is critical. This led to the introduction of normal 'red and blue' colours to denote critical and non-critical tasks respectively. On another development the contracts manager made a practical suggestion. This respondent claims that:

"The internal desk, I allocated 4 weeks to complete it, upon the approval and detail description received from the client. It has been noted that the lead-time for the desk is 3 weeks and it will take another 3 weeks to fix".

This participant asserts that using the TPC system may reduce design information problems with the inclusion of the 'specific control flows' and introduction of input duration. The senior project manager also stressed this view by stating:

"Like CM is saying, the control side is also important and useful. You see the programme item 8, there was no drawings and details specification during the programming stage so I put 4 weeks for duration only to realize just last week that it is a complex work which might take not less than 6 weeks and 2 to 3 weeks to place the order. I think QS also under price it. I think if we were using this then the architect, engineer or client would have provided us with some sort of information".

These practitioners highly recommend the TPC system to address or reduce other related information flow problems associated with PDP. In spite of this good commendation, the academic participant sounded a statement of caution. This respondent argues, *"the information gathering bit is my problem that will be time consuming. How do you get the information for such task? There should be contingency duration in planning…".*

All the information can be collected using the project information data and from the collaboration meetings. This is one of the differences of using the TPC system as it requires collaborative input for larger projects, whilst, the conventional PDP is prepared by individuals (planner). The TPC system may be led by individuals but requires information from other parties to be input them into the system. This is to make the PDP as realistic as possible. This is what the lead planner suggests: *"…planning should be 90% proactive and 10% reactive"*. This discussion led to the introduction of 'information required' tab which adopts the traffic light system as shown in TPC concept (see figure 11.7). In addition, TPC was commended for other inherent benefits, for example, one senior participant argues that:

"It is very good especially when it comes to the subcontractors bit. They just price the BoQ without checking the "control" of the task. Then they turn up on site and they say give me more money because I didn't include for this and that; but with your system the subcontractor is required to give proposed resources for a particular task. Another interesting thing about your system is the actual dates that you have incorporated and the comparator, which will help to settle dispute and claims. I think it is good for managing the works".

This participant from a main contractor's perceptive suggests TPC is also very good in terms of planning for subcontractors. However, the subcontractor's perspective seems different, as they believe it is good for managing main contractors. The director of a subcontracting company, CS-01, asserts that:

"George as far as subcontractors' are concerned, I can say that we come to site generally prematurely. The preceding work may not be finish and we may not have a clue when to come but we normally follow our programme date to arrive on site prematurely, which cost us money. We may start late; however, we are still held to by our programme that is why you can see that our programme is behind schedule. This boils down to the start date of maybe a single task or late site commencement. This stuff [TPC] will be good for us in this aspect especially to know when a task actually started".

From a subcontractor's perspective, the TPC system is good in mitigating problems with start dates and other related problems arising from late starts and delays. A subcontractor respondent from CS-02 further stressed that subcontractors are not involved in the initial planning and less information is given during tendering. This respondent claims:

"Let me tell you, we don't fix the duration, they [main contractor] do. They want it at certain time and certain cost. To be honest with you we price a job and we don't know some of the details, the ones you call 'controls' so we come to site with few bodies trying to achieve the time at that cost. For example, the work on the 6th floor we have been waiting for another contractor for 3 days now but at the end of the day they will tell us that we are behind programme".

This participant further concluded that the TPC system is very useful for both main contractors and subcontractors'; however, he advises that the researcher ensures that it is made simpler through software. Therefore, this respondent stated:

"…very useful tool I think but my only suggestion is that it should be made simple in terms of time used to prepare so that subcontractors will benefit. I think it is very good, on a scale of zero to five I will give you 4 till you turn it to software which will be easier to use. I propose it should be software that will make it easier and relatively cheaper. As for the main contractors I think they really really need it to plan and manage the entire project".

The above analysis indicates that practitioners have high commendation for the TPC system and it arguably will be easily adopted into the industry. In addition to this high commendation from practitioners, the researcher introduced the TPC system again to Professor Glenn Ballard, the developer of LPS.

11.7.3 Evaluation of TPC with Professor Glenn Ballard

Professor Glenn Ballard has been partly involved in this research as the TPC system reviewer and evaluator. The researcher had the opportunity to meet with him in 2012 but this particular interview was conducted on the 14th May 2013. His advice and criticism to this research is deeply appreciated. Professor Glenn Ballard is the developer of LPS as discussed in chapter three of this thesis and also a co-founder of 'lean construction'. Ballard is a renowned scholar in construction management and LPS is arguably one of the main methodologies in Lean construction. Unsurprisingly, LPS and lean construction are used interchangeably. LPS is the one of the contemporary techniques that adopts other theories apart from the conventional scientific management. Although it was not explicitly acknowledged in his thesis, LPS is the only technique that adopts interpretivism as its epistemology, thus using social actors to understand 'real world' problems of project control. LPS is arguably a critic of the conventional techniques, although LPS is still dependent on these conventional techniques for the planning (master and look ahead planning).

In this same limitation, the TPC system has been developed and is arguably second to LPS to adopt social constructivism and interpretivitsim as the ontology and epistemology for the study. There are arguably other similarities such as promotion of collaborative control. Therefore, discussing the TPC system with Ballard was a major challenge but interesting for the improvement of the TPC system. One may argue that the LPS is a competing technique to the TPC system. In as much as this could be a fact, the researcher slightly disagrees as LPS is mainly a control system as confirmed by Ballard, whilst, TPC is a planning and control system. In addition, theoretically, the TPC system adopts both task management and flow management together with sustainable value, whilst LPS focuses on social flow and value through the production process as discussed in previous chapters. Ballard generally gave commendation of the TPC system; however, he gave constructive advice as well as cautions. He commends the visual presentation of the TPC system. Ballard asserts that TPC is an 'inter-tool', which confirms its purpose of being an innovative and holistic system; however, he cautioned on its actual validation. He stated *"you are doing a type of constructive research and producing a product that is inter-tool and intended to be useful in the world so actual validation may be the challenge"* In respect of his caution of validation, the researcher showed him samples of the implementation of the TPC system in the case studies. Ballard appreciated the practicality of the system. Nevertheless, he gave another caution by stating:

"At the first levels is a reminder of the deliverables, then you capture them into more detail, it could be really heavy, for example, if there is a supplier here, he supply the raw materials here, he turns component to sub system, right, it is a practical example".

The researcher replied that "…yes, I agree with you, the level of details depends on the user or the team just like the traditional WBS. I think they should know where to stop and I don't think in construction one will go down to the raw materials level". Ballard finally claims that the TPC system is a novel planning system. He therefore asserts that:

"…George, it looks to me like it is a different approach in planning, right, you are trying to capture addition information in the plan. What you are arguing is, what you are proposing for planning is, plans with different information not easily or achievable in primavera [conventional techniques]"

Despite Ballard admitting that it is a novel system, he believes it is a more of a planning system rather than being a control technique. He argues that:

"I sense it is not talking so much on the control section as the planning, right. In practice I think it is a planning tool, right. I think in control it is going to be a management tool that will work behind the seen and it may be very successful".

Ballard described TPC as more of planning system than control, whilst LPS is mainly described as a control system; therefore, there is a possibility for these two techniques to complement each other. In this respect, Ballard asserts that:

"One of the needs in the LPS is using it as a pull plan. Yes, you can use it for pull planning [in the LPS] but I think the challenge is to provide people with information without overwhelming them with details. I mean it is challenge not just your challenge… But I think it can be used together with last planner".

After further discussion on the collaborative use of TPC and LPS, there was a suggestion of collaboration between the two systems. Ballard argues that:

"I can see you want to use the LPS approach to develop the initial planning and the milestone, as you approach each phase or milestone then you expose it which will be collaborative planning with the people how are going to do the work".

After a positive commendation from Professor Glen Ballard on the TPC system, he made recommendation for further research on the practical collaboration between the two systems. He recommended that: *"see whether you can use it as a support tool for schedule analysis for pull plan [pull plan is a representation of logic network]…"*

It is therefore concluded in this chapter that the TPC system has the potential of improving project planning and control in 'real world' construction industry and it is empirically grounded; however, a further detailed implementation may be required as further studies.

11.8 CONCLUSIONS

The chapter presented the cross analysis and discussion on the three main analysis chapters (i.e. chapters 8, 9 and 10). The general success factors, problems and possible improvements associated with project management, especially project planning and control, were presented as well as the CPMMP. This cross analysis and discussion established the problems associated with project planning are common across organisations. A total of 88 interviews were conducted for this study, which include 40 in research stage 2, (chapter 8), 33 in the case studies (stage 4, chapter 9) and 15 from research stage 4 (chapter 10). These respondents are from different organisations and practices, which encompass senior academics and practitioners, mostly senior management, involved in project management and project planning (main contractors, subcontractors, consultants, clients, developers, and engineering companies). Therefore, the empirical themes established could be argued to be a representation of the main industrial problems and requirements for planning. For example, in all the research stages it was evident the Gantt chart is the dominant technique for PDP, which opposes the CPM suggested in literature, although they are closely related. It is further confirmed with the literature that managing project based on TCQ is insufficient; hence the 4Es management model was introduced.

The 4Es model has its roots in the economics theory of value for money, which extended to 4Es to manage complex projects such as construction. The earlier research paper by the researcher (Agyekum-Mensah *et al.* 2012) suggests '4Es is everyday reality'. This 4Es ensures that the TCQ and other parameters are achieved without any trade-offs. For example, 'time is just one of the measures of one's effectiveness', thus being on schedule does not necessarily mean managing time but effectiveness. The 4Es model is a performance model incorporated in the TPC system (see figure 11.9). The 4Es is also the main management factor for achieving sustainability in construction.

To develop a system such as the TPC, it is prudent to ensure sustainability is achieved; therefore, this study introduces the 4Es and 4Poles sustainability model. This model ensures sustainability is achieved in using the TPC system. Sustainability concepts in literature are based on the triple bottom line (economic, social and environment). These underlying factors have been flawed because they allow trade-offs. The contribution of technology has been ignored in the sustainability discussion except in this study. Scholars have described sustainability to 'mean nothing', arguably due to the lack of management factors. Therefore, the study introduces the 4Es and 4Poles model to make sustainability achievable as part of the TPC system. (This is also presented in Agyekum-Mensah *et al.* 2012b).

The main focus of the chapter is the development of TPC concept and system, which is based on the empirical analysis presented in chapters 8 to 10, corresponding with the present state of knowledge in chapters 2 to 6. This is graphically presented in figure 11.6. Twelve task requirements were established empirically, which is an extension to the seven flows proposed by Koskela (2000). Besides the flow concept, which is relatively new in planning, TPC introduces the complete task duration method, which includes connecting task duration, input duration, the planned duration and output duration. The conventional techniques only capture the planned duration, thus this is a development to the existing understanding of task duration. All these other durations mentioned are empirically substantiated through the research process stages discussed previously. Normally, in practice, duration is for only the planned task but the commencement dates for the task may be different from the plan; therefore, TPC introduces the complete planned and actual task duration. This is also new to the conventional techniques.

Furthermore, the TPC concept introduces the 'comparator', which is a review process to the task. The comparator adopts the traffic light system, which informs the team of the state of the task after assessment. Similarly, the task information management tracker is also introduced to indicate the information received and required. This also uses the traffic light system to manage the design and stakeholder information requirement for the task and the project in general. This led to the discussion on the TPC system's main parts that differ from the conventional systems. The notable differences discussed include theoretical underpinning, the 4Es Management model, 4Es and 4Poles model of sustainability, the representation of flows, using delivery breakdown system (DBS), promoting collaborative planning and control, and introduction of the review process (comparator and information requirements indicator). The TPC system is therefore suggested to be novel, holistic and sustainable planning and control system; however, its practicality was also explored and presented in this chapter.

The implementation of the TPC system in the case studies was successful, as discussed. This was followed with an expert evaluation group who were required to give feedback on the TPC system. Both practitioners and academics involved in the evaluation gave positive feedback with commendation for TPC system. It is acknowledged that participants gave a few suggestions and cautions, which led to the improvement of TPC system, and recommendation for future work. Therefore, the next section is the concluding chapter of this thesis and presents the summary and review of the objectives as well as recommended further studies.

CHAPTER TWELVE: CONCLUSIONS

12.1 INTRODUCTION

Chapter twelve concludes this thesis and it presents the summary of this entire research project which highlights the research findings as well as the significance of the study. In addition, the research recommendations for industry and academia, and future work are presented. Project planning is established to be an essential part of project management, yet the planning and control techniques available to general practitioners are insufficient in managing real world construction projects. In addition, project planning should set a foundation for related functions; however, the techniques available to practitioners only concentrate on schedule. Therefore, project planning and scheduling are used interchangeably, although schedule is just one part of project planning. In response, this study develops an innovative and holistic planning and control technique to deliver sustainable projects.

12.2 RESEARCH SUMMARY

The research aim is stated fully in the next section; however, it is worth mentioning briefly in this section as it presents the overview of the study. The aim of this study originated from the claim in literature of the insufficient and unrealistic project planning and control techniques available to the general practitioner, which was empirically demonstrated in this study. Therefore, this research develops an innovative and holistic project planning and control, the TPC system, which is recommended to supplant the conventional techniques to make project planning as realistic as possible and to deliver sustainable projects. Figure 12.1 presents the overall summary of the thesis structure which includes a brief description of the chapters.

To review, discuss and analyse the data to achieve the aim and specific objectives, the researcher adopted a five model thesis structure, which encompasses twelve chapters. These chapters correspond with the research objectives as well as the research process, which are clearly identified in chapter seven (the methodology chapter). This section summarised the work done in the chapters of the thesis. Chapter one, the introduction chapter, introduces the study and presents the overview of this thesis. This chapter presented the context and the rationale of the study which included the background of the problems examined.

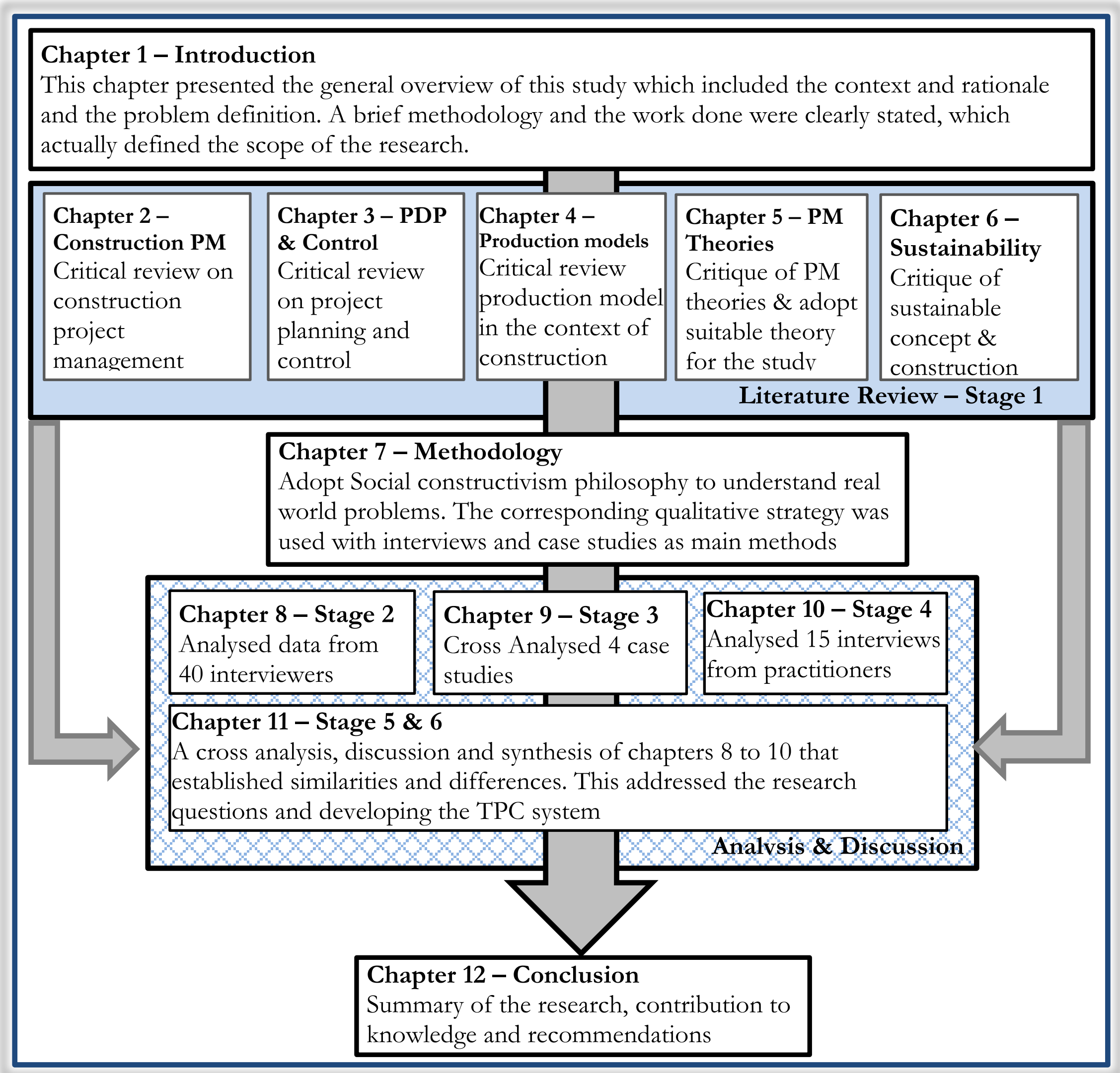

Figure 12. 1: Summary of the Overall Thesis Structure and Brief Description

12.2.1 Literature Review – Research Process Stage 1

Chapters two to six (which is also the research process stage one as well as addressing research objective one) present a critical review of the literature which identifies knowledge gaps as well as the present state of knowledge in the field of construction project management. Figure 12.1 above presents the summary of all the chapters and the knowledge gaps are detailed in each chapter.

12.2.2 Chapter Seven – Methodology

The epistemological and ontological orientation of this research is appropriately situated within interpretivism and constructionism respectively. This is opposing the dominant positivism and objectivism epistemology and ontology respectively.

The very essence of this study is to develop a conceptual understanding of construction project management, and develop an innovative and holistic planning and control technique to improve the current practice. Thus, it is to "understand human behaviour" rather than "explaining human behaviour". In this respect, constructivism is deemed appropriate for this research, hence, its corresponding strategy, the qualitative approach is adopted. This research utilised interviews and multi-case studies as the main research methods for the data collection techniques. However, for the purposes of research logic and to achieve the aim and the objectives of this study, this research used six separate, yet, interrelated and overlapping research process stages, where the first stage was based on the existing knowledge (literature review), and the remaining five are the contribution to knowledge through empirical data collection and analysis. Figure 12.1 illustrates the relationship of the chapters with the research process stages. The following are brief descriptions of the stages.

In research stage two, forty participants were interviewed including fifteen experienced practitioners, fifteen senior academics and ten university students. The third stage involved four case studies where twenty-six practitioners were interviewed as well as utilising documentary evidence and observations. Additionally, the research stage four interviewed fifteen senior practitioners from different sections in construction, which includes the stake holders in the London Olympics 2012 project. Therefore, there were in total, 81 interviews (circa 5,000 minutes). The data collected was qualitatively analysed using mainly content analysis but more specifically a bespoke grounded theory. It is bespoke because a literature review was conducted before the data collection and analysis. The analysis became the foundation of developing the TPC system and its implementation. The developed TPC system was implemented and an expert group from the case studies including academics with interest were commissioned for review of the newly developed TPC system. The feedback was positive and they had support for the TPC system to supplant the conventional techniques. Notwithstanding, some critical suggestions were made which are recommended for further studies.

12.2.3 Analysis and Discussion – Research Process 2, 3 and 4

The analysis and discussion section encompasses three separate chapters, eight, nine and ten, which are research process two, three and four respectively.

12.2.3.1 Chapter Eight – Research process 2

This chapter presented the analysis and discussion of research process stage two. This chapter directly relates to chapter two and it addressed research objective two. The main focus of this chapter was the understanding and conceptualisation of construction PM; this included the construction project and PM constraints. Thus the analysis was concluded by defining a construction project as "*reality out of imagination within an explicit period and boundaries for both specific and social benefits"*. This could be broadly defined as "*concepts transformed through execution to purpose use within explicit period and boundaries"*

The analysis established an extension to the conventional project constraints of time, cost and quality (TCQ) which is dominant in literature by identifying Complexity and Risk as the additional construction project constraints (see figure 8.2). The analysis was concluded with a differentiation between construction project constraints and construction PM constraints, where construction PM constraints were represented with a star (which is the five project constraints) connected with communication (see figure 8.5). A construction project and its management (PM) were conceptualised, where the emphasis was placed on the concept, delivery and Construction Project Management Managerial Process (CPMMP). This led to the introduction of a definition for construction PM as the *overarching procedure of attaining reality out of imagination within an explicit period and boundaries for both specific and social benefits.*

Finally, as this study adapts the IDEF0 model as a suitable modelling technique for this research, it was important to investigate the awareness of it in the UK construction industry. The analysis established that IDEF0 is little known and seldom used in the UK construction industry (the reasons for this are presented in detail in chapter 8); however, it is deemed to have the potential to be explored in the UK construction industry.

12.2.3.2 Chapter Nine – Research Process Stage 3

This chapter was core to the research, which is research stage three, and addressed research objectives three and four. In addition, it addressed the research question of the investigation of the industrial problems associated with project management, and planning and control; and identified the requirements and task flow for delivery planning and control respectively. This stage utilised the multiple case studies approach and used interviews, documentary evidence and observations. The analysis presented a cross discussion between the cases establishing their similarities as well as the differences. Therefore, the first section presented the commentary and analysis of project planning as practiced, drawing from the documentary evidence and observations, whereas the industrial problems associated with construction PM and project planning were explored using interviews (both unstructured and semi-structured). In a complete understanding of the problems, the success factors as well as possible improvements were investigated (the researcher suggests that in qualitative research, cross examination is key to the validation of the data). The analysis was concluded with the presentation of the task flow and requirements of planning and control which set the foundation for the development of the TPC system.

12.2.3.3 Chapter Ten – Research Process Stage 4

This chapter complements chapter nine to fully address research objective three. In total, fifteen interviews were conducted with senior practitioners involved in prominent projects in the UK which included the London 2012 Olympics project. In the research process stage three (analysed in chapter 9), the participants were mainly from the case studies (main contractors' perspective), this stage explored practitioners views from most of the stakeholders and organisational frameworks such as developers, contractors, consultants and clients.

The chapter was concerned with practitioners' views on success factors, problems and improvements for construction PM and project planning and control. The conclusion for the success factors for construction projects was consistent with Hubbard's (1990) study which established that the success of project is hinged on its management (PM). The analysis established eleven factors in successful PM and the highest ranked were effective communication, project planning and experience and competence. One of the most intriguing factors discussed under this section was the importance of the evaluation process which complements and validates the CPMMP discussed in chapter eight. This evaluation process was incorporated into the development of the TPC system.

12.2.3.4 Chapter Eleven – Research Process Stage 5 and 6

This chapter addressed research stages five and six. Stage five, which is the first section, presented the development of the novel and holistic Project Delivery Planning (PDP), which is called Total Planning and Control (TPC) System, whilst stage six focused on the implementation of the TPC system and its evaluation.

The developing the TPC system and its theory was informed through practice, which is arguably contrary to the tradition of 'theory informs practice' (discussed later in this chapter). Therefore, the development of the TPC system was a combination of the first four research stages. This chapter presented a cross analysis and discussion of the previous three analysis chapters (eight, nine and ten), identifying their similarities as well as their differences. This is in keeping with the research questions which were formulated from the research aim and objectives; thus this chapter fully addresses the research questions. Therefore, this section presents a summary of how the questions were addressed.

Q1 - What are the industrial problems and challenges associated with project planning and control, and what are the essential drivers and flows required for successful task completion?

This research endeavoured to address practical problems to enhance the current planning and control techniques in construction. In so doing, the concept of construction project management was addressed. Paul Wells once said, "there is no practice without theory and no theory without practice" (Wells 2007, p. 9). This emphasises that the theory and new techniques complement each other. Therefore, chapter eight (research process stage 2) addressed the understanding of a construction project and the conceptualisation of construction PM; therefore, establishing a new CPMMP, construction project constraints and PM constraints as discussed earlier in this chapter and chapter eight.
The core of the research question, Q1, was discussed in chapters nine and ten (research stage three and four respectively). The empirical data collected for research stage three (chapter nine) were case studies focused, whilst that of the research stage four (chapter ten) were from general practitioners. Therefore, the empirical themes established from both stages is argued to be a representation of the main industrial successes, problems and improvements associated with construction PM and planning and control. For example, in all the research stages, there was evidence the Gantt chart is the dominant technique for PDP, which opposes the CPM suggested in the literature, although they are closely related.

Adopting a cross examination approach in qualitative research, three main groups were considered, i.e. success factors, problems and improvements. Most of the attributes identified in both chapters were matching; however, there were a few different themes identified. The cross analysis and discussion amalgamated some of the attributes to form clusters of themes. For example, twenty nine attributes were identified for success factors in construction projects but formed four clusters of themes, which still reveals that construction project success is hinged on PM. The intriguing development was the respondents, from research stage four, suggesting that managing the newly developed construction PM constraints was key to the success of the project. The success factors to construction PM were grouped into the Hard PM process and Soft PM process, but surprisingly, the success factors for project planning identified in both chapters were perfectly matching. The problems associated with construction PM saw sixteen themes identified, which include inadequate planning, lack of review and information flow. An interesting factor identified is 'inadequate techniques' which suggest that practitioners do agree that the techniques available to them are insufficient. This was highly echoed in the area of improvement as project planning was ranked highest. Twelve main problems were identified with the conventional project planning system which became the basis of addressing research question Q2.

Q2 - How can the project planning and control problems identified in Q1 be addressed in an innovative system to enhance the current practice?

This research question is mainly connected with research objective six. Before the development of the novel TPC system, the insufficiency of managing projects based on TCQ was addressed by introducing the 4Es (Economic, Efficiency, Effectiveness and Ethics) management model. This model has its origins in economics literature as value for money achieved through managing of Economic, Efficiency and Effectiveness factors. These factors became the main themes for the analysis. However, the limitation with this VfM concept is, it addresses the delivery of a product or project but does not factor in the involvement of people and the environment. This perhaps justifies its slow adoption into the construction industry. To meet these concerns, this study introduces the fourth 'E', which is the 'Ethics'. Ethics govern people's behaviour and control their environmental impact. Therefore, from the analysis, the VfM concept is extended to 4Es to manage complex projects such as construction. The earlier research paper by the researcher (Agyekum-Mensah *et al.* 2012) suggests '4Es is everyday reality'.

These 4Es ensure that the TCQ and other parameters are achieved without any trade-offs. In essence, 'time is just one of the measures of one's effectiveness', thus being on schedule does not necessarily mean managing time but being effective. The 4Es model is also presented as the performance model incorporated in the TPC system. In addition, the sustainability of the developed TPC system led to the introduction of another model, the 4Es and 4Poles model of sustainability (This has been published in a journal by the researcher, Agyekum-Mensah *et al.* 2012). The underlying factors of sustainability (social, economic and environmental) have been flawed because it allows trade-offs. Again, scholars have described sustainability to 'mean nothing'. Arguably, this is due to lack of management factors and the contribution of technology has been ignored in the sustainability discussion except for this study. Therefore, this study introduced 4Es (which is a management model) and 4Poles (which are factors of sustainability including technology).

This essential focus of the chapter was the development of the TPC system which is presented in figure 11.6. The twelve task requirements, which were empirically established, was an extension to the assertion of Koskela's seven flows. Besides the flow concept, which is relatively new in planning, TPC introduces the complete task duration method, which includes connecting task duration, input duration, the planned duration and output duration. The conventional techniques only capture the planned duration, thus this is a development to the existing understanding of task duration. All these other mentioned durations are empirically substantiated through the research process stages discussed previously. Normally, in practice, duration is for only the planned task but the commencement dates for the task may be different from the plan; therefore, TPC introduces the complete planned and actual task duration. This is also new to the conventional techniques.

Furthermore, the TPC concept introduces the 'comparator', which is a review process of the task. The comparator adopts the traffic light system, which informs the team of the state of the task after assessment. Similarly, an information management system is also introduced to indicate the information received and required. This also uses the traffic light system to manage the design and stakeholder information requirements for the task and the project in general. This led to the discussion on the TPC system's main parts that differ from the conventional systems. The notable differences discussed include: theoretical underpinning, the 4Es Management model, 4Es and 4Poles model of sustainability, the representation of flows, using delivery breakdown system (DBS), promoting collaborative planning and control, and introduction of the review process (comparator and information requirements indicator). The TPC system is therefore suggested to be an innovative, holistic and sustainable planning and control system; however its practicality was also explored and presented in this chapter.

Evaluation of the TPC system

To evaluate the practicability of the TPC system, it was implemented in the case studies which were successful. An expert evaluation group, which includes the senior project managers and some academics with interest in the study, was formed. The group was mainly to give feedback on the TPC system and their feedback was very commending. Beside the evaluation group, a critique interview was conducted with Professor Glenn Ballard (the developer of LPS), whose comments were positive and encouraging.

This ensures that the aim, research objectives and the research questions are fully achieved with positive commendations. Later in this chapter, the evaluation of the aim and object is also presented.

12.3 EVALUATION OF THE RESEARCH AIM AND OBJECTIVES

The aim of this research is to explore the industrial problems associated with project planning and control, and to develop a holistic planning and control system (Total Planning and Control system) through the incorporation of production models to deliver sustainable projects. This aim is achieved by conducting rigorous qualitative research which utilised clear philosophical and methodological assumption, and vigorous research processes that sufficiently addressed the specific objectives. All the findings were gathered together to develop a holistic and novel planning and control system, Total Planning and Control system. There were six specific objectives for this research.

1. *Critically review the literature on the concept of project management, planning and control, and production modelling techniques as it applies to the construction industry. In addition, review the concept and understanding of achieving sustainable construction in a project management context.*

This objective is addressed by research process stage one, the literature review, which is presented in the thesis chapters two to six. The review presented separate chapters for clarity of argument and for the logic in reading so that the important elements in the sections are distinguished. Chapter two reviewed construction PM as this is where the study is situated. Chapter three focused on Project planning and control which is the core of the study. Chapter four was concerned with the production and modelling techniques so that a suitable modelling technique was adopted for the development of the TPC system. Chapter five critiqued the PM theories in the context of construction, whilst chapter six presented the state of knowledge on sustainability as an important part of the TPC system.

2. *Empirically investigate the understanding and definition of a construction project and other projects in order to conceptualise the construction project management managerial process.*

This objective is achieved through a qualitative research strategy, research process stage two and the analysis is presented in chapter eight. In total, forty semi-structured interviews were conducted with senior academics and practitioners associated with construction PM or project planning. The analysis of the empirical data was conducted using content analysis, specifically a bespoke grounded theory. The result established a clear difference between construction projects and other projects which led to the introduction of definitions for a construction project as well as construction PM. The study also revealed a conceptualisation of construction PM and a construction project is suggested to be complex production.

3. *Empirical investigation of industrial problems associated with project management, and planning and control.*

This third objective is achieved through qualitative research stages three and four, which utilised multiple case studies and interviews respectively. The results and analysis is presented in chapters nine and ten accordingly. The two chapters were cross analysed and discussed in chapter eleven to establish the general themes for success factors and problems associated with PM and project planning. The results discovered a distinction between project success and PM success as well as project problems and PM problems. From both research stages, combined problems associated with PM and planning were achieved. This led to the achievement of the requirements and flows for project planning.

4. *Identify the requirements; factors and task flow for project planning and control.*

This objective was realised through research process stage three, utilising the multiple case studies approach. Qualitative data collection techniques were used which included interviews (both unstructured and semi-structured), documentary review and observations. The findings set the basis for the development of the TPC system

5. *Adapt the methodologies identified to suit the construction process and from the first four objectives develop an innovative holistic project planning and control system called the Total Planning and Control (TPC) system.*

This main objective is achieved through its corresponding research process stage five, which is presented in chapter eleven of the thesis. Through the literature review, research stage one, IDEF0 was considered a suitable modelling technique to be adapted for the study and a bespoke PM theory was also utilised. From this, together with the research stages two to four, the holistic planning and control system TPC was developed. The TPC system was set as the basis for related functions such as cost, scheduling, logistic planning, resources planning and procurement. It is a collaborative planning and control system and uses 4Es as the management model. It helps to obtain knowledge on complex systems, such as construction. It practicality was explored by implementing it in the case studies.

6. *Implement and evaluate the TPC system through the Case study projects.*

Finally, this objective is accomplished through research process stage six, where the TPC system was implemented in the case study project. The implementation was successful and an evaluation group was setup to offer a critical evaluation of the TPC system. The feedback was collected both in tick box questions and qualitatively. Both results were positive and practitioners suggest TPC supplants the conventional techniques. The model is adaptive to any project type or size, according to the case studies selected.

The evaluation of the research aim and objectives indicate that the research has satisfactorily achieved its aim and objective with positive commendations from both academics and practitioners. Figure 12.2 presents the general layout of how the aim and objectives were achieved through the study. The figure illustrates the relationship between the aim, objectives, the research process (methodology) and the thesis chapters.

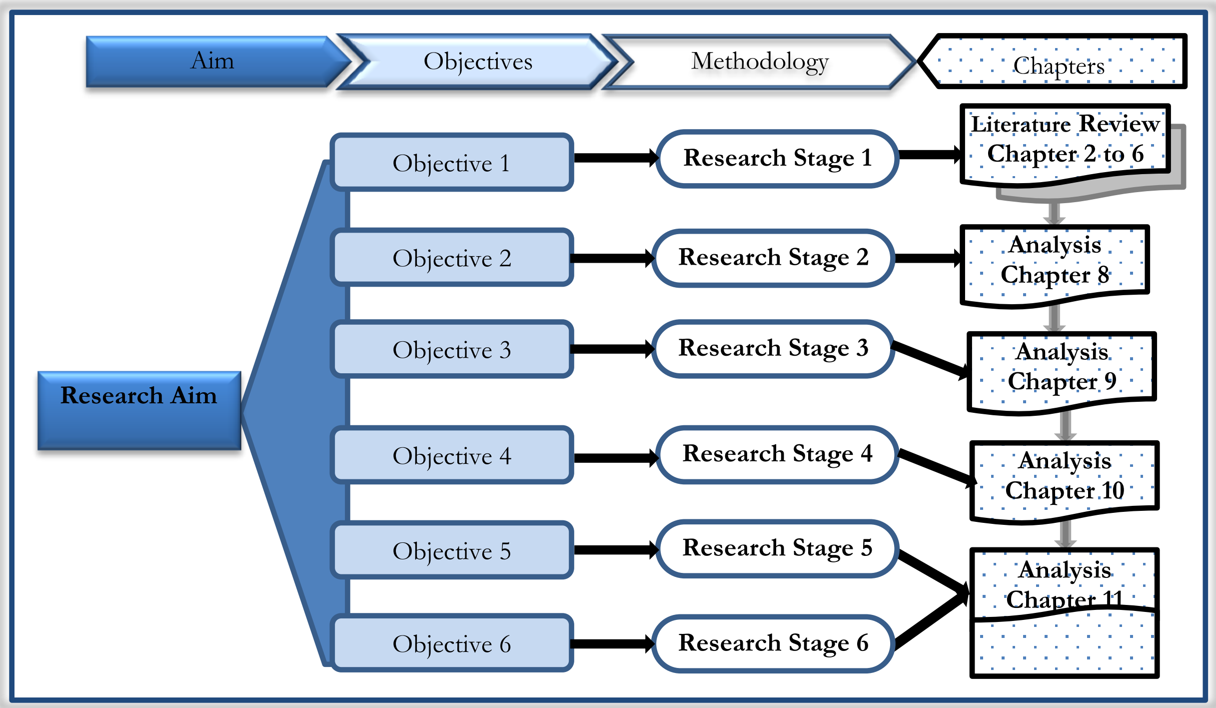

Figure 12. 2: The Layout of meeting the Research Aim and Objectives

12.4 FINDINGS AND CONTRIBUTION TO KNOWLEDGE

The section is the summary of the main findings and original contribution to knowledge for the study. The main findings are concerned with the empirical data and its analysis which are presented in chapters eight to eleven.

12.4.1 Summary of Research Findings

The research was focused on developing a holistic and novel planning and control system to enhance current practice. Therefore, this research investigation has identified and established the following findings that would be valuable lessons that can be used and other researchers and practitioners could conduct further research. These main findings were presented in the analysis chapters eight to eleven that are established in relation with the literature review. The research presented a new understanding and definition for a construction project and a concept for construction project management. The study revealed the industrial problems associated with construction project management, and project planning and control. It also discussed the expert improvements in these areas. The success factors of construction projects, project management, and planning and control were established from the practitioners' stand point. Furthermore, the study discussed project planning and control as practised in the construction industry. This led to the establishment of task flows and requirements for project planning and control.

12.4.1.1 Project Management

- It was clear from the interviews that some of the numerous problems within the construction industry in general and project management in particular are due to a lack of common understanding and representation of ideas. There were different views on what is a construction project, since it has not been clearly defined or discussed within the existing literature. Some of the interviewees argue that construction is all about buildings and the likes of dams, bridges, roads; and railways fall under civil engineering. However, others disagree with this stance as they deemed all the examples mentioned are under construction as well as buildings. Construction which literally means, "to build" notwithstanding, other types of construction involve "de-construction" such as refurbishment, rehabilitation, conversion and demolition.

- Diverse understandings and definitions exist for a construction project, although the interviewees differentiated construction projects from other projects. Themes identified for construction projects were different to the themes in literature about projects, including, physical change, build, unique, complex, vision, ideas, realisation, plan, people and civil life. This led to the concept of "reality out of imagination" and a new definition of a construction project and PM.

- Prior literature claims that both project constraints and client aims revolve around Time, Cost and Quality (TCQ). Although literature have criticised the insufficiency of the TCQ because of its trade-off between Time, Cost and Quality, there has been no effective alternative approach, thus it remains the cornerstone problem. This study therefore introduces new project and PM constraints which is an extension to the TCQ. In addition, it develops a new management model, 4Es. (Published in Agyekum-Mensah, 2012 and Agyekum-Mensah *et al.,* 2011).

- In the analysis of research stage two, respondents considered project management as mainly planning and in research stage three, planning considered to be schedule (this is not peculiar as it is consistent with the literature). This, therefore, implies that project management is limited to 'scheduling'. In as much as scheduling is an important part of PM, this assumption is misleading.

- As the success factors in successful construction projects, PM and project planning and control were identified in the study, where project planning was dominant in all.

12.4.1.2 Planning and Control

- The main tools and techniques for project planning or management within the UK construction industry are Gantt chart and PM Software. This was established throughout the data collection methods. The dominant software is Microsoft Project in research stage two, whilst the research stage three (multiple case studies) it was Asta project. A few of the software also mentioned in research stage two include Primavera, Asta Power project and Project Commander.
- There is a lack of understanding of techniques used in software. Most of the interviewees in research stage two, which included academics and university students, referred to software as technique and vice versa. There is lack of understanding of the main techniques such as Bar chart, CPM, flow diagram and histograms which are adopted in software such as Microsoft project. This problem should be addressed by educational institutions through modules on project planning.
- Project Planning is established to be a major driver in both a construction project and its management as the study reveals that it is a success factor both in projects and PM. However, insufficient time is allowed for project planning and it is done by individuals with less experience, competence and knowledge of the construction process. The so-called Planners are people who are competent in particular planning software rather than in construction, thus failing to identify the critical task within the limited time.
- It is established that for most of the subcontractors, project planning is unwritten. It is down to the supervisors to memorise day to day tasks. It was argued that this is due to their lack of involvement in project planning.
- It was obvious through the study that practitioners admit to the insufficiency of the current techniques available to them together with the other main problems discussed in the study. There is an urgent call from both practitioners and academics for suitable project planning techniques for construction projects.

- The study identified the main success factors in project planning and control as well as their associated problems. It was established that the success of a construction project is hinged on PM; likewise, the success of PM is hinged on planning. The intriguing success factor identified was 'knowledge management' that includes experience, knowledge and competence. Practitioners stressed this factor; however, it is scarce in construction management literature.
- The causes of delay and tasks being behind schedule were qualitatively investigated opposing the traditional quantitative strategy which makes use of recycling themes in the literature. Obviously, planning was the chief culprit, but there were also themes that were identified as an extension to the themes in literature. For example, health and safety was established as one of the main causes of delays to construction projects which is not covered in literature. Similarly, common understanding, experience, competence and knowledge and review process are also not properly covered.
- This research established twelve task flows or requirements for planning which were the basis of developing the TPC system.

12.4.1.3 Construction as production and the IDEF0 model

- The study confirms that although construction is a form of production, it is a 'complex production'. The literature categorises projects as 'project production'; however, practitioners believe it is not just a project production but complex.

- It is established that IDEF0 has the potential to be adopted into the UK construction industry as in other countries; yet, this research established that IDEF0 is little known and used in the UK construction industry. The reasons could be one or more of the following:

    1. Lack of Knowledge
    2. Limited exploration
    3. Software distraction

12.4.1.4 Sustainable construction

- The sustainability concept is dependent on the triple bottom line (economic, social and environment). However, the factors have been flawed as it allows trade-offs. Sustainable construction debates have overlooked the contribution of project management; however, this research suggests it is intrinsic in achieving sustainable construction. This led to the introduction of technology as part of the factors in the 4Poles of sustainability. (Published in Agyekum-Mensah *et al.* 2012)

12.4.2 Original Contribution to Knowledge

The Oxford dictionary defines 'originality' as the "ability to think independently and creatively". In this stance, the author classifies this study as original since he conducted this study independently and creatively. However, in terms of doctoral research, Hart (1998), and Phillips and Puge (1994, 2010) have discussed the definition of originality in research. Hart (1998) identifies six definitions of originality. These include: without copy or imitation; not been done; new in style, character, substance or form; authentic, the result of thought, and produced using your (researcher's) own faculties. Similarly, NTU (2012) establishes that a PhD degree is awarded to a researcher who has critically investigated and evaluated an approved topic resulting in an independent and original contribution to knowledge and has demonstrated an understanding of research methods appropriate to the chosen field. This is consistent with Silverman (2005) claims that originality is only one of four criteria upon which PhD research is examined. Silverman (2005 p. 68), citing of the University of London PhD criteria, argues that the examination of originality of PhD research is based on (1) the research is genuinely conducted by the researcher (2) the thesis is satisfactory as regards literary presentation, (3) that the thesis is suitable for publication…as submitted or in abridged or modified form, (4) that the thesis forms a distinct contribution to knowledge of the subject, and affords evidence of originality by discovery of new facts and/or the exercise of independent critical power. Silverman's emphasis was on the latter being the main criterion for originality of PhD research.

Conversely, Phillips and Pugh (1994, 2010) established nine definitions for originality and contribution to knowledge. They claim that originality is not restricted to rocket science but also the researcher's understanding of the subject area and how research is being conducted in that field of study. Phillips and Pugh (1994, 2010) stated that originality "does not mean an enormous breakthrough which has the subject rocking on it foundation" but doing empirically based study that has not been done before; using already known ideas, practice or approaches but with a new interpretation; creating a new synthesis that has not been done before; applying a technique usually associated with one area to another; and adding to knowledge in a way that has not been done previously.

The contribution of this research originates from the limitations of current planning techniques, and the need to provide a deeper understanding of construction project management as well as to develop a holistic project planning and control to enhance the current practice. This led to the development of a holistic and innovative planning and management system, Total Planning and Control, for construction projects.

12.4.2.1 Primary Contribution

This study primarily contributes to construction project management knowledge by qualitatively exploring the actual operational problems in the construction industry and extending the innovation from lean constructionists and production models to develop an innovative total planning and control system that is advancing forward to make project planning and control more applicable in reality.

This primary original contribution to knowledge is itemised in the following sections.

12.4.2.2 Methodological Contribution

- This research adopts social constructivism to understand and develop project planning and control system, which opposes the conventional approach of the scientific method. Thus contributing the construction management knowledge that the social constructivism ontology could be adopted for planning and control research. Again, this research contributes by emphasising the importance of cross examination and soft protocol in qualitative research data collection. It should be acknowledged that the only technique which implicitly adopts this social constructivism in developing planning and control technique is the work of Glenn Ballard's LPS[53].

12.4.2.3 Theoretical contribution

- This research contributes to the limited literature on a construction project management concept and its managerial process. It develops the concept of "reality out of imagination" and concludes by establishing the three main Project Management Managerial Processes as, Planning, Control and Evaluation as opposed to the existing literature.
- It develops a new conceptual project management model 4Es (Economic, Effective, Efficient and Ethics) and this opposes the existing TCQ concept (published in Agyekum-Mensah, 2012 and Agyekum-Mensah *et al.*, 2012a).
- It contributes by developing the project management model and sustainability model (4Es and 4poles model for sustainability) to close the sustainable construction gap and will enhance projects delivery (published in Agyekum-Mensah *et al.* 2012b).

[53] Detail of LPS is presented in chapter 2 and partly in chapters 5 and 7

12.4.2.4 The Total Planning and Control (TPC) System

- The research develops a holistic and innovative planning and control technique, the TPC system. This technique is based on the industrial requirements and task flow for construction tasks. It is also based on the industrial experts' experiences in the construction industry. The TPC system is developed based on the complexity of construction projects and a bespoke TFV theory, therefore, appreciating the complex relationships among tasks and team.
- This study contributes empirically to the understanding of workflow in construction. In total, twelve flows were identified. TPC covers eleven out of the twelve flows identified, which is an extension to Koskela's assertion of seven flows. The flows were categorised into two main types, that is, the task flow and the soft flow. The TPC system encompasses the value creation within each task by the introduction of the comparator, the task duration formula (all the required durations to complete a construction task successfully), the information required gauge, flow management and common understanding of the task.
- The study develops the methodology for implementing the TPC system. This includes: the introduction of Deliverable Breakdown Structure (DBS), Flow management and the principles for calculating or determining task duration for realistic project completion, and in addition, the use of 4Es as the performance indicators or assessment.
- The practicability of the TPC system was explored through its various implementations in the case studies project. The results and feedback promise significant benefits for project planning and control, process improvement, and managing of task flow, therefore, reducing time, cost, improving communication and promoting collaborative working. It is also evident in one of the case studies that it reduces disputes.

12.4.2.5 Industrial success factors and problems relating to project planning and control

- This research contributes by establishing the industrial problems and challenges of project management, planning and control with experts' review on the required improvements. Furthermore, the success factors for construction projects, PM, planning and control have been established from the practitioners' perspective.

- In addition, it contributes to the better understanding of project constraints (where project constraints are complexity, risks, time, cost and quality) and project management constraints.
- The research contributes to the causes of delays in the UK construction industry which has not been explored in this century. Again, it utilised a qualitative strategy which ensured new themes were explored, rather than the conventional quantitative method.

12.4.2.6 Publications and Academic activities

- During the period of this research, a total of nine academic papers have been published, comprising three journals and six conferences (see academic publication below). Three journal papers are being developed. The researcher has also been involved in conferences and journal reviews.
- Three other Journal papers have been developed from this thesis (not yet published).

12.5 RESEARCH RECOMMENDATIONS

The increased awareness of the insufficiencies in the conventional planning techniques necessitated this research aim to develop a holistic and innovative planning and control system, the TPC, to improve the current practice. Although this research is applied research, it is grounded in theoretical assumptions as well as empirical expositions. The research adopted a qualitative research strategy and the constructivism philosophy, which utilised cross examination data collection techniques. Therefore, in concluding this study, other possible further studies are suggested. In this respect, the recommendations of this study are twofold, that is, recommendations for the industry and academia, and for future work.

12.5.1 Recommendations for the Industry and Academia

Evidently, this research aimed to improve the current planning and control system and to deliver sustainable projects by developing the TPC system. The study resulted in many important outputs; some of these are enhancing practice, enhancing performance and understanding of the subject area.

12.5.1.1 Adopting the Total Planning and Control (TPC) Concept

Adopting the TPC system will enhance planning and control, and project management as well as improving performance and overcoming the following:

- limitations of planning and management of construction projects

- communication barriers
- lack of collaboration due to inter-disciplinary and iterative nature of construction
- lack of common understanding and workflow problems
- limitations of evaluation (thus promoting learning and improving skills)
- Set as foundation for related functions, such as, cost, logistics, risks, procurement and early warning planning
- Unrealistic programmes
- Limitations of digital data management

The TPC system was developed based on industrial practice, thus it is flexible to all types of project which ensures both client and contractor satisfaction. The TPC system includes a methodology such as Delivery Break Structure (DBS)

12.5.1.2 Applying the TPC system

The construction and engineering industry is encouraged to apply the TPC system so as to ensure maximum output of effective and sustainable project delivery. The TPC system is developed to overcome the limitations of the conventional techniques and ensure that projects are effectively, efficiently, economically and ethically (4Es) delivered. The 4Es managing model ensures that the project is delivered on time, cost, and quality, whilst resources and environment are ethically and efficiently managed. This model does not allow trade-offs. Again the application of the TPC system ensures sustainability is considered throughout the project through the 4Es and 4Poles model of sustainability. Furthermore, the TPC system adopts the collaborative planning and control approach which ensures all parties are considered. This serves as a motivation and gives the subcontractors a 'spirit of belonging and ownership' of the project. Although the DBS in the TPC system is similar to the conventional WBS, the focus of the breakdown is on the deliverables, rather than the task, as in the real world, the projects are executed by subcontractors. The evaluation process introduced in TPC is essential for lessons learnt and improvements in future projects. The TPC system is an innovative tool and is recommended to be used in the construction industry for realistic planning and effective management of projects.

12.5.1.3 Planning and Control in Academia

It has been evident throughout this study that project planning and control is essential in construction project as well as project management. It is also evident that the conventional techniques are insufficient in managing construction projects. These findings are in keeping with the literature; however, it is difficult to comprehend that even senior academics and university students involved in project management could not suggest other techniques apart from Gantt chart and other software. It is established that project planning is given little attention in educational institutions; thus, there is lack of understanding and appreciation of planning techniques other than software. It is therefore encouraged that planning and control modules should be essential in construction project management courses. Equally, substantial training and continuous professional training should be provided to practitioners to enhance their knowledge in contemporary planning and control systems such as the TPC system. Any useful tool such as the TPC system could make a positive contribution only when people are exposed to them to be used.

12.5.2 Recommendations for Future Work

This research identified some areas which are worth recommending for future work.

12.5.2.1 Application of TPC in other projects rather than construction

The main purpose of this research was to develop a holistic and an innovative planning and control, the TPC system, for construction projects. This system was implemented in the context of construction projects only; however, this system could be deployed in other industries other than construction. Therefore, it worth researching the application of the TPC system in other project related industries.

12.5.2.2 Developing Software for the TPC system

The implementation of TPC was led by the researcher using AutoCAD and hyperlinks. All the planning was done from scratch which made it difficult and time consuming to model a process. It is therefore recommended to develop software for the TPC System to facilitate its application.

12.5.2.3 Collaboration with other closely related techniques

The development of the TPC system and its implementation, although successful, did not explore the collaboration with other techniques such as the Last Planner System (LPS). When the researcher met with Professor Ballard, the developer of LPS, for the evaluation of the TPC system, he suggested that TPC is more a planning technique, whilst LPS is a control technique; therefore he recommended further research on their collaboration, which is laudable. Again with growing awareness and use of Building Information Modelling in construction, collaboration is recommended.

12.5.2.4 Exploring the TPC system for programme or portfolio management

After a successful implementation of the TPC system in case study three, the researcher was requested to implement the TPC system in 'many projects that are being managed by the case study company at the same time' i.e. programme management. The researcher explained that due to the limitations of research which included limited resources, time, and working with defined aim and objectives (which is not peculiar to this research but most PhD research), this request was out of the research scope. It is therefore recommended for further work.

12.6 FINAL COMMENTS

Many years ago, the researcher was reminded of the saying that "when you plan well, you will not work hard". This is a common advice given by guardians or parents, but little did the researcher know that this statement is essential to his field of study, construction project management. This complements the common statement in the construction industry that, "fail to plan, plan to fail". All these quotations emphasise the importance of realistic planning in all areas, especially in construction which has constraints with many factors. On the contrary, the techniques available to practitioners are insufficient in planning and managing construction projects. In this response, this study develops a holistic and innovative planning and control system, TPC, to enhance the current practice and to deliver sustainable projects. The TPC system was applied successfully in the case studies and the feedback from the expert group was positive and commending. The feedback suggests the TPC system has the potential of supplanting the conventional techniques to make project planning as realistic as possible, which is the main purpose of this study.

Ackoff, a Professor Emeritus of Management, emphasised this importance of planning when he argued:

"Planning is [may be] costly and time consuming but there is probably no other activity of a company that can yield so large returns on investment" (Ackoff 1970 p. 8).

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ACADEMIC PUBLICATIONS

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1. **Agyekum-Mensah, G**., Knight, A., Pasquire, C., and Coffey, C., (2014). "Effective Management of Engineering Projects using 4Es Model", *Key Engineering Materials Journal,* vol. 572, pg 655-659
2. **Agyekum-Mensah, G**., Knight, A., and Coffey, C., (2012). "4Es and 4Poles model of sustainability: Redefining sustainability in the built environment", *Structural Survey*, vol. 30, iss. 5, pg 426-442
3. Yung, P., and **Agyekum-Mensah, G.,** (2012). "Productivity losses in smoking breaks on construction sites: a case study", *Engineering, Construction and Architectural Management*, vol. 19 Iss 6, pg 636-646

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1. **Agyekum-Mensah, G**., Knight, A., Pasquire, C., and Coffey, C., (2013). "Effective Management of Engineering Projects using 4Es model", *In* Su, D., (Ed) Procs. *5th International ADM*, 25-28 September 2013, Valencia, Spain.
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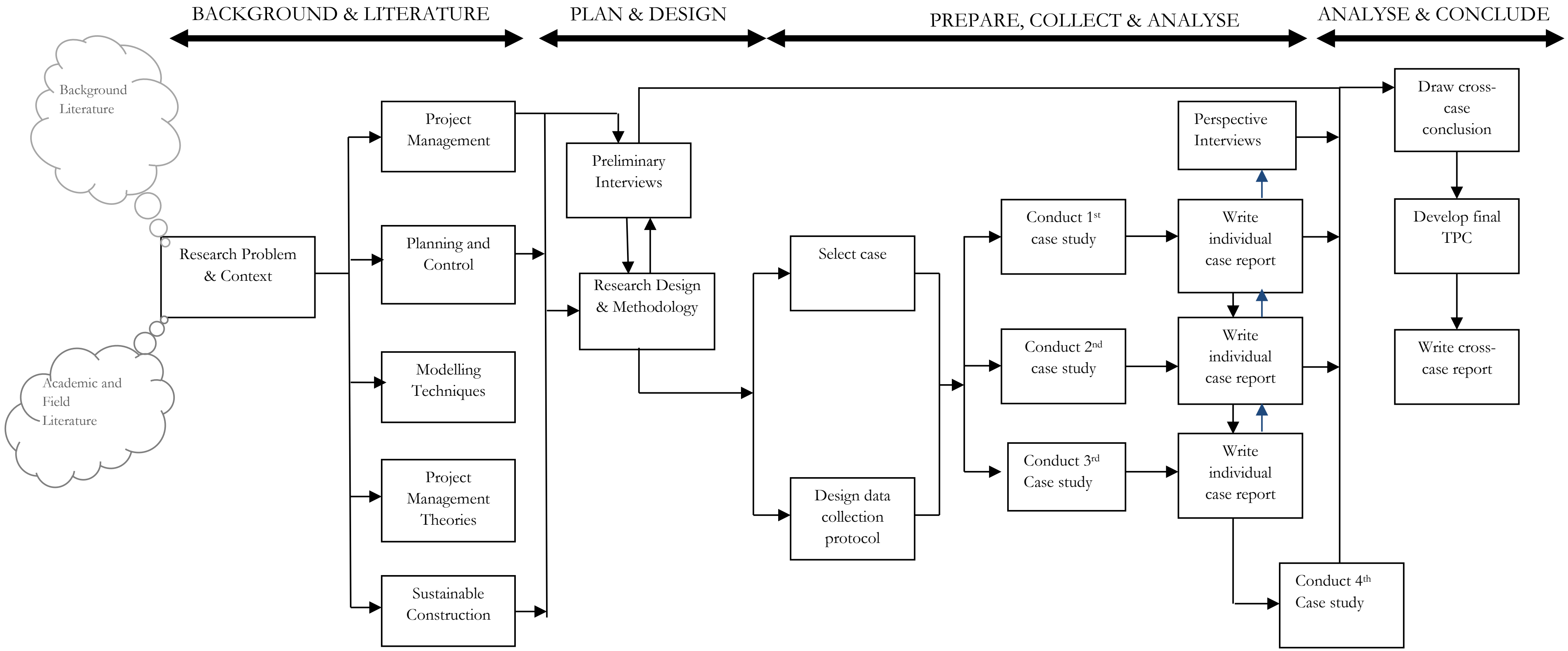
Poster Presentation

1. **Agyekum-Mensah, G**., (2013). "Effective Management of Engineering Projects using 4Es model" for *'What I did last summer' competition*.
2. **Agyekum-Mensah**, G., (2011). Construction project management enhanced by the adaptation of IDEF0 model in *East Midland Research Conference*, Vitae

APPENDICES

Appendix 1: The Research Map and Research Design



Appendix 2a: Stage 2: Interviewers Information

Item	Highest Qualification	Years of experience (years)			Professional Qualification
		Academics	Practice	Total	
PRACTITIONERS					
P1	PhD	40		40	FCIOB
P2	MSc	-	20	20	MACIA, Eng. Warrant
P3	PhD	10 (PT)	40	45	MICE, FCIOB, MAPM
P4	MSc	-	16	16	MRICS, MCIOB, MAPM, CCC
P5	PhD	1year	4	5	SLIA, RIBA (Training)
P6	MSc	1 ½	8	9 ½	MAPM, ICIOB
P7	B.Eng	-	30	30	None
P8	BSc	-	42	42	ICIOB
P9	HNC	-	45	45	SMSTS
P10	MBA	-	20	20	None
P11	BSc	-	8	8	RICS (APC)
P12	BSc	-	7	7	None
P13	BSc, MBA		16	16	MRICS
P14	BSc		12	12	ICIOB
P15	MEng		22	22	MICE, MAPM
ACADEMICS					
A1	BSc	3years	10	13	MRICS
A2	MSc	11years	7	18	BQSM
A3	PhD	2years	4	6	None
A4	MSc	7years	-	7	None
A5	PhD	10years	-	10	None
A6	MBA, DBA	20	16	36	MCIOB, MAPM, MCMI
A7	MSc	8	32	40	FCIOB
A8	PhD	2	10	12	MRICS
A9	PhD	2	6	8	None
A10	PhD	1	40	41	FCIOB
A11	MSc	4	5	9	None
A12	MSc	6	16	22	MRICS; MCIOB
A13	PhD	18	2	20	MBSE
A14	BSc	25		25	None
A15	MA	12		12	RIBA (Not yet full member)
UNIVERSITY STUDENTS					
S1	2nd Year BSc				None
S2	2nd Year BSc				None
S3	3rd Year BSc				None
S4	3rd Year BSc				None
S5	2nd Year BSc				None
S6	2nd Year BSc				None
S7	2nd Year BSc				None
S8	MSc		3	3	None
S9	MSc		2	2	None
S10	PhD		4	4	None

Appendix 2b: Case Studies Interview Participants Codes

Item	Case Study	Code	Position	Experience
1	Case Study 1	CS-01-SSR1	Projects Manager	47 years
2		CS-01-SSR2	Cost Manager	10 years
3		CS-01-SSR3	Contracts Manger	45 years
4		CS-01-USR1	Director of Projects	28 years
5		CS-01-USR2	Contracts Manger	16years
6	Case Study 2	CS-02-SSR1	Contracts Manager	27years
7		CS-02-SSR2	Senior Project Manger	33 years
8		CS-02-SSR3	Cost Manager	23 years
9		CS-02-SSR4	Project Manager	25 years
10		CS-02-SSR5	Site Manager	12 years
11		CS-02-SSR6	Construction Manager	45 years
12		CS-02-SSR7	Engineer	14 years
13		CS-02-SSR8	Project Engineer/Planner	19 years
14		CS-02-SSR9	Site Manager (Health & Safety)	21 years
15		CS-02-USR1	Contracts Director	28 years
16		CS-02-USR2	Senior Project Manager	15years
17	Case Study 3	CS-03-SSR1	Project Manager/Planner	10 years
18		CS-03-SSR2	Project Manager	18 years
19		CS-03-SSR3	Architect	19 years
20		CS-04-SSR4	Operation Manager	24 years
21		CS-03-SSR5	Project Manager	14 years
22		CS-03-USR1	Commercial Director	19 years
23		CS-02-USR2	Contracts Manager	41 years
24	Case Study 4	CS-04-SSR1	Project Manager	16 years
25		CS-04-SSR2	Site Manager	13 years
26		CS-04-USR1	Senior Project Manger	29 years

Case Study Consent Form

Research Project: ______________________________

Case Study Project: ______________________________

NOTE: This consent form is to be retained by the researcher and kept secure. At the completion of the research it should be disposed of in a secure fashion.

Researcher to list all procedures relevant to data collection

- Documentary evidence/Observation
- Interviews
- Introduction and implementation of the Total Planning & Control (TPC) System
- Evaluation of TPC System

I agree to be interviewed by the researcher

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I understand that details of the material discussed are confidential and agree not to disclose any of the information given to any other party

I agree to the interview being audio recorded for interviewer's reference only

I agree to the use of anonymised quotes in this thesis and other academic publications

Participant's name: ______________________________

Signature: ______________________________

Date: ______________________________

Interviewer's name: ______________________________

Name Position and Contact address of the Researcher
George Mensah
Doctoral Researcher
Nottingham Trent University

Email: george.mensah@ntu.ac.uk

NOTTINGHAM TRENT UNIVERSITY

THIS RESEARCH IS INVESTIGATING THE UNDERSTANDING OF PROJECT AND PROJECT MANAGEMENT WITHIN THE BUILT ENVIRONMENT

Academic…………..years of experience Industrial Practitioner………………years of experience

Academic Qualification(s) …………………………………………… Professional Qualification(s)……………………………………

1. What is a project?
2. What is construction Project?
3. What are the differences between other projects and construction projects?
4. What is project management?
5. What are the main factors/roles within project management
6. Could you please list the main project management tools used or available
7. What are the main roles and responsibilities for the following

Contract Manager	Project Manager	Construction Manager

8. Is construction project a production system? ***Yes or No*** … If Yes which of the following, please tick

   Linear …………Lean…………..Complex…………………Point…………………Flow…………Other…………………………….
9. Do you know about IDEF0? ***Yes / No*** Have you use it before ***Yes / No*** If ***Yes*** why?
10. What is IDEF0 technique
11. In one or two words describe

Construction Project	Project Management

THAN YOU FOR YOU TIME

INTERVIEW PROTOCOL

RESEARCH CASE STUDY

Introduction

Good morning (afternoon). Thank you for accepting to be interviewed within this case study project. The purpose of this interview is to get a clarification and understanding the project management (planning and control) procedures on this project.

This interview is planned not last for more than an hour. During which several question will be asked. Where possible I might interrupt so to get further clarification and save time as well.

Voice Recording

I trust it is fine with you to record this conversation. This will enable me get all the details and conversely have an attentive conversation with you. I assure you this will be for the purposes of my research only thus this tape will be held confidential.

Consent Form

Before we proceed, could you please read and sign this consent form

---

Interviewee Details

Q1 Could you please confirm your position and briefly your responsibilities?

Q2 What is your highest qualification? What is your background and years of experience?

Q3 How long have you been with this company and on this project?

How does cost affect project planning and control

General Questions

Q4 What is your general view about construction project management and especially project planning and control?

How would you describe this project in terms of its project and construction management?

- Procurement route, execution, control, planning, designers, subcontractors

Q5 To what degree do you think this project is successful?

1. Project Management
2. Project Planning
3. Project Control

Q6 In your opinion what are the factors to successful

1. Project Planning
2. Project Control
3. Project
4. Project Management

Q7 In what way could 1), 2, 3, …….. be improved

1. Project management
2. Planning
3. Control

Detail Questions

Could we talk about details and approach?

Q7 Could you briefly explain how this project planning was carried out?

People involved; approaches used; software; were there any particular concept used

What are the advantages? What are the limitation of planning if any

What makes this different from other planning

Q8 Could you briefly explain how this project is being control?

People involved; approaches used; software; do you use any particular concept

What are the advantages? What are the limitation of planning if any

What makes this different from other control

Q9 According to your planning schedule, there were activities which were completed:

- ahead of schedule - what contributed to its achievement?
- on schedule - what contributed to its achievement?
- behind schedule - what contributed to it?

Q10 What could be the causes for subcontractors not to achieve their look ahead programme?

Q11 What causes the Designers (Architect & Engineer) not achieve their planned date?

Do you hold LAD against subcontractors and Designers (Architects and Engineers)?

Specific Questions

Q12 From the progress report on October, 2011 in the project document, it was stated that the entire project was behind by approximately five weeks, but three weeks was given as extension of time. Why?

You did apply for ten weeks but three weeks granted, would that be enough to complete the project?

You even increased the working hours but 3hours each day including working on weekends that was not enough so what next? Who paid for the additional cost?

Q13 Let us look at a copy of the planning schedule

- there are no links in activities
- could it contribute to low achievement of planned work

Q14 In opinion how can planning and control be improved?

Closing Questions

Q15 In your opinion what are the causes of delays?

Q16 Do you know about Integrated Definition Zero (IDEF0) or Structured Analysis Design Techniques? If yes tell me about it?

Q17 Our next meeting its adapted form would introduction for implementation

Any other clarifications or comments

Remarks

Many thanks for your time and your in-depth discussion, it is well appreciated.

GM-Doc

Consent

- I agree to be interviewed by the researcher
- I understand that details of the material discussed are confidential and will not disclose any of the information given to any other party
- I agree to the use of anonymised quote in this thesis and other academic publications

---

General Details

Name:

Academic and Qualifications: Years of experience:

Company name:

Type of Company: Client Consultant Contractor Developer

Position:

Responsibility:

Questions

Q1: Success factors

1. What are the factors to a successful project?
2. What are the factors to a successful project management?
3. What are the factors to successful project planning?
4. What are the factors to successful project monitoring and control?

Q2: Problems

1. What are the problems associated with construction project management?
2. What are the problems associated with project planning, and monitoring and control?
3. What are the causes of delays?

Q3: Improvements

1. How can project management be improved?
2. How can project planning be improved?
3. How can project monitoring and control be improved?

Q4: Specific Questions

1. Could you briefly explain how your project planning was carried out?
2. What are the causes of subcontractors not achieving their look ahead programme?
3. What are the causes of Designers not achieving their look ahead programme?

Conclusion

1. What are the inputs, constraints and resources/mechanism to a task
2. Do you know about IDEF0 or SADT?

Any other Comments

Many thanks for your time.

Name and Contact of the researcher
George A-Mensah
Doctoral researcher
Nottingham Trent University
E-mail: george.mensah@ntu.ac.uk

Evaluation of Total Planning and Control (TPC) Systems Implementation

Position:…………………………………………………….	Total years of experience……………………

Academic Qualification:……………………….………	Professional qualification:……………………

1. Please complete the following by ranking where 1 is least and 5 is highest for the attributes of TPC system

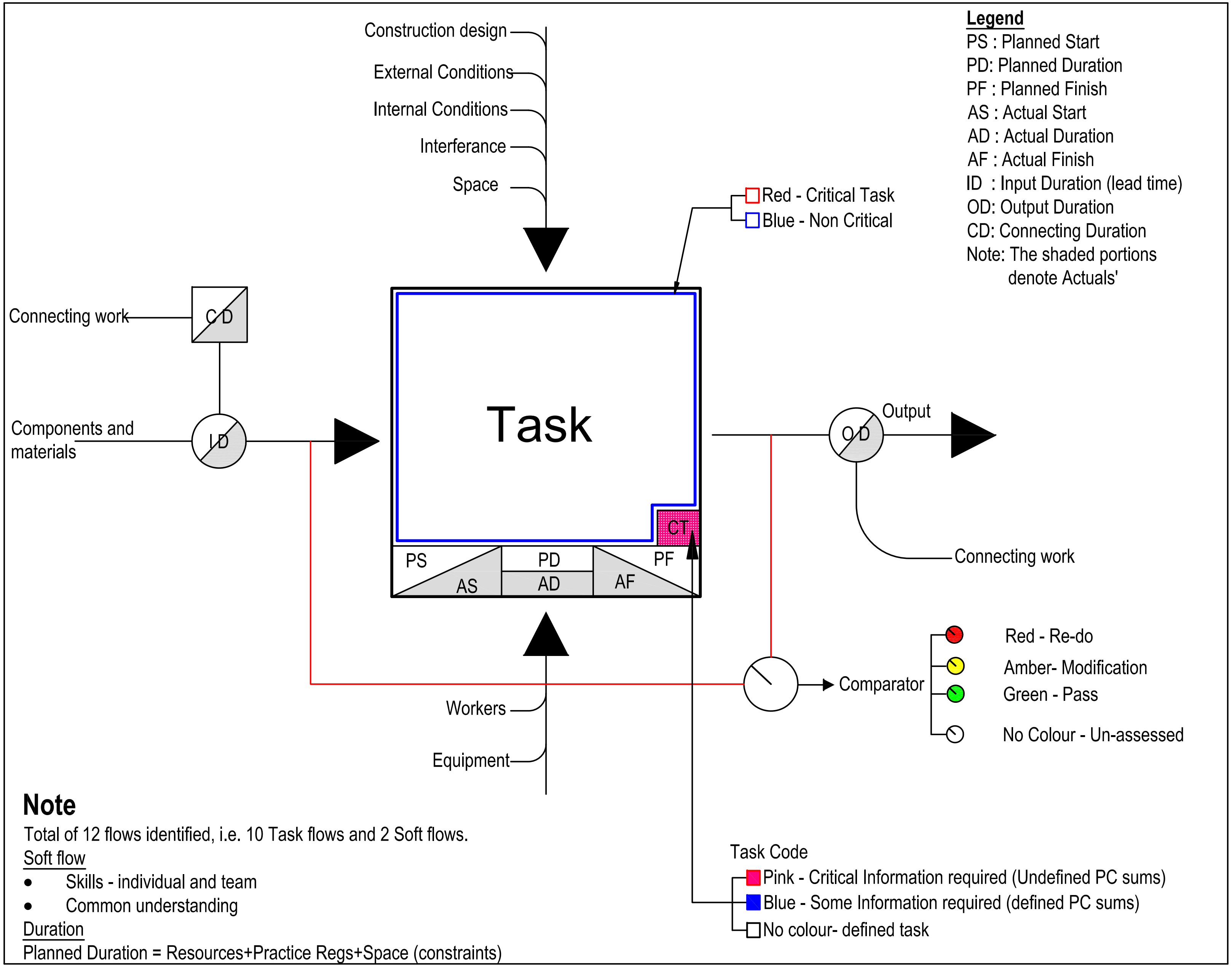
Attributes	1	2	3	4	5	Comments
Simplicity						
Holistic						
Consensus						
User friendly						
Suitability for Planning						
Suitability for Control						
Suitability for project management						
Collaborative						
Systematic						
Training required						
Uniqueness						

2. Do you think TPC is a drastic change to the existing practice or techniques? Yes or No Why?……………………………………………………………………………………………………
3. How can TPC be improved?
   - ……………………………………………………………………………………………………
   - ……………………………………………………………………………………………………
   - ……………………………………………………………………………………………………
   - ……………………………………………………………………………………………………
     ……………………………………………………………………………………………………
     ……………………………………………………………………………………………………
4. Any other comments……………………………………………………………………………
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………
5. If you want to know the more about the final TPC system and its methodology, please provide your contact email: ……………………………………………………………

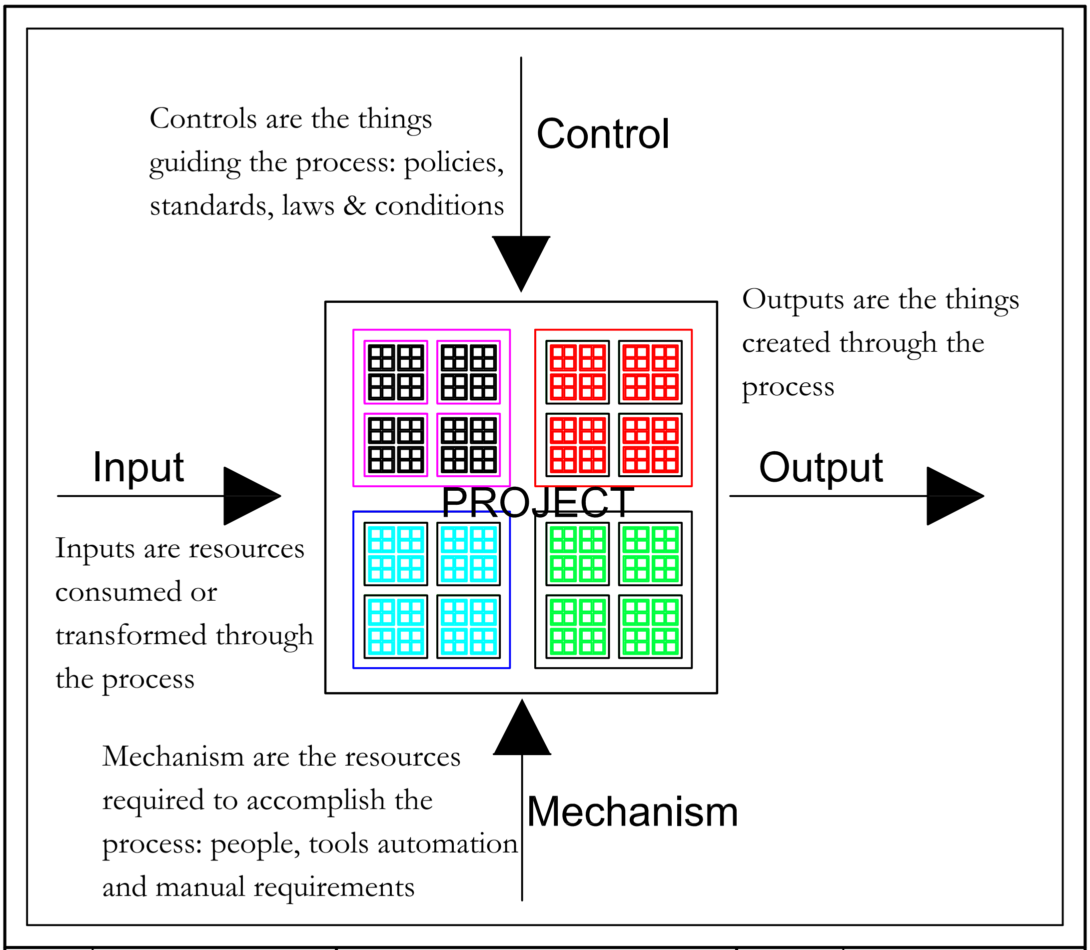
Thank you for your time and your valuable contributions

GM-PhD- Doc- evaluation

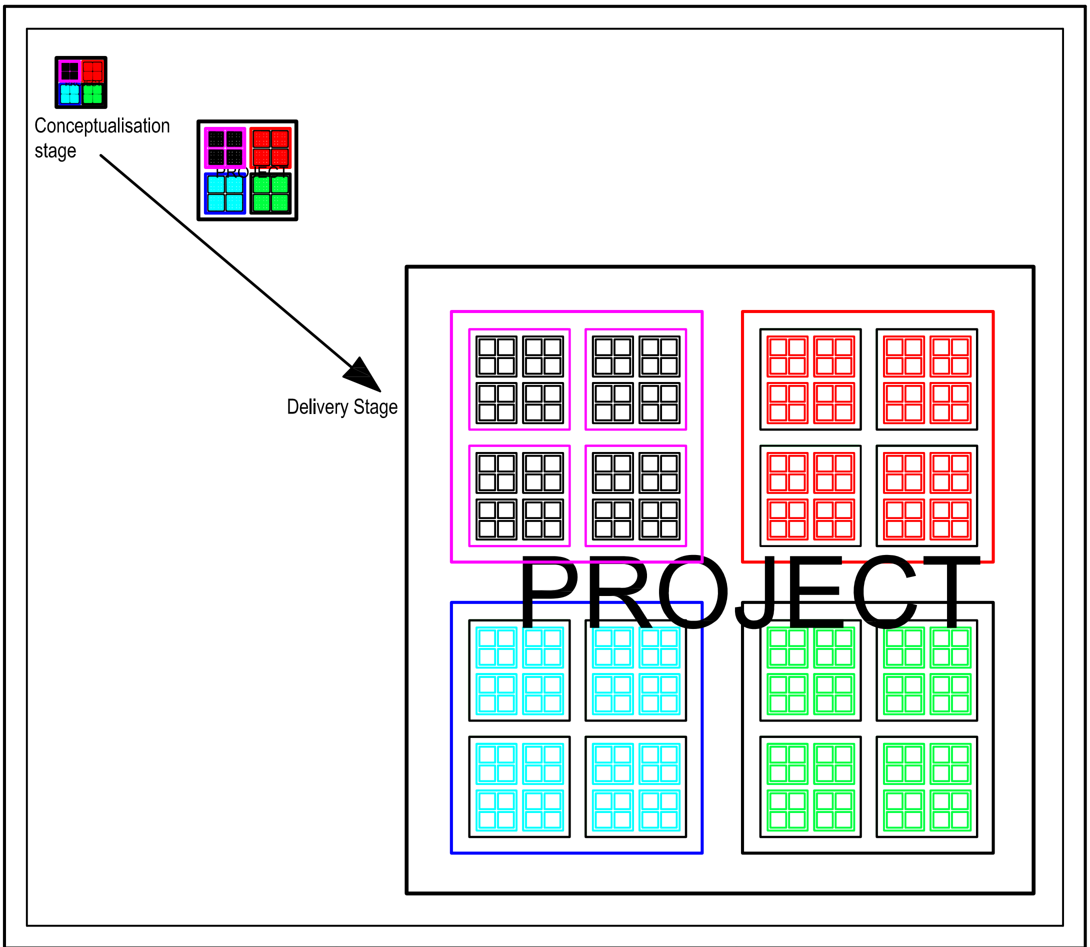
Appendix 8 - Total Planning and Control Concept



Activity	CONCEPT OF TPC	PROJECT	PM	George Mensah
Activity Ref.	CT	TPC FOR CONSTRUCTION TASK	Date	14th October, 2012
Sheet No	1 of 1.		Rev.No.	GM/PhD - Rev. 5

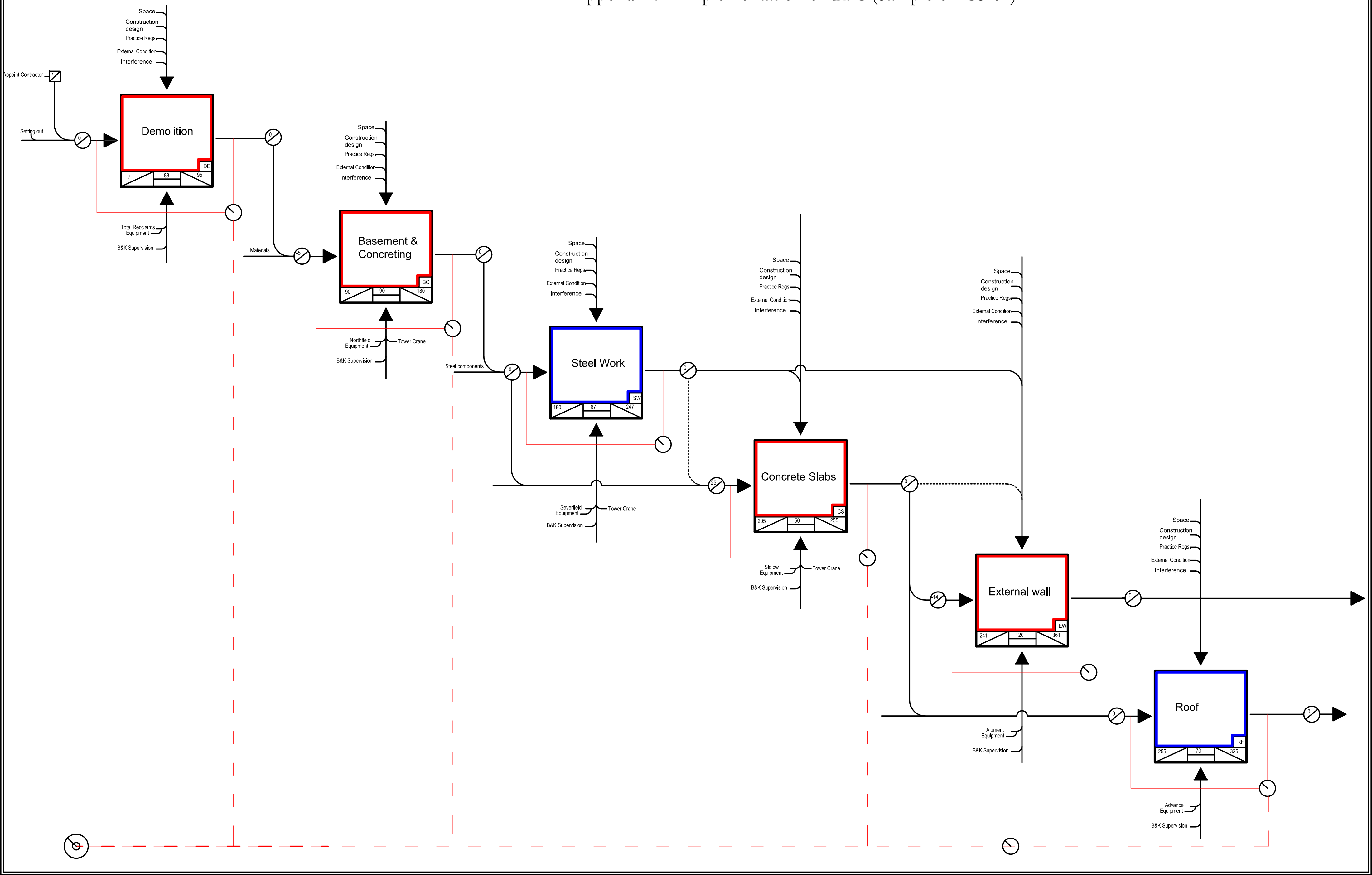


Activity	Concept of IDEF0	PROJECT	PM	George Mensah
Activity No.	GM0.	Process Model	Date	6th January, 2011
Sheet No	1 of 1.		Rev.No.	GM/PhD/Concept 1 Rev. 0

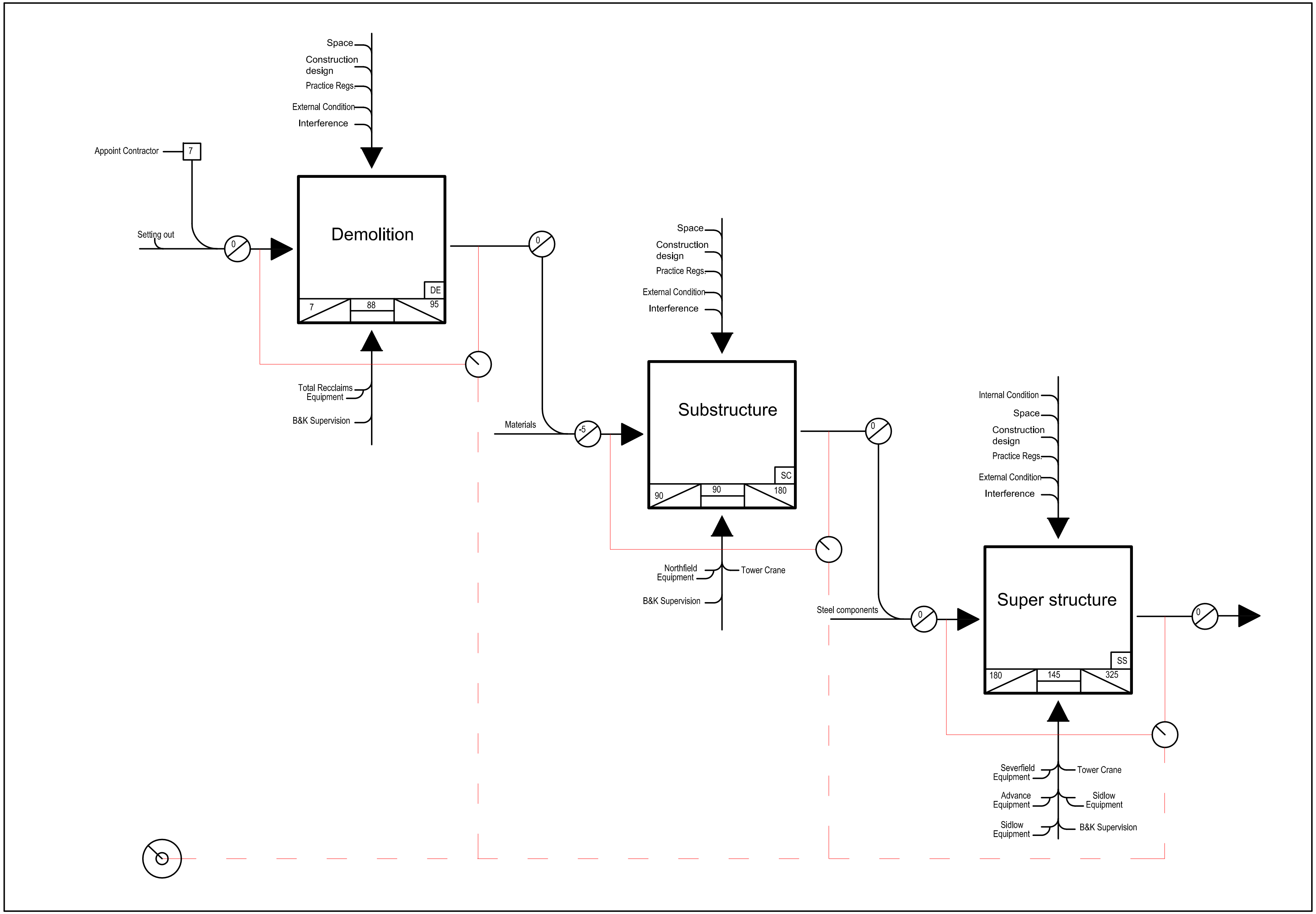


Activity	Concept of Project	PROJECT	PM	George Mensah
Activity No.	GM0.	TPC System - DBS	Date	14th August, 2012
Sheet No	1 of 1.		Rev.No.	GM/PhD/Concept 1 Rev. 1

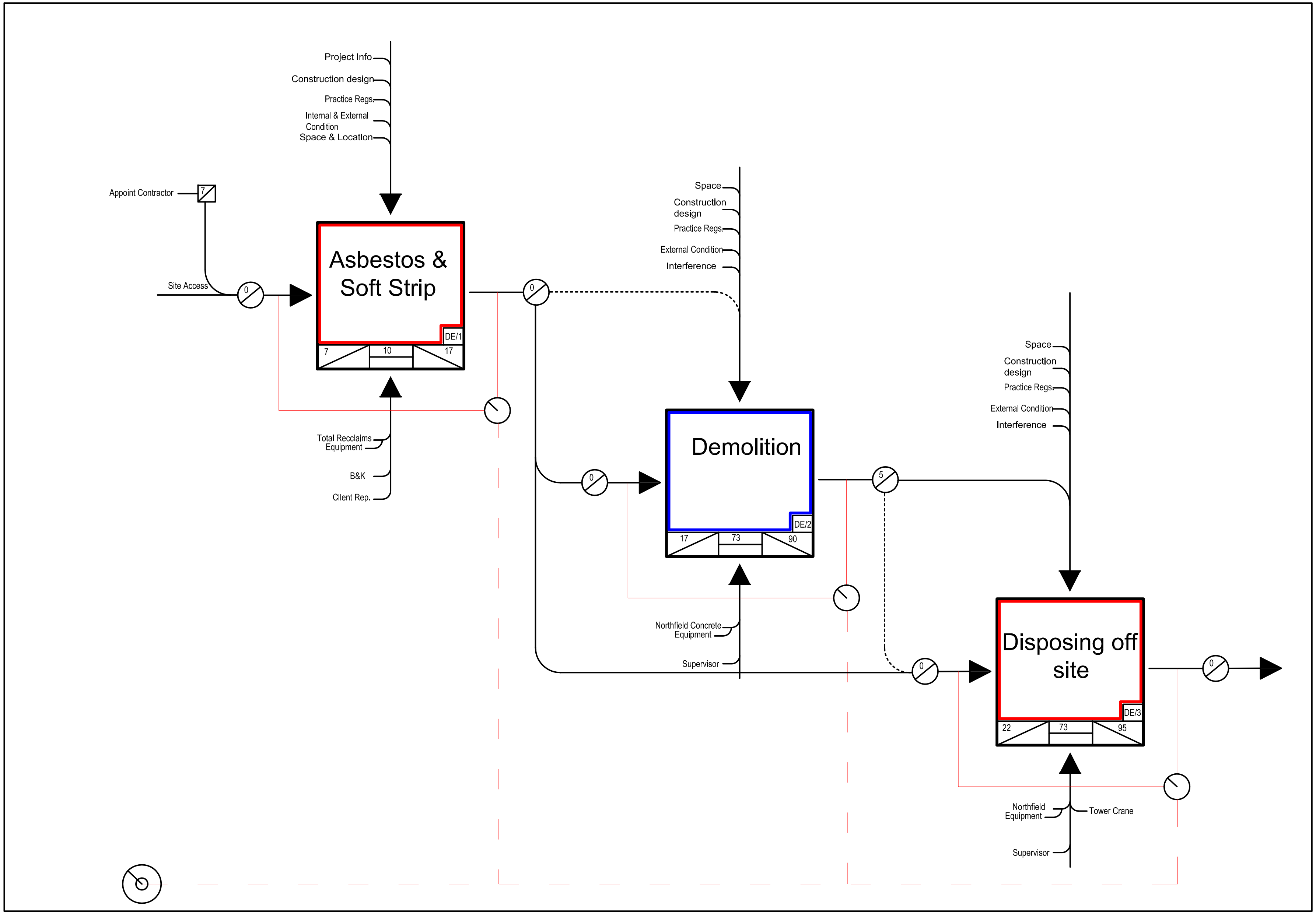
Appendix 9 - Implementation of TPC (Sample on CS-02)



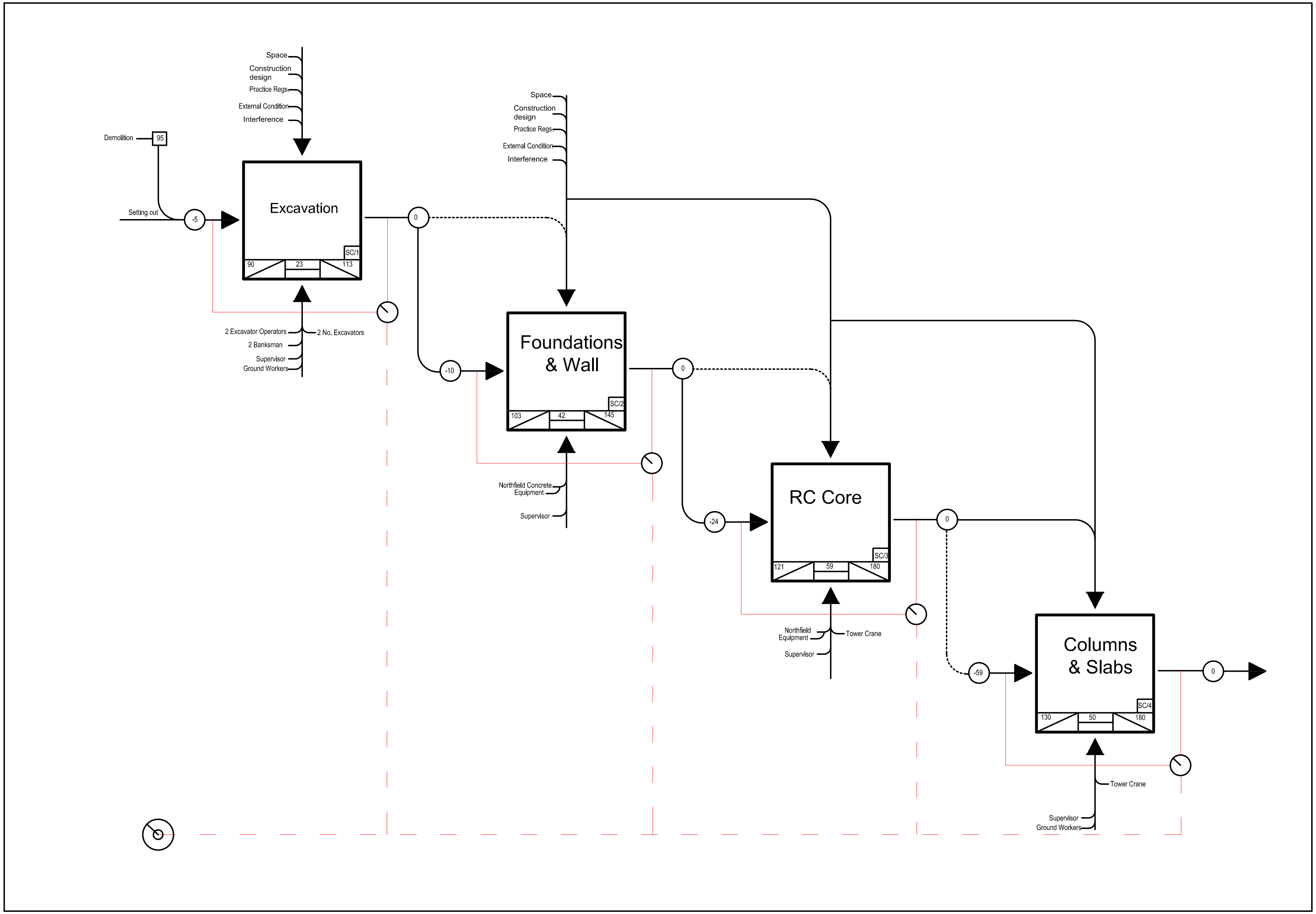
Activity	PROJECT - LEVEL	PROJECT	Project Green	PM	George Mensah
Activity Ref.	P			Date	7th August, 2012
Sheet No	1 of 1.			Rev.No.	GM/PhD - Progreen - Rev. 0



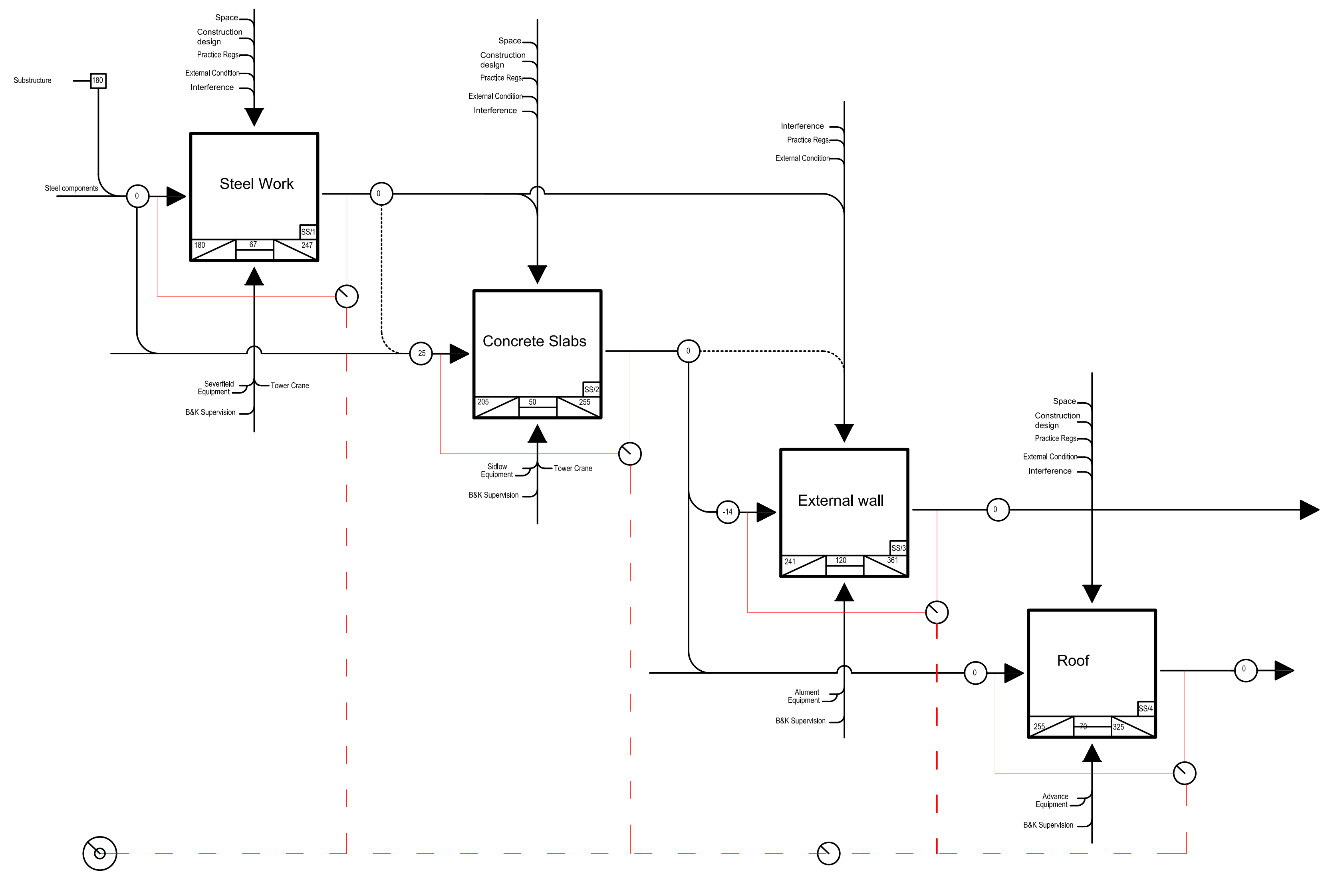
Task	Project- Level 1	PROJECT	PM	George Mensah
Activity No.	PG	Project Green	Date	8th August, 2012
Sheet No	1 of 5.		Rev.No.	GM/PhD - PG - Rev. 0



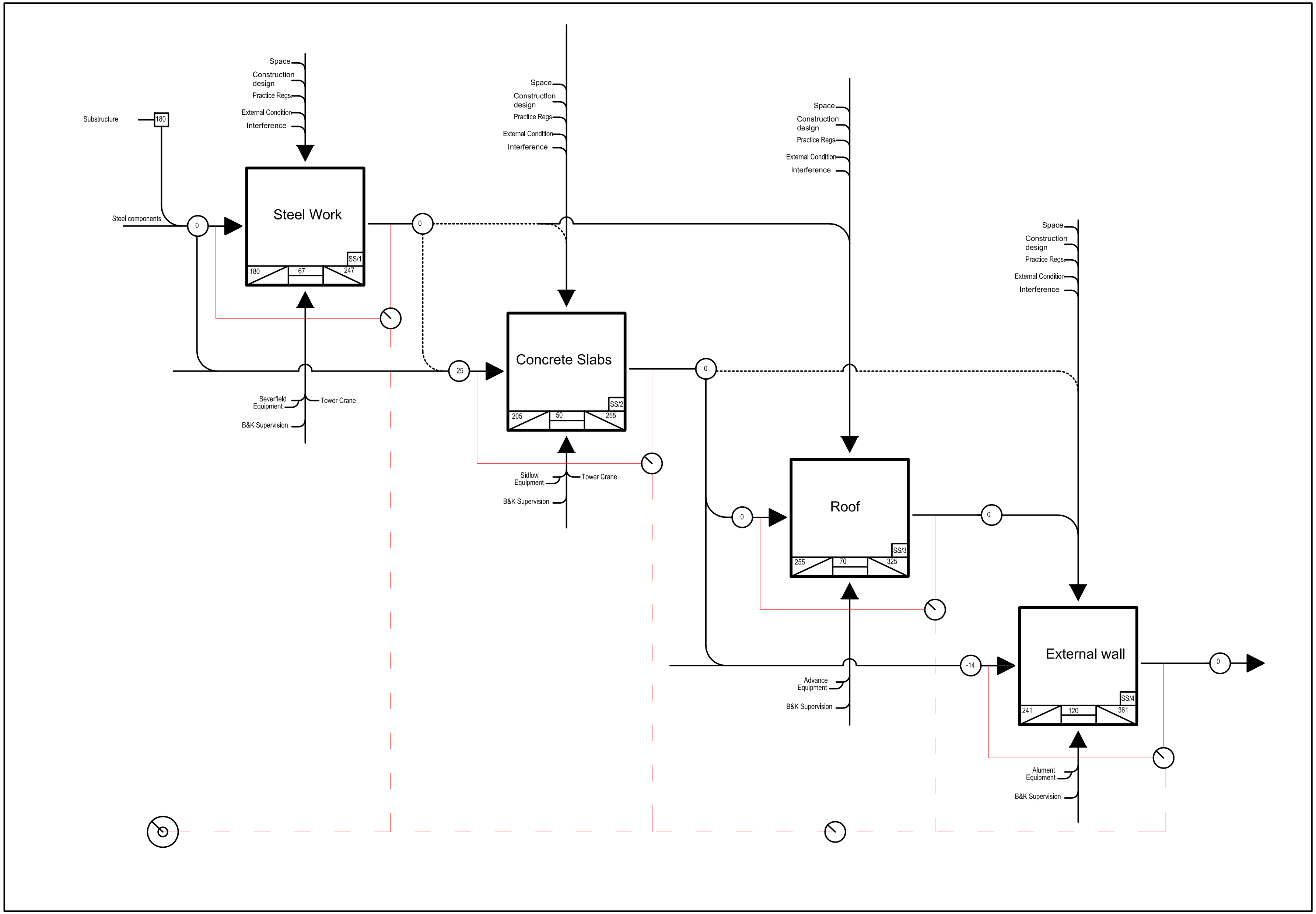
Task	Demolition - Level 2	PROJECT Project Green	PM	George Mensah
Activity No.	DE		Date	8th August, 2012
Sheet No	2 of 5.		Rev.No.	GM/PhD - PG - Rev. 0



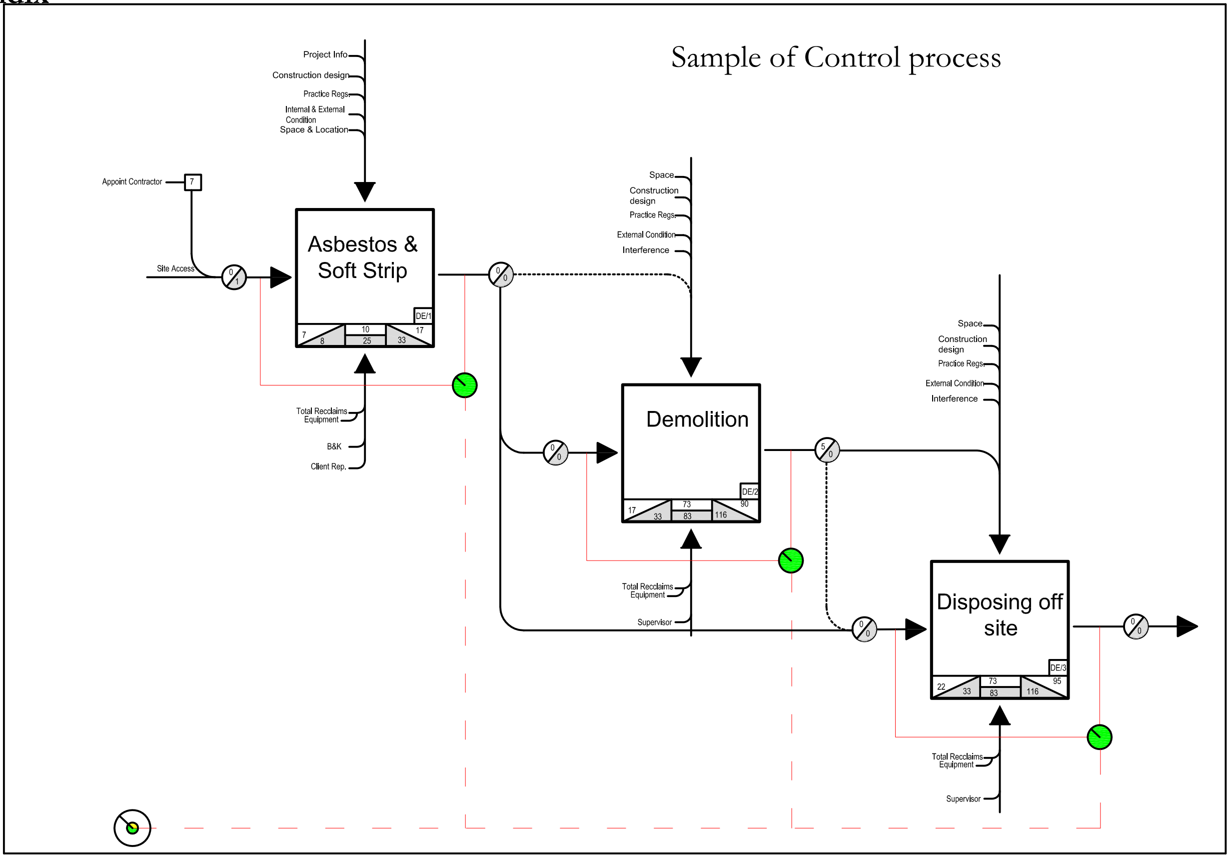
Task	Substructure - Level 2	PROJECT Project Green	PM	George Mensah
Activity No.	SC		Date	8th August, 2012
Sheet No	3 of 5		Rev.No.	GM/PhD - PG - Rev. 0



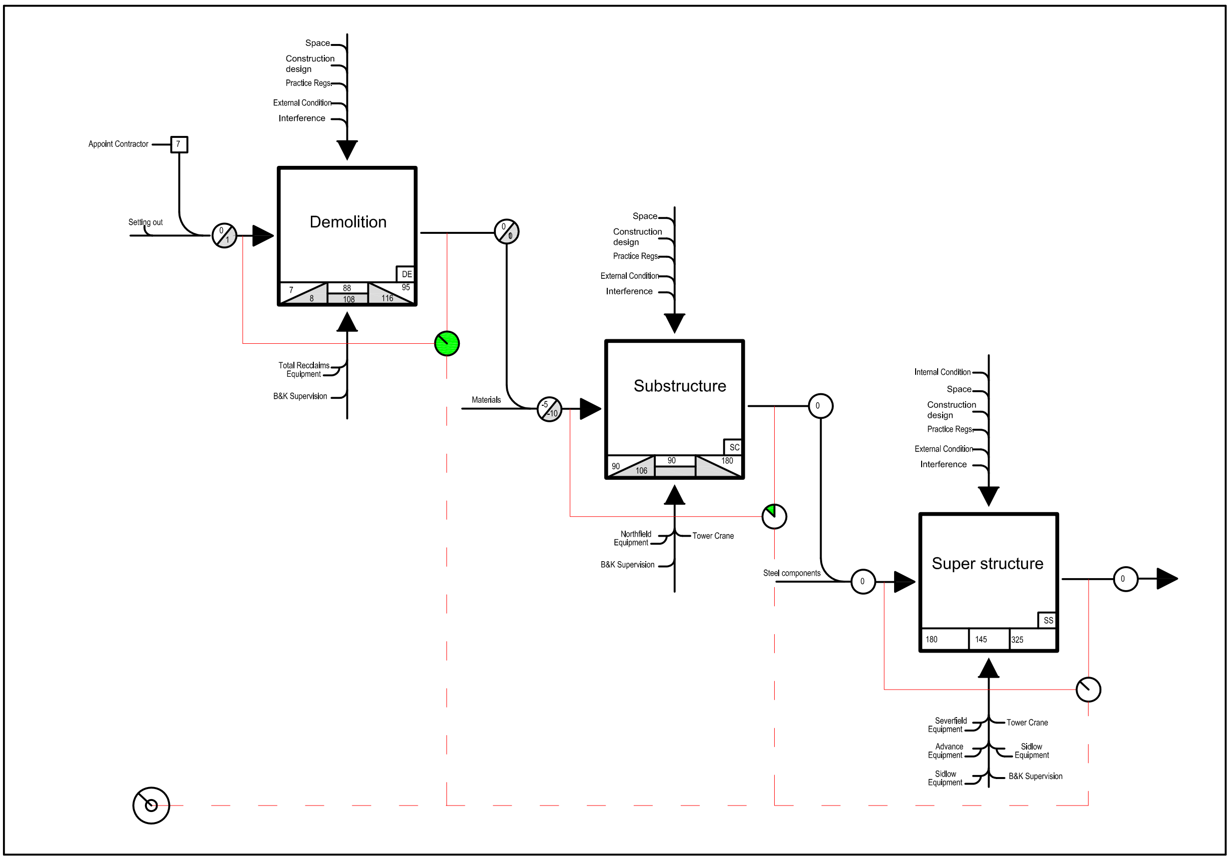
Task	Superstructure - Level 2	PROJECT Project Green	PM	George Mensah
Activity No.	SS		Date	8th August, 2012
Sheet No	4 of 5.		Rev.No.	GM/PhD - PG - Rev. 0



Task	Superstructure - Level 2	PROJECT	PM	George Mensah
Activity No.	SS (R1)	Project Green	Date	8th August, 2012
Sheet No	5 of 5.		Rev.No.	GM/PhD - PG - Rev. 0



Task	Demolition - Level 2	PROJECT	PM	George Mensah
Activity No.	DE - Control	Project Green	Date	8th August, 2012
Sheet No	1 of 2.		Rev.No.	GM/PhD - PG - Rev. 0



Task	Project- Level 1	PROJECT	PM	George Mensah
Activity No.	PG - Control	Project Green	Date	8th August, 2012
Sheet No	1 of 2.		Rev.No.	GM/PhD - PG - Rev. 0

Appendix 10 - Samples of Photos

The Scaffolding delaying the other trades – Space and Connecting work

Design problems and lack of workflow thus causing interference and internal problems

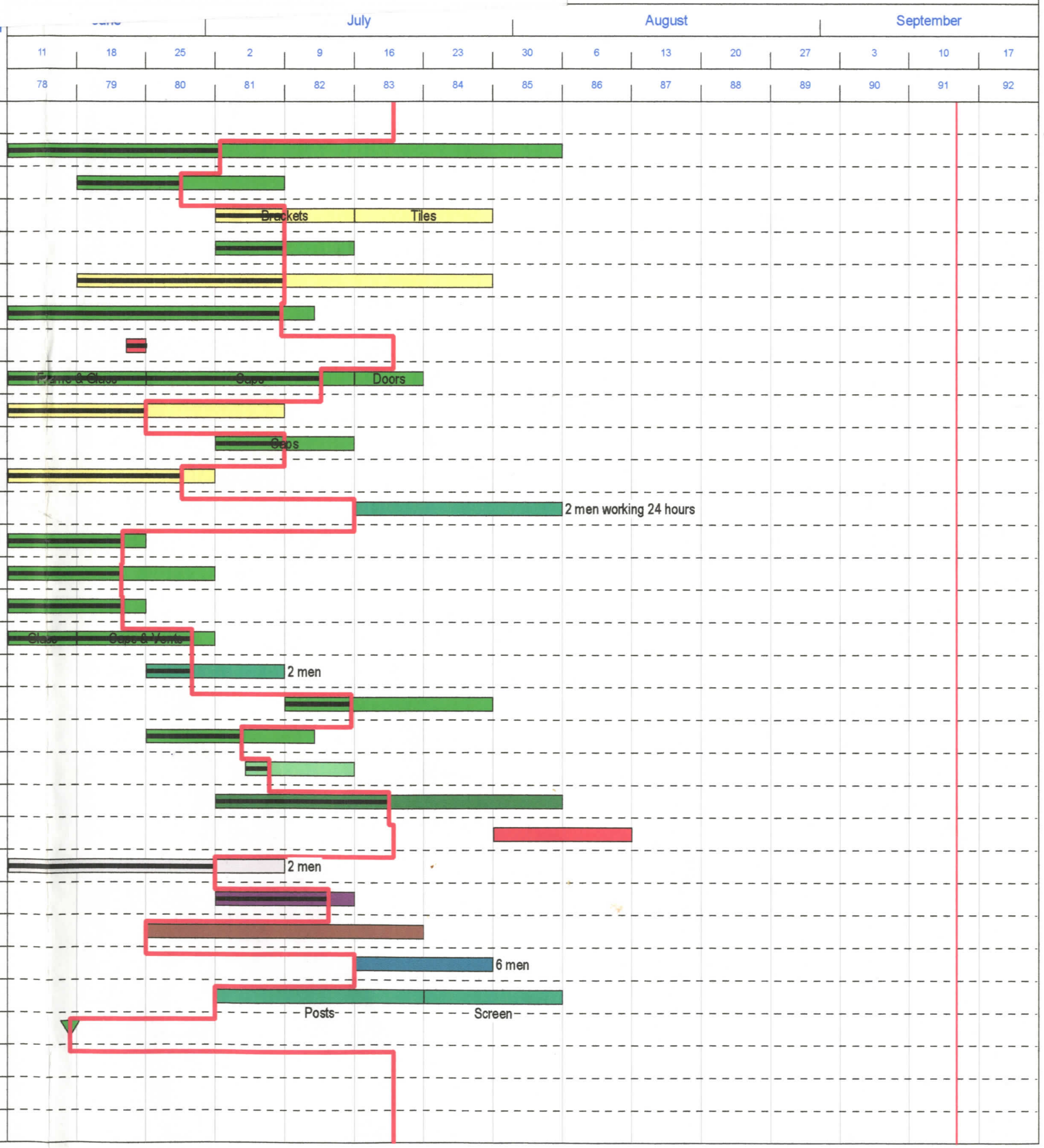
The Machine obstructing the other works – Work flow and interference

This work has been left, however progress report indicate block work complete – the importance of the review process in TPC

The use of sticker notes for planning and control observed in case study three

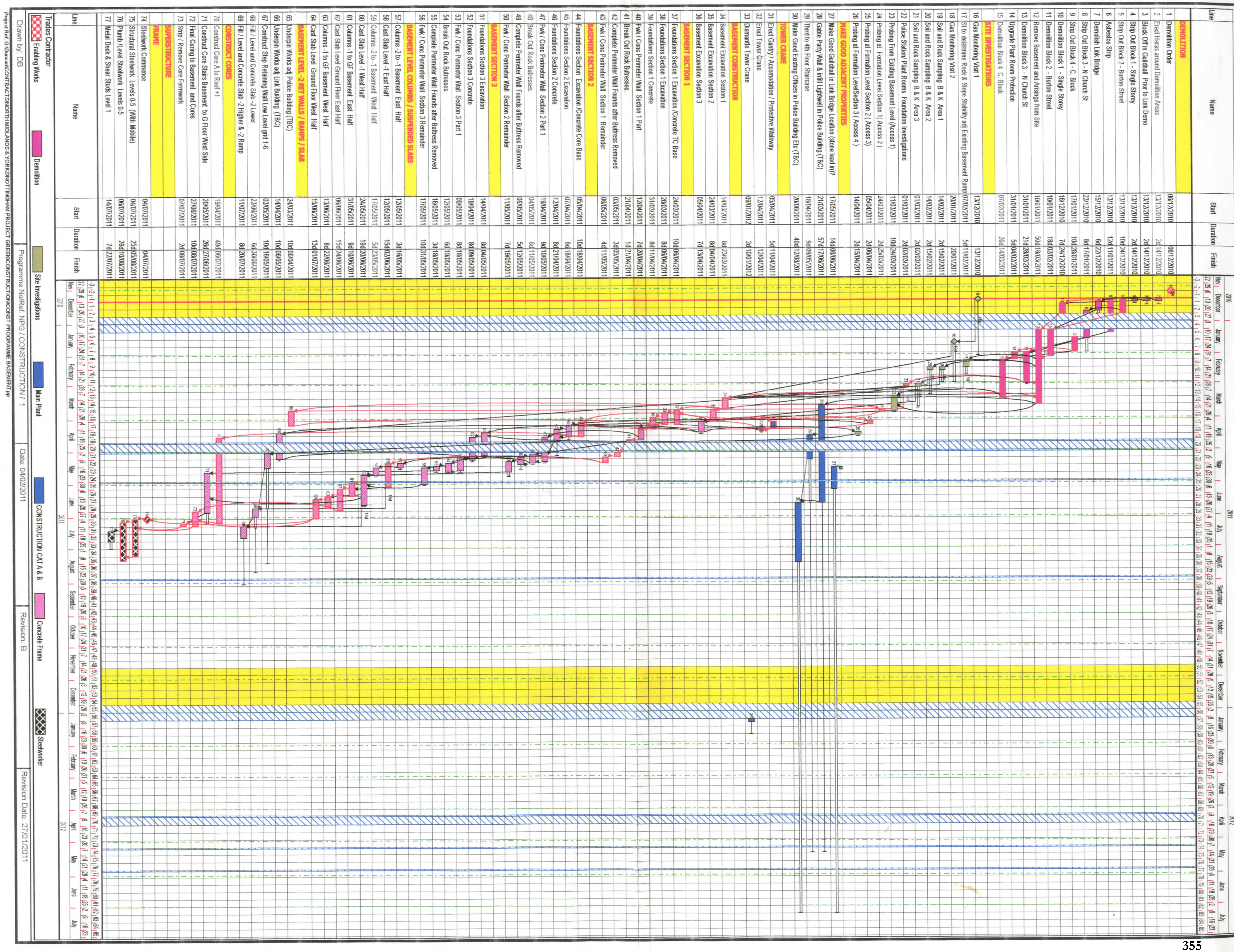
Appendix 11 - Project Control

Row	Activity	Contractor	Resources	% Comp.	%
1	Facade				
2	Complete Facade	[redacted]		69.6%	38%
3	Phase 1 South, West & North Elevation - Complete Top + Bottom Flashings			100%	50%
4	Phase 2 North & West Elevations - Terracotta Tiles			64.3%	25%
5	Phase 3 South, East, West & North Elevation - Missing units & Flashings		Team 2 x 4 Men	100%	50%
6	Phase 4 South & Roof Level Terracotta		Team 3 x 2 Men	76.2%	50%
7	Phase 5 South & West Elevation - Complete Glazing & Flashings		Team 4 x 4 Men	100%	90%
8	High Level sign			100%	100%
9	Phase 6 South + East Elevations - Glazed		Team 2 x 4 Men	92.9%	76%
10	Phase 7 North, East & West Elevations - Terracotta Tiles		Team 5 x 10 Me	100%	50%
11	Phase 8 East Elevation - Glazed			100%	50%
12	Phase 8 North Elevations - Terracotta Tiles			100%	85%
13	Phase 8 East Elevation - Walkway & Bagguettes			19%	0%
14	Phase 11 South Elevation - Glazed		Team 6 x 2 Men	100%	85%
15	Phase 12 North Elevation - Glazed		Team 6 x 2 Men	100%	55%
16	Phase 13 West Elevation - Glazed		Team 6 x 2 Men	100%	85%
17	Phase 14 North + East Elevations - Glazed			100%	90%
18	Phase 15 Tower - Panels			100%	35%
19	Phase 16 Balustrades - Glazed			52.4%	33%
20	Phase 17 West, North + South Elevations - Glazed			100%	58%
21	Phase 17 West, North + South Elevations - Louvres			100%	20%
22	Phase 18 Soffits			51.4%	50%
23	Low level sign			0%	0%
24	Phase 19 Barrel Vault Roof soffit & flashings			100%	75%
25	Phase 20 Internal backing panels			100%	80%
26	Granite Cladding			89.3%	0%
27	External doors			28.6%	0%
28	Plant Screen			51.4%	0%
29	Target Watertight date (All glazing complete)			100%	0%
30					
31	Items not shown on Alumet's programme				
32	Items in line with Alumet's programme dated 14.06.12 issued 18.06.12				



Appendix

Appendix 11 - Copy of Project Planning (Linked Gantt chart)



Overdue	
Due this week	
Complete	

List of Key Dependencies Required for M&E Completion & Commissioning Works

Issue Date:-	21/08/2012

Floor	Area	Dependency	Latest date required by	Impact	Comments	Completed / Closed out
Ground floor	Toilets	IPS to drill	08/08/12	Required to allow push buttons to be fitted	In Progress, some IPS panels are still missing.	
All Floors	Toilets	Access points to all SVP's still not accessible as detailed previously	24/08/12	Prevents full testing & access to SVP at each floor		
All Floors	Ground & Basement	Drainage gullies need to be cemented and sealed in.	24/08/12	To allow drainage to be completed		
All Floors	South West Electrical Riser	2 Hour fire wall to be installed	24/08/12	Allow generator to be commissioned and installation of rising bus-bar.		
Basement -1	Chiller room	Door lintels to chiller plantroom to be altered and door height raised	End August	Required to allow withdrawal of chiller tubes	Not critical to M&E works but will require resolving before the end of the project	
Basement -1	Roller Shutter	Connection & Control details	02/07/12	Complete Access Control Design		
Basement -1	Roller Shutter	Roller Shutter & Vehicle Barriers Installed	03/09/12	Allows access control system connections and commissioning		
Ground floor	All areas	Ceilings required	06/07/12	Preventing completion of 2nd fix M&E	1 week required from when walls available before ceilings can be released	
Ground floor	North & South toilet areas	Doors fitted	20/07/12	Required for air balancing		
Ground floor	Whole floor	External Façade to be completed	31/07/12	Required for air balancing		
Ground floor	Whole floor	Area cleared	03/08/12	To allow data install		
Ground floor	Whole floor	External doors fitted	31/07/12	Required for air balancing		
Ground floor	Whole floor	Floors completed, floor tiling complete - All build activities complete other than decoration etc.	30/07/12	Required for air balancing		
Ground floor	All toilets	Tiling to complete	13/08/12	Required to allow sanitary to be fitted		
Ground floor	North and south cores	Ceilings to be completed	07/08/12	Required to allow grills to be fitted for air balancing		
Ground floor	Access Controlled Internal Doors	Electronic Locks Installed	22/08/12	Allows access control system connections and commissioning		
Ground floor	Facade	External Revolving & DDA Doors installed	25/08/12	Allows access control system connections and commissioning		
Ground floor	Receptions	Internal Revolving & DDA Doors installed	25/08/12	Allows access control system connections and commissioning		

Mensah, George

From: Mensah, George
Sent: 09 January 2012 18:21
To: [redacted]
Cc: Knight, Andrew; Pasquire, Christine
Subject: Case Study

Dear [redacted]

Many thanks for your valuable time and contribution during our meeting this afternoon. I will also like to thank you again for your acceptance to use your project as a case study for my PhD. I confirm that all information will be for academic purposes only and will be treated with high confidence.

The project will be in the following four stages as discussed earlier

- Documented data (I can do it alone on site)
- Interviews (by appointment)
- Model briefing and testing (by appointment)
- Evaluation

All I need for the first stage is the documents folders on site and I can do it alone. Could you please confirm when I can commence and your other available dates for the interviews.

I have copied in this email my Director of Studies (Dr Andrew Knight) and Supervisor (Prof. Christine Pasquire) for their info.

I look forward to hearing from you soon.

GeorgeMensah

Nottingham Trent University
School of Architectural, Design and the Built Environment
Burton Street
Nottingham, NG1 4BU

Email: george.mensah@ntu.ac.uk