# Managing complexity in project teams

# Managing Complexity in Project Teams

A THESIS

By

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# Abstract

The traditional approach to the management of projects in the construction industry is constantly challenged, in particular the implementation of processes and the application of the project management knowledge base in complex projects. These challenges require a non-linear approach, a transformation from the control to the behavioural paradigm and a better understanding of how complexity in projects can be managed.

Interconnections between the various project parties, from individuals to companies, have always been identified as an area which requires attention. Indeed, project management sub-processes that have to consider interconnections, such as selection of project team members, structuring the project teams as well as the management style adopted, are either not implemented or the execution remains subjective, despite the existence of appropriate techniques. Considering that complexity occurs in non-linear systems and interconnections, the lack of appropriate means affects the implementation of such sub-processes and consequently performance. Investigating the complexity of the interconnections for the two sub-processes and the management style adopted and enabling the management of its effects must enhance implementation and thus project outcome. Therefore, the development of a framework is proposed which, by using existing knowledge and complexity characteristics, will allow project management (PM) practitioners the multiple implementation of actions for the management of the effects of the complexity of interconnections on construction projects through the two sub-processes and the management style adopted.

The rationale of this investigation is that interconnections, formed between and affected by social entities in projects, give rise to complexity, which can be managed by improving the project organisation and the management style followed. A research strategy was established which encompassed a survey, interviews and case studies with both UK client and construction PM practitioners. The survey results confirmed previous findings and indicated that, although PM practitioners are aware of techniques and are given guidance, these are neither implemented nor considered. Consequently, project management outcome remains only at acceptable levels. Interviews confirmed that the complexity of interconnections is not considered and very limited actions are taken to manage its effects when organising project teams or considering the management style to be followed. Indeed the effect of complexity of interconnections on project performance is dramatic as established through the case studies.

Therefore, consideration should be given to means for managing complexity of interconnections when selecting team members, structuring the project teams and when deciding on the management style to be adopted. Awareness and guidance on processes currently given to PMs has to materialise, and this can be achieved through the use of the framework for managing the complexity of interconnections.

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# Acknowledgements

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My deepest gratitude goes to my wife and daughters who between the years of 2005 and 2009 supported me endlessly on this 'selfish' task. I have missed being around them and spending our free time together, but as a result I cherish every minute more than before and promises made will now have to be delivered.

Finally I would like to address all those who have been questioning the reason for carrying out such a demanding task at this late stage in my life. The simple truth is that my main driver has been leaving behind a legacy and also because I always enjoyed to:

*"See what no one else sees";*
*"See what everyone else chooses not to see*
*out of fear,*
*conformity and*
*laziness";*
*"See the whole world anew each day".*
From the film Patch Adams.

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# List of abbreviations

| Abbreviation | Description |
|---|---|
| 16PF | 16 Personality Factors |
| ANT | Actor Network Theory |
| APM | Association for Project Management |
| ASK | Attitudes, Skills and Knowledge |
| BoK | Book of Knowledge |
| BPO | Behaviour-to-Performance-to-Outcome |
| CAS | Complex Adaptive Systems |
| CPM | Critical Path Method |
| EVA | Earned Value Analysis |
| FE | Finite Element |
| FEA | Finite Element Analysis |
| FS | Finite Structure |
| ICB | IPMA Certification Board |
| IPMA | International Project Management Association |
| MSP | Managing Successful Programmes |
| PCH | Project Control Handbook |
| PERT | Performance Evaluation and Review Technique |
| PEP | Project Execution Plan |
| PM | Project Manager |
| PMI | Project Manager Institute |
| RM | Risk Management |
| SNA | Social Network Analysis |

# List of definitions

| | Description |
|---|---|
| Complexity | The dealing with interconnections between dynamic systems and the change |
| Interconnections | The links between individuals in a team and between the teams in projects |
| Performance | The rate of the total of the durations of work completed against the total durations planned for a specific period |

# Chapter 1 – Introduction

This chapter describes the work undertaken for this thesis which concerns the management of the effects of complexity of interconnections in the project management sub-processes of selecting project team members, structuring the project team and the management style followed.

The background outlines the importance of the topics under investigation and presents the general theoretical context within which the research is based. It also presents the problem encountered by the construction industry when not considering the effects of the complexity of interconnections on the project management sub-processes investigated. The advantages to be gained by resolving the problem(s) are described in the research justification section followed by the definition of the purpose, the aim and the research objectives. The research methodology developed to conduct this investigation and a synopsis of the findings is portrayed in the respective sections. Finally the organisation of the thesis provides a brief description of the content of each chapter.

## 1.1 Background

'*Construction best practice is often limited to the domain of instrumental rationality with little attention to the underlying processes of social construction*'. (Green, 2003).

Project management literature, as highlighted by Green's (2003) statement above, suggests that the practice of project management is in a state of flux. The traditional approach to the management of projects is constantly challenged by developments in technology, the global economy, rapid changes in society, the exponential increase of knowledge and levels of various types of complexity. This has resulted in a call (Applebaum, 1982; Green, 2003; Jaafari, 2003; Soderlund, 2004; Ivory and Alderman, 2005; Turner and Muller, 2005; Winter and Smith, 2006) for project management theory to be transformed from its current control paradigm to a behavioural one. The argument being that such a change will allow for more emphasis on the soft features of projects, such as team working, leadership and cultural and behavioural issues, which are often ignored by the control approach of budget, functionality, time, quality, cost and contract.

The control paradigm has driven the development of tools, processes and procedures in the construction industry for a number of years. However, this has not delivered an improvement to the project outcome (Thomas and Mengel, 2008). Instead, working groups, reviews and reports have been commissioned in an attempt to improve the risk orientation and behavioural aspects of teams in the industry, for example the Latham (1994) and the Egan (1998) reports. Furthermore Morris (1994) has argued that '*project management is a discipline that remains stuck in a 1960s time warp*' and Turner (2005) questions the depth of the project management knowledge base and in particular its application to complex projects.

Gorog (2006) also asks for the Bodies of Knowledge to be reengineered otherwise *'project management will remain an avowal of faith'*.

There is a need for a shift in project management in construction towards the behavioural paradigm. Two project management sub-processes, which are considered under the behavioural paradigm, are selecting project team members and structuring the project team. Additionally the management style adopted by project management practitioners is closely related. Processes for selecting project team members do exist and the advantages of team formation are extensively described (Sommerville and Dalziel, 1998; Cattell and Schuerger, 2003; Raiden et al., 2004; Belbin, 2004; Baiden et al., 2006; Benton, 2006; Edum-Fotwe and McCaffer, 2007). However, the industry continues to follow a subjective approach in selecting team members (Hinds et al., 2000; Ogunlana et al., 2002; Green, 2006). Similarly, in structuring project teams, a field that is extensively authored (Mintzberg, 1973; Newcombe et al., 1990; Shirazi et al., 1996; Turner, 1999; Moore, 2002), the recommended processes are not followed (Moore, 2002). With regard to the management style followed in projects, friendlier procurement methods have contributed towards transformation in the adopted approach (Keegan and Den Hartog, 2004; Kadefors, 2006;) and team leadership is identified as one of the 12 core behavioural competences which support effective project management (Cheng and Dainty, 2005). However, inter-company 'narratives' (Green, 2006) and the lack of educational / training material on the management style to be followed when dealing with complexity (Thomas and Mengel, 2008), cause concerns.

A number of other authors, Gersick (1988), Geyer (1988), Stacey (1996), Pinto (2002), Jaafari (2003), Soderlund (2004), Thomas and Mengel (2008), have raised concerns and note that research is required to establish competencies in managing complexity in projects and their environment. Complexity in the management of projects is being investigated and various proposals have been developed in the last decade (Gidado, 1996; Baccarini, 1996; Williams, 1999 and 2002; Jaafari, 2003; Bertelsen, 2005; Geraldi, 2008; Girmscheid and Brockmann, 2008; Thomas and Mangel, 2008; Whitty and Maylor, 2009). Initially it was solely described by the technical complexities in projects (Gidado, 1996; Williams, 1999) and how these are developed and can be managed; but, more recently, proposals are being made in terms of overcoming non-technical complexity (Jaafari, 2003; Bertelsen, 2004; Girmscheid and Brockman, 2008).

Recognising projects as complex adaptive systems (CAS) and questioning how their interacting agents – the people – can be managed, motivated and interfaced becomes the Project Manager's (PMs) essential means for delivering the project successfully (Cooke-Davies, 2004). However, although most of the above-mentioned references indicate that interconnections generate complexity, no work has been done as of the present time that will enable the management of the effects of complexity arising from interconnections in projects.

The problem is that project management has not moved on from processes developed 50 years ago, despite numerous calls for a shift towards the behavioural paradigm. Project management processes, focusing mainly on the social constructs which generate interconnections, are not implemented and the industry is faced with the complex issues of social / behavioural repercussions from a set of incorrectly implemented processes. In addition Newtonian, or otherwise linear / precision-driven processes (Bertelsen, 2002a) such as CPM, PERT, RM, EVA, fail to consider the effects of non-linearity, or the impact of social behaviours, or how these might affect team work when implemented (Thamhain, 2004a, 2004b).

Complexity of interconnections, arising out of the people and teams that come together to deliver a project – the independent but interacting agents (Thomas and Mengel, 2008), remains another issue which has yet to be addressed. Sub-processes such as selection of team members and structuring the project team as well as the management style adopted are not only inappropriately implemented but also fail to consider the effects of the complexity of interconnections.

## *1.2 Research Justification*

The above indicates that the problem with project management lies in the linear processes developed 50 years ago which cannot resolve the current complex socio-behavioural issues. These issues can be resolved by providing a new framework for project management; a framework that will be developed by building on past experiences – lessons learnt from the linear processes. It will need to identify the requirements and introduce a new approach and premises by considering and extracting findings from developments in other fields, such as complexity. A framework that has to address today's problem, will be sufficiently flexible to accommodate gradual changes and enable the management of complexity in projects.

The framework will allow for the management of projects as non-linear entities (Bertelsen, 2004), will consider the 'social construction' (Green, 2003) and finally will enable the management of complex adaptive systems (Cooke-Davies, 2004) as these are formed in projects. The advantages arising from the research and development of such a framework will facilitate:

- A better understanding of the interconnections between team members;
- An improved team structuring mechanism;
- An improved delivery of the management style followed; and
- The PM's management of the effects of complexity of interconnections on the sub-processes and contribute towards the delivery of a successful project management outcome.

## *1.3 Purpose*

The purpose of the this Thesis is to deliver a framework for the management of the complexity of interconnections in the project management sub-processes of selecting project team members and structuring the project team as well as the management style adopted. The thesis will:

- Review and analyse the current practices and approaches implemented in the three project management topics.
- Investigate complexity of interconnections in projects, particularly the use and effect of its characteristics through the two sub-processes and the management style adopted;
- Investigate the effects of the complexity of interconnections on the project performance;
- Identify and propose necessary actions which will enable the management of complexity through the areas investigated, thus improving the execution of the sub-processes and the project outcome.
- Develop the necessary tool(s) and approach that will enable the Project Managers to manage the effects of complexity through the two sub-processes and the management style adopted from the very early stages of the project's life.

The outcome will be the development of a unique and reproducible framework with the required supporting actions and software tool and which will be expandable to cover the other project management sub-processes.

The reasoning behind the decision to investigate the three sub-processes, stems from the author's agreement with Lansley's (1994) proposal that in order to manage projects three basic questions need to be addressed:

1. How do we organise?
2. How do we manage?
3. How do we solve problems?

The research focuses on the first question by considering the selection of team members and the structuring of project teams, whilst the management style followed falls under the remit of the second question. Finally, the third question is addressed as part of the solution proposed by this Thesis, since complexity of interconnections is in fact part of the problem created within projects.

### 1.3.1 Aim

The aim of this research is to investigate the effect of the complexity of interconnections, through the sub-processes of selecting team members, structuring the project team and the management style(s) on the project performance thereby developing a framework which will enable the effective management of these effects.

### 1.3.2 Objectives

The objectives of the research are:

1. To determine how far down the project organisational level, techniques for selecting team members are implemented and team structure and management style are defined and to produce a state of the art report.
2. To investigate if the current approach for selecting members, structuring the teams and the management style followed considers the effects of complexity and to produce a state of the art report.
3. To examine how complexity, which arises from the interconnections, affects project performance.
4. To identify the tasks to be undertaken when selecting team members, structuring project teams and deciding on the managing style to be adopted in order to manage the complexity of interconnections,
5. To develop and validate a framework that will support the sub-processes of selecting team members, the structuring of the teams and deciding on the management style to be followed in order to manage the complexity of interconnections and contribute towards the improvement of the project outcome.

The output is a framework which, for the purposes of this research, will enable the PMs to manage the effects of the complexity of interconnections through the two sub-processes of selecting team members and structuring the project teams as well as the management style to be adopted. Moreover, the framework will become the basis for expanding into all the other project management sub-processes.

Table 1.1 is drawn to provide clarity and tie the literature review chapters and the research methods used to the research objectives.

Table 1.1 Tying of research objectives to the literature review and research methods used

| Objectives | Literature review Chapter | Research Method | | | |
|---|---|---|---|---|---|
| | | Survey | Interviews | Case Studies | Validation |
| Objective 1 | 2, 3 & 4 | ✓ | | | |
| Objective 2 | 5 | | ✓ | | ✓ |
| Objective 3 | | | | ✓ | |
| Objective 4 | | | ✓ | | ✓ |
| Objective 5 | | | | | ✓ |

## 1.4 Research Method

In order to establish the current levels of implementation of the sub-processes under investigation, as well as exploring the intricate subject of complexity, a research strategy was developed and implemented. A strategy which would not only cover the requisites of the research but also represent the practitioner PMs from both 'sides' of the 'notional fence' in projects, the contractor and the client. Therefore, a multi-method was developed which included both a quantitative and qualitative approach, such as postal questionnaires, interviews and case studies. The importance of the appropriate representation of the two different strata – client and contractor – and a required certainty of response, demanded the application of stratified sampling (Stopher and Meyburg, 1979; Dietriech, 2001).

The purpose of the postal questionnaire was to reach a wide sample of project management practitioners, from the most junior to the most senior level, and to investigate the current levels of implementing the sub-processes of selecting project team members, structuring the team and the management style followed. In order to examine the concept of complexity, particularly that concerning interconnections and its characteristics, a 'face to face' approach was necessary to better explain new terms and concepts. This could be performed by conducting interviews. Finally, case studies were implemented to determine how complexity of interconnections, through the three sub-processes, affects the project performance.

## *1.5 Findings*

Three core hypotheses were formulated in order to conduct the investigations. These hypotheses were:

1. Hypothesis 1.1 (H1.1): The available techniques for setting up (selecting and structuring) project teams and the management style in construction projects are implemented down to the lowest project organisation level.

   Hypothesis 1.2 (H1.2): The implementation of selecting team members and structuring the project team processes down to the lowest project organisation level and the management style are positively correlated with improved project management outcome.

2. Hypotheses 2.1, 2.2, 2.3 and 2.4 (H2.1, H2.2 & H2.3).

   H2.1 - Complexity characteristics are considered when selecting project team members.
   H2.2 - Complexity characteristics are considered when structuring the project team(s).
   H2.3 - Complexity characteristics are taken into account when considering the management style to be followed on a project.
   H2.4 - Complexity of interconnections is inversely correlated to the project performance.

3. Hypothesis 3.

   H.3.0 - A framework is required to be developed for managing the effects of complexity of interconnections caused by the sub-processes of selecting team members, structuring the project team and the management style followed.

Table 1.2 below ties the research hypotheses to the research objectives.

Table 1.2 Tying of research hypotheses to the research objectives

| Objectives | Hypotheses | | | | | | |
|---|---|---|---|---|---|---|---|
| | H1.1 | H1.2 | H2.1 | H2.2 | H2.3 | H2.4 | H3 |
| Objective 1 | ✓ | ✓ | | | | | |
| Objective 2 | | | ✓ | ✓ | ✓ | | |
| Objective 3 | | | | | | ✓ | |
| Objective 4 | | | | | | ✓ | |
| Objective 5 | | | | | | | ✓ |

The results obtained from the implementation of the multi-method stemmed from, 91 responses to survey questionnaires, 31 interviews and from the five case studies which covered all three stages of the project lifecycle.

Results from the survey questionnaires regarding current practices for selecting team members, structuring the team and the management style adopted, hypothesis H1.1, confirmed findings covered by the literature review. When selecting team members the process remains subjective, very minimalist and personal profiling is not used at any level. Structuring of the project team is not performed and, in particular, it is not implemented to the lowest level of the project. With regard to the management style adopted, no decision is taken of the required style, however, a small majority of responses indicated that the style followed is equally 'situational' and 'egalitarian'. Therefore hypothesis H1.1 was refuted. Also, findings from the survey questionnaires refuted hypothesis H1.2 indicating that there is no positive correlation between the current approach taken when implementing the two sub-processes along with the adopted management style and the project management outcome.

Results from the interviews demonstrated that complexity is not defined, instead it is considered as a response to technical 'problems', although interfaces and other behavioural issues were identified as a cause. Furthermore there are no tools available to practitioners for managing its effects, thus refuting hypotheses H2.1, H2.2 and H2.3

Results from the case studies indicated that there is an inverse correlation between the effect of complexity of interconnections and project performance. As complexity of interconnections increased, project performance decreased and the graphical representation of the drop resembled the behaviour of underdamped vibration control systems. Thus, hypothesis H2.4 was confirmed.

In general the two sub-processes of selecting team members and structuring project teams, as well as the management style adopted, are not implemented in a way that will enable the management of the effects of complexity of interconnections through its characteristics. Therefore hypothesis H3 was confirmed and the need for a framework was established. The framework will be used to guide practitioners towards implementing the necessary actions to manage the effects of the complexity of interconnections. This will improve the contributions of the selected sub-processes and the management style towards an entirely successful project management outcome.

## 1.6 Organisation of Thesis

The thesis is organised in ten chapters. Chapters two to five cover a review of the literature for the areas being investigated. Chapters six and seven cover the research method and the results obtained. Chapters eight and nine cover the analysis, validation and discussion of results and Chapters 10 and 11 the recommendations and conclusion. A brief description of the content of each chapter follows and Figure 1.1 provides a holistic view of the layout and the linkages between the chapters. Also, the description of the basic definitions used in this Thesis is presented in the 'List of definitions' on page xxi.

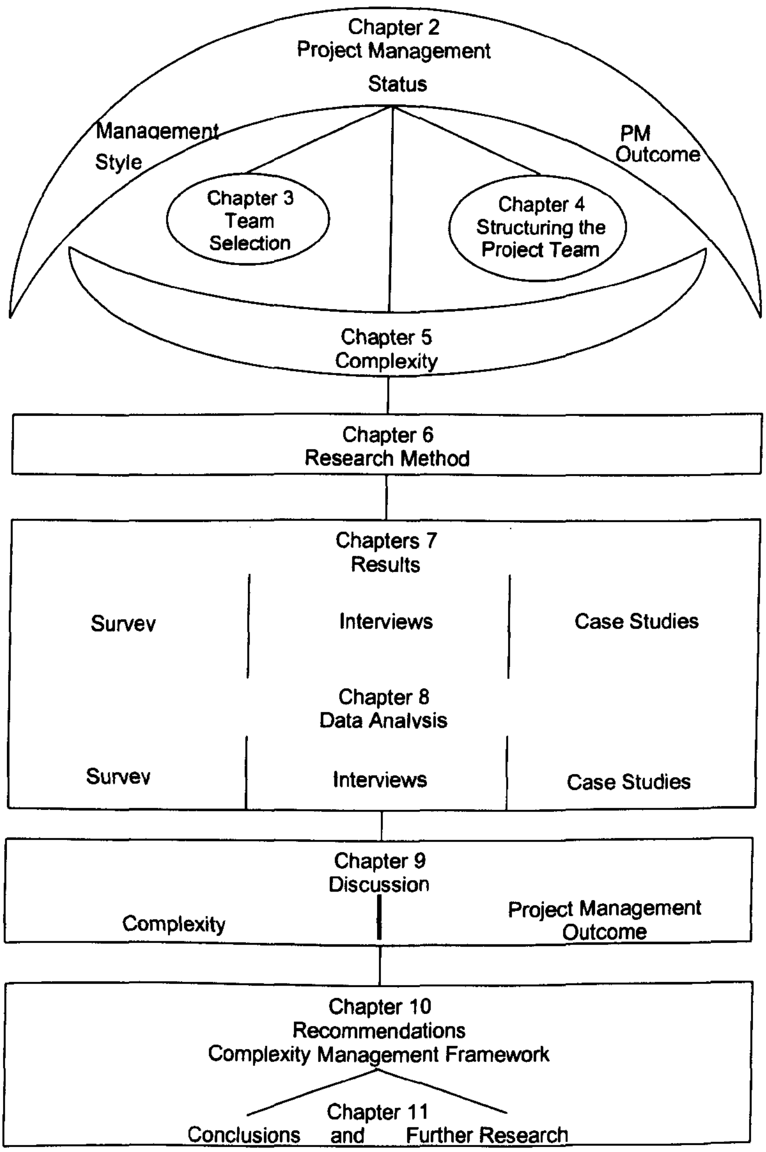


Figure 1.1 A holistic view of the chapter layout of this Thesis.

As depicted in Figure 1.1 above, the research method follows on from the literature review chapters since the latter establishes the set of questions that need to be investigated and the former defines and describes the research strategy and the sampling approach undertaken in order to investigate the hypotheses.

### 1.6.1 Chapter Two

Chapter Two presents one of the four background reviews and the essential literature relating to the study. It also covers some of the major current issues in project management. Topics considered include:

- the status of project management as a profession or occupation;
- projects as disturbances or wicked problems;
- the memetic paradigm; and
- refuting a project management metaphor from within.

Literature on the management style to be followed is reviewed within this chapter as most of the authors consider this as an attribute of the Project Manager. Finally, the chapter closes with the review of the literature concerning the measurement of project outcome. This was used to define the approach taken for structuring the postal questionnaires for the three sub-processes investigated.

### 1.6.2 Chapters Three and Four

In these two chapters a review of the literature on selecting project team members and structuring project teams is conducted. The chapters describe current thinking, issues and concerns raised from previous work. In addition to the above, review findings are used to triangulate results from the postal questionnaires and the interviews.

### 1.6.3 Chapter Five

The last chapter of the literature review covers the topic of complexity. The review encompasses the development of theories that led to the theory of complexity, the sources, types and characteristics and closes with the current thinking, issues and concerns of complexity in construction.

### 1.6.4 Chapters Six and Seven

Chapters Six and Seven present the rationale and strategy developed for the implementation of the research multi-methodology, the implementation stage and the data collection.
The hypotheses formed, the sampling approach and the phasing of the implementation, which lasted almost 10 months, are explained in detail in Chapter Six.
The results from the two main phases of implementation are presented in Chapter Seven. Tabular, as well as graphical, output depicts replies obtained from respondents, interviewees

and the five case studies. Extensive detailed results are also presented in the respective appendix.

### 1.6.5 Chapters Eight and Nine

The analysis, validation and discussion of the data collected are presented in Chapters Eight and Nine. The discussion follows the phasing of implementation by 'setting the scene' from the quantitative results, then exploring complexity with the results from the interviews and finally linking complexity with the project performance through the discussion of the case study results. Validation of the results obtained is presented in Chapter Nine.

### 1.6.6 Chapter Ten

In this chapter the recommendation is made for the development of a framework that will enable the management of the complexity of interconnections for the sub-processes investigated. The framework uses the complexity characteristics and identifies actions that should be implemented in order to manage its effects. Objectives for the framework are defined and the decision matrix process is used to select the appropriate approach. The validation process of the framework developed and the output obtained as well as the results obtained are presented in this chapter. Furthermore, a recommendation regarding the sub-process of structuring the project teams is made in the supplementary findings and the chapter closes with the research limitations.

### 1.6.7 Chapter Eleven

The investigation is brought to a conclusion by describing the results for each of the research objectives raised in Chapter Six and the conclusion reached with regard to the framework for managing the complexity of interconnections for the sub-processes investigated.

Recommendations for future research are presented in terms of extending the framework developed; work on project performance and the implementation of basic processes; expanding on the similarity discovered between project performance and underdamped vibration control systems; finally, recommendations are made for continuing research on the supplementary findings for the development of the Finite Structure approach to structuring project teams.

# Chapter 2 – Project Management, Management Style and Outcome

## 2.1 *Introduction*

In this chapter a literature review of three topics is conducted. This comprises of the status of project management and two of the areas under investigation: the management style followed by PMs and the measurement of the project outcome.

The literature review of project management and its status is considered relevant to this research as it plays a highly influential role in the underlying issues of the processes investigated. It will also provide an insight when examining the outcome of the investigations. The intention is not to regurgitate knowledge and concepts already highlighted by a number of authors in the past, such as P.Morris, A.Walker, J.K.Pinto, D.Lock and others, but rather to review current concerns raised by professionals and academics alike regarding the status of project management. This will be conducted by exploring some of the current suppositions, deliberations, thinking and alternatives related to project management that have been published in major journals and conferences. Issues, trends and concerns influence the project management environment, sometimes even impeding the progression of the field. The review will provide the required insight in order to make an informed evaluation of the results obtained.

As the behavioural and social implications of projects take a more centre stage, the leadership or management style of the PM is a topic which requires reviewing. In particular, when considering how PMs should deal with complexity, the style of the leader of the transient teams is also of significance. Therefore, several theories regarding management style are reviewed and a number of questions are raised which require investigation in the current situation.

Finally, a review is undertaken covering the latest thinking on measuring the success of the project management outcomes, thus enabling the measurement of the impact that the effects of the complexity of interconnections have.

## 2.2 *Status of Project Management*

Some of the current suppositions, deliberations, thinking and alternatives published in major journals and conferences regarding project management will be reviewed in this section.

### 2.2.1 Project Management

A number of authors, Pinto (2002), Jaafari (2003) and Soderlund (2004), have raised their concerns and note that further research is required to allow for the management of complexity in projects and their environment. Comparing the academic view of the current state of

Project Management against the institutional approach and the practitioners' world, through practices that companies employ, it is clear that the current methodologies do not provide the anticipated / required level of support to Project Managers and particularly so when dealing with complex projects (Turner, 2005). Project Management continues to attract criticism (Thomas and Mengel, 2008) and the gap between Project Management theory and the developing practice is widening (Turner, 2005; Gorog, 2006). A number of concerns are raised regarding the growing criticism of the Project Management Bodies of Knowledge (Turner, 2005; Winter and Smith, 2006), which do not explain the behaviour of complex projects and attempt to codify the principles of project management (Crawford et al., 2006).

The institutional world (APM, IPMA, PMI), including the UK Government, attempt to impose fixity in the processes by introducing initiatives such as PRINCE2, Managing Successful Programmes (MSP), books and bodies of knowledge, as well as levels of competencies and certification (Thomas and Mengel, 2008). At the same time, companies that have a direct interest in project management attempt to provide guidance (BAA, Thames Water), develop their own project management competency courses (Parson Brinckerhoff, Brown & Root) and establish a certain approach and develop their own methods. For example, project handbooks (BAA, Parsons Brinckerhoff, Brown & Root), or the powerful process intranets established by major contractors (Carillion, Laing O'Rourke, Balfour Beatty, MWH and others) are internal project management guidelines or interactive project management tools. In essence most of the initiatives reiterate static and machine-like concepts based on theory developed 50 – 60 years ago (Morris, 1994). Furthermore, the predicament of project management is not just that the processes were developed half a century ago, but that the practice is now faced with the complex issues generated from the backlash of social behaviours instigated by a set of incorrectly implemented processes. In addition, the majority of the processes promoted, e.g. CPM, PERT, RM, EVA, are Newtonian and developed by engineers (Bertelsen, 2002a). None of these, when implemented, considered the effects of non-linearity, the impact on social behaviours, teamwork or the depth and breath of issues around the structuring of project teams.

In addition to the challenge that socio-behavioural issues pose for project management, it is confronted by the ambiguity regarding its status as a profession or an occupation (Turner, 2005; Gorog, 2006) and by the fact that promoting the use of 'Bodies of Knowledge' implies that it remains an avowal of faith (Gorog, 2006).

### 2.2.2 Profession or Occupation

A challenge that each and every Project Manager faces is establishing their status. Construction organisations employ Project Managers based on their past experience – what has been delivered in terms of projects of a particular type: civil works, building, services, fit-out, etc. and not on their project management capabilities or qualifications (Green, 2002; Ogunlana et al., 2002). Additionally a number of institutions (RICS, CIOB, IChemE) have created and are expanding into Project Management as an occupation - stream of their 'sphere of influence' - with the exception of the Association for Project Management (APM), which, apart from Project Managers, incorporates a number of other disciplines within project management, for example, planning and project control. Therefore, from the practitioners' side there is no clear understanding of whether project management is a profession or an occupation. Concerns have been raised in journals of project management (Turner, 2005) and with papers in conferences (Gorog, 2006) regarding the status. Turner (2005) argues that project management cannot be characterised as a profession because:

- It is not recognised as a proper academic discipline
  - reason: It is not known where the academic community sits. Is it within management, engineering, the built environment or computer science?
- There is no sound theory of project management. It is based on empirical rather than theoretical knowledge;
- Of the lack of academic research conferences; and
- Of the recognition afforded to the research journals.

Earlier, Turner (1999) had indicated that attempts by APM and PMI to establish a foundation for project management by issuing the Project Management Book of Knowledge and the Body of Knowledge respectively is 'knowledge based on conjecture' rather than theory.

Gorog (2006) also questions whether project management is a profession or an occupation and indicates that, for the latter, the phenomenon of 'best practice' will suffice, whereas for the former, a more robust theoretical basis is required. He also draws a distinction between the terms 'use' and 'apply'. The term 'use' implies '*the employment of a certain project management device*', whilst 'apply', implies '*the employment of the best-suited project management device within a certain organisational context*'. He postulates the need to move project management from the status of and 'occupation' to that of a 'profession' by establishing premises and axioms. This will enable the setting of a base which will allow PMs to '*apply*' best-suited devices and distance the profession from the '*phenomenon*' of best practice, which is powered by the machine metaphor. By doing so, this will allow it to move towards metaphors '*embedded in context*' and thus consider the profession in the dynamics of its environment (Green, 2006). Enabling project management to shift from the machine metaphor to more appropriate ones, or consider combining metaphors (Morgan, 1997), requires a shift in mindsets and re-thinking of the processes which have not been reviewed since the 60's (Wild, 2001). More powerful concepts such as those considered by Moore (2002) could be used to refute or at least raise reservations about the applicability, thus enabling a gradual shift.

### 2.2.3 Refuting a metaphor from within

The use of metaphors as a tool to translate and gain insight into the concept to be analysed has been employed extensively by a number of authors (Grant and Oswick, 1996; Morgan, 1997; Green, 1998).

The machine metaphor encompasses the systems engineering approach to project management where projects are considered as open, as opposed to closed, loop systems (Moore, 2002). Projects as open systems influence and are influenced by the external '*conversion process*' (Moore, 2002). However, since projects are considered as systems then these must expend energy; any system that expends energy obeys the basic laws of thermodynamics and the second law of thermodynamics states that as the universe is winding down it becomes increasingly disordered (Moore, 2002). In order for any system to become efficient and be 'in control' it tends to keep the levels of entropy very low. Therefore there is a natural tendency for an open system or project to attempt to stay in a state of order - law entropy - against a law which states that things are increasingly becoming disordered and attempts to convert low entropy systems into high entropy ones (Moore, 2002). Whereas closed systems, by their nature, cannot react to this universal power, open systems identify the risk and, in order to conceal the fact, they introduce disorder or spontaneous changes which consequently increase entropy. However, a system in disorder, or continuous introduction of change, requires flexibility, thus, in the case of project management, the linearity imposed through best practice and standardisation causes more problems. Following this reasoning, it becomes clear that the machine metaphor, when considering the system engineering approach, refutes itself. Thus it can be deduced that there is a failure in the machine metaphor and the concept of projects as systems controlled by predetermined models e.g. best practice.

Despite the above conclusion, companies, institutions and government bodies are still promoting the machine metaphor. Perhaps the time has come for project management to be looked at through other metaphors and from a different perspective in order for it to become a profession. A number of metaphors have been described by Morgan (1997) and could be used by PMs during the delivery of the project. However, from a recent review of the literature a more topical metaphor is emerging, that of the 'dramaturgical' metaphor (Green, 2006). Following Handy's (1993) trail of thought - who first used the theatre metaphor - Green (2006) employs the metaphor to depict PMs participating in the 'project management drama' where the overall plot is the challenge to generate reality for the audience '*that will capture their imagination and commitment*'. This, as Green (2006) indicates, could be useful when considering the '*context of micro-worlds*' within projects.

Paradigms also exert a powerful influence in describing alternative perspectives and allowing for different mindsets to be considered. Some recent paradigms can be combined to enable an improved description of the project management challenges.

### 2.2.4 Projects as disturbances

Wild (2001) states that '*projects are streams of disturbances punctuated by crises and occasional episodes of calm*'. Considering that every project is a change (or causes a change) to its environment, be it physical, process, or otherwise, it is therefore a stream of disturbance. As this disturbance flows down in time, as the main physical unit of measuring change around us, we are progressively attempting to cope with or obstruct this disturbance to our environment. The obstruction is either in terms of wanting more or less of the outcome or even minimising the effect of anaclytic behaviour blues (Harvey, 1999). These obstructions could be induced by individuals or groups, and could also, include mistakes or omissions which become incumbent pathogens (Busby and Hughes, 2004). These pathogens, depending on their magnitude, cause crises of different scales. A number of reasons, such as an omitted detail in a project brief, a rushed drawing, a delayed delivery, a change or inappropriate appointment of personnel, a clash of personalities, reporting noises (Antoniadis et al., 2006) could cause crises, small or large. Understanding the cause(s) for these disturbances and identifying and taking the appropriate actions to prolong calmness is the role of the PM and this is why metaphors and paradigms become an apposite tool.

### 2.2.5 The Memetic paradigm for Project Management

Memes can be considered as recipes or instruction manuals for doing something cultural (Dennett, 2003). This includes behaviours, words or sounds that are copied from person to person. A memetic approach to cultural and economic evolution considers evolution occurring for the good of memes.

A memetic approach to Project Management would consider the evolution of ideas, concepts, theoretical models, methodologies and practices as behaviours driven by self-interested memes. Whitty (2005) compares the traditional consideration of project management against the memetic and makes the following two statements:

- '*Traditionally, Project Management is considered to be a conscious initiative, a means for individuals or organisations to control and adapt to their environment, and to make sense of the world in a reductionist way.*'
- The '*Memetic theory suggests that Project Management behaviour is driven by our interpretation of reality; a reality largely created by the language we use.*'

The memetic consideration of project management could be used to explain why projects vary since people's behaviour varies not just from project to project, but from day to day and the complication increases as, in the memetic consideration, it is '*created by the language people use*' (Whitty, 2005). Additionally, under the memetic paradigm, the Body of Knowledge (BoK) and similar tools are considered as 'repositories of ideas' (Whitty, 2005).

However, one could compare the benefits of such memes against points made earlier (Turner, 1999; Gorog, 2006).

Whitty, referencing Senge (1990), describes how we use mental models and language to explain and understand the world and carries out a linguistic interpretation of the definition of a project in the PMI BoK. He indicates that '*the attributes of a project are highly subjective*' and that '*projects are simply a synthesis of human sensation and expectations about how multiple resources are used*'. Using this description, he concludes that it is the project that drives the Project Manager, the team and the stakeholders, rather than the other way round. '*Memetically the PMI BoK is considered to be a vehicle for recording and propagating a recipe for creating projects.*' Whitty emphasises the critical role of the project team to the project. Furthermore, he supports the idea that teams are not simply the sum of the individuals, nor that teams should go into an autopilot when they get on a project.

Depicting project management as a set of memes, defined by the Oxford Dictionary as 'elements of culture that may be considered to be passed on by non-genetic means, especially imitation', enables or rather exposes those memes / behaviours or interpretations that are false. One would agree with the memetic view that the social systems are constructed by knowledge processes, however, the local culture intervenes dramatically to give these knowledge processes a local characteristic(s). That is the reason behind the APM BoK being so different to the PMI BoK, or why the Japanese approach to construction (and its management) is so different to the ones practised in the UK or USA. It is the local culture that formulates the knowledge processes which construct the social system. However, in the current climax of globalisation, one could imagine the fierce battle(s) between the local project management memes against the global ones, or even the one between Eastern versus Western societal / philosophical approaches, or the linear Newtonian view versus the non-linear complex one.

A concern that is raised, if we are to consider project management from a memetic perspective, is the fact that all those who practise project management, and those who have done so for the past 50 years, do not follow / implement those memes. For example 'Fail to plan is a plan to fail' and 'Project Life Cycle' are only two of the memes that Whitty (2005) quotes from Dvir, D., Raz, T. and Shenhar A.J. (2003) for the former and Labuschange, C. and Brent, A.C. (2005) for the latter, yet neither of these are followed (Morris, 1994; Winter and Smith, 2006). Furthermore, concerns are raised regarding the memetic paradigm and could say that the memetic perspective should be stronger within a company, since processes, practices and 'traditions' are more closely followed within a company. However, we see that even when forced, e.g. through the various standards that companies establish, personnel do not always follow them. We also see that things that 'are always done this way' and do not conform to the memes within BoKs. Therefore the memetic perspective does not provide us with any clearer an approach to understanding why globally accepted Project Management recipes are not followed in practice.

What is ignored when describing a project as a '*synthesis of a human sensation*' (Whitty, 2005), is that a number of systems that are interconnected in order to deliver the expected outcome are all reduced to a sensation. The importance of the transient, dynamic and complex adaptive systems (Moore, 2002; Bertelsen, 2004) are oversimplified and as a sensation it does not provide any insight into the complexities. This argument is weakened further if we acknowledge that memes deposited in BoKs are not implemented, or indeed considered to be the obstacles that have kept project management stuck in a time warp back in the 1960's (Morris, 1994).

### 2.2.6 The Virtual Project Environment

If we are to consider the project as a '*synthesis of a human sensation*' (Whitty, 2005) we will also have to make allowances for the current project world which is becoming increasingly virtual. Edum-Fotwe and McCaffer (2004) indicate that there is a need for a new paradigm for managing in a virtual project environment. As flexibility increases it necessitates '*greater individuality and consequently more teamwork*'. However, it also increases the need for trustworthiness, fidelity, responsibility and reliability. The paradox identified by the authors is that of a simultaneous increase and decrease in control. This is actually demonstrated by the remoteness of the team members - '*lack of face-to-face contact*' - and at the same time the requirement to ascertain that the PM knows what is going on. Therefore, there is a shift in the control function from "*what is done to who does it and how does it interface with the other tasks and activities*".

### 2.2.7 Assumptions-led projects

The project environment is becoming more virtual and some initial steps are taken by companies and academia to explore the benefits of 'Second Life', as some very recent research has shown (Kapogiannis et al., 2008). Projects and project management processes are still initiated with high levels of uncertainty, or a '*high assumptions to facts ratio*' (Thiry, 2002) and tools and techniques are used to accelerate '*knowledge of the project situation through information gathering*' in order to reduce uncertainty (Thiry, 2002). However, because project delivery becomes a project success factor, for continuity purposes an 'as soon as possible' approach to delivering the project is adopted and a number of assumptions are made. For example, it is assumed that:

- Project management processes, tools and techniques will automatically kick-in and resolve all problems and uncertainties and that knowledge will be embedded to all within a matter of days;
- The approved business case has covered all issues and has answers to all questions;
- No fundamental changes to the scope, or the contract or commercial strategy will occur;

- The team that will meet, or not in the case of virtual teams, for the first time will operate like a well-oiled machine.

Given that the above 'assumptions' are not met, Bertelsen (2002b) raises the question of whether project management is a 'wicked' problem.

### 2.2.8 A 'wicked' problem

*As described in the previous section* and from the work by Rittel and Webber (1973), *it* can indeed be said that project management is a 'wicked' problem. The dependency of the solution on the actual status is what has been portrayed as being a 'wicked problem'. Wicked problems are also described by www.poppendieck.com/wicked.htm as the problems where, as the solution evolves, the preconditions to the problem change. This occurs frequently in construction and a simple example could be a change in the project brief because of stakeholder / project environmental influences (Hughes, 1989).

### 2.2.9 Project Management definition

Bertelsen (2004) argues that it is the understanding of the construction process that remains incomplete, pointing out that construction projects are essentially led by engineers and accountants, whose basic approach is process / order driven, rather than one that treats projects as a living organism (Morgan, 1997). Linearity and ordered systems exist only in theory (Bertelsen, 2004) and we attempt to simulate the real world by approximation (D'Azzo *and Houpis, 1981). The traditional and narrow* understanding of construction processes (Bertelsen, 2004; Green, 2006) has 'imposed' a transactional approach to managing projects (Walker, 1996) which does not consider *'the underlying processes of social construction'* (Green, 2003), or the complex and dynamic environment.

Project management is in a state of flux and, as already depicted, a number of issues puzzle both academics and practitioners. Current project management definitions, such as those given below, do not encompass the latest thinking or the issues that have been raised above.

A) The project management definition given by the British Standard BS6079-1:2000:

*'The planning, monitoring and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality and performance.'*

B) The project management definition given by APM BoK (2006):

*'... is the process by which projects are defined, planned, monitored, controlled and delivered such that the agreed benefits are realised. Projects are unique, transient endeavours undertaken to achieve a desired outcome.'*

C) The project management definition given by Morris (1994):

*'... the process of integrating everything that needs to be done as the project evolves through its life cycle in order to meet the project's objectives'.*

Therefore a more contemporary definition is required, one which will encompass such issues as complexity and dynamism and the various sides to the project. Such a definition is presented below and supports the approach taken on this research.

> The management of transient, dynamic and complex adaptive systems/agents, so as to deliver the expected change within certain parameters which are set by seemingly ordered and stable environments.

By systems / agents, the definition refers to client and contractor companies, teams, individuals and the project environment. The word 'expected' is preferred because it can represent new / novel as well as other types of projects (e.g. refurbishment, etc.).

The management style of the person that will lead the complex adaptive systems and deliver the expected change is a critical point that needs to be considered. This will be reviewed in the following section.

## *2.3 Management Style*

Whilst considering complexity in project management, one cannot disregard the management style which will enable the management of its effects in projects.

The approach taken in this thesis regarding management and leadership is that recognised by Walker (1996), where *'the two cannot be separated'*, leadership and management in projects are intrinsically linked. A description follows of several theories regarding management style, recognised as prevailing in construction, their importance in the management of the team and the outcome. A number of questions are also raised from the literature review that will need to be investigated. It should be clarified that throughout this work the words leadership and management style will be used interchangeably.

Senge et al. (1999) define leadership, as "*the capacity of a human community to shape its future, and specifically to sustain the significant processes of change required to do so*" and continue on to say that '*...leadership actually grows from the capacity to hold creative tension*'. By this definition, there should be more than one leader in any organisation because there are many people at different levels who play critical roles in generating and sustaining creative tension. This however, conflicts with the linear approach to leadership where things predominate and management is through control, hierarchical linear thinking and mechanical means (Whatley, 1994). In order to attain and sustain a style of creative tension a 'people' approach is required (Whatley, 1994). Brodnick, as referenced by Moore (2002:194), asserts that '*leadership in non-linear systems emerges from the dynamic <u>interactions</u> between their sub-systems*' (underlining by author). In particular the management style required for non-linear systems calls for adaptability, openness and an understanding of the relationships of the whole, not just the part. In linear systems things preponderate whereas in non-linear, complex adaptive systems, people prevail Whatley (1994). Such an approach is taken in the automotive industry by Toyota where the leadership style supports a 'people involvement' approach in a 'learning organisation' (Liker, 2004).

In an environment where change is continuous, such as that of construction, one might envisage that the three types of leaders proposed by Senge et al. (1999) could be suitable. These types are:

1. The local leaders
2. The internal leaders
3. The executive leaders

In a similar approach, Walker (1996) indicated that leadership should be charismatic, inspirational and forward thinking and, in describing construction projects, he identified the 'operating' and the 'management' systems. Personnel in the former have professional / technical skills and those in the latter have management skills. The operating system is led by the management system which *'carries out the decision-making, maintenance and regulatory activities'*. Indeed the PM's ability to integrate, understand and motivate people in the operating system and manage relationships with all the parties is essential (Walker, 1996). The PM's leadership style is, amongst other things, one of the factors that influences the teams' creative effort (Johns, 1995; Moore, 2002; Crawford, 2005), or, at the other extreme, one that causes projects to fail (Applebaum, 1982). Gardner (2006) emphasises that the successful teamwork outcome depends on management style and the skills of the manager, rather than the technical expertise and Handy (1993) suggests that there are three possible criteria for effective leaders:

1. Leadership traits: effective managers have certain common traits
2. Leadership styles: effective managers adopt certain styles
3. A contingent approach: effective managers adapt their styles to suit the circumstances.

A comprehensive list on leadership theories and brief information on each one is shown in Table AP.A-2.1 in Appendix A. The table was compiled from an extensive review by Turner and Muller (2005) as well as the author's literature review on the subject. Turner and Muller (2005) indicate that there are six main schools of Leadership theory:

1. The Trait school
2. The Behavioural or Style school
3. The Contingency school
4. The Visionary or Charismatic school
5. The Emotional Intelligence (EI) school
6. The Competency school

Turner (1999) identified four management styles for effective project management, shown in Table 2.2, and described the level at which the three parameters – team decision-making, team decision-taking and flexibility, were implemented by each management style, shown in Table 2.3.

Table 2.2. Four management styles for effective project management (Turner, 1999)

| Management style | Description |
|---|---|
| Democratic | Consult their team and then take action |
| Autocratic | Dictate to the team what is required and how it should be done |
| Bureaucratic | Management through rules and procedures |
| Laissez-Faire | Allowing the team to get on with the work and manage themselves. |

Table 2.3. Level of implementation of the three parameters by management style of project manager (Turner, 1999)

| Parameter | Laissez-faire | Democratic | Autocratic | Bureaucratic |
|---|---|---|---|---|
| Team Decision-making | High | High | Low | Low |
| Team Decision-taking | High | Low | Low | Low |
| Flexibility | High | High | High | Low |

Whereas Frame (1987) suggested that a different PM should be allocated by project stage, Turner and Muller (2005) matched each one of the project management styles to a corresponding project stage and the type and the 'character' of the teams that need to be managed (see Table 2.4 below).

Lansley (1994) also identifies three management styles which focus on the orientation taken by the leader, shown below in Table 2.5

Table 2.4. Leadership styles, project team types and the project life cycle by Turner and Muller (2005)

| Leadership Style | Stage | Team Type | Team Nature |
|---|---|---|---|
| Laissez-faire | Feasibility | Egoless | Experts with shared responsibility |
| Democratic | Design | Matrix | Mixed discipline working on several tasks |
| Autocratic | Execution | Task | Single discipline working on separate tasks |
| Bureaucratic | Close-out | Surgical | Mixed working on a single task |

Table 2.5. The three management styles identified by Lansley (1994)

| | Management Style |
|---|---|
| **Orientation** | **Description** |
| Task / Production | Managers concentrating on matters of '*efficiency, productivity and systems of management control*' |
| People / Relationships | Managers prioritizing people issues such as '*welfare, development and involvement*' as opposed to their personal position in the organisation |
| Corporate | Managers focus on medium to long-term company goals instead of short-term relationships. |

It is important to note that various management styles are to be avoided by PMs. In particular, Applebaum (1982) indicates that mechanistic and bureaucratic management techniques result in failure, whilst Turner (1999) suggests that technocratic, bureaucratic and sales person styles should be avoided.

However, despite the extensive literature available and the emphasis given to the subject, inadequate consideration is given to the leadership style (Edum-Fotwe and McCaffer, 2004) and it is striking how little change has occurred since the mid '60s in construction processes (Wild, 2001). With the changes in the project environment and a more virtual approach being taken, the PM now not only has to bring the teams together but also to manage the boundaries and their interconnection in a virtual environment.

Edum-Fotwe and McCaffer (2004) highlight the need for a new paradigm to manage a virtual project environment and for reducing another dimension of complexity which is introduced by the '*group's interactions*'. The difference between the traditional project managers is that they work '*in the system rather than on the system*' and the PM of the former must have the following characteristics:

- *Provide leadership through decision-making*
- *Act as a catalyst for results*
- *Facilitate the decision making of other project team members*
- *Act as coach and mentor*
- *Act as a living example.*

In addition to the above, Edum-Fotwe and McCaffer (2004) and Turner and Muller (2005) identify a number of issues and responsibilities that PMs will need to address through their leadership style. These are:

- *Technology*
- *Culture and Ethics*
- *Autonomy*
- *Isolation, Respect, Trust, Honesty,*
- *Prudence, Courage,*
- *Responsible use and sharing of power.*

In the new virtual project environment a new style of leadership should include activities such as team and task integration, business analysis and emotional intelligence (Edum-Fotwe and McCaffer, 2004). With regard to emotional intelligence and the Eastern style of management, Pheng (1995) advocates that PMs who want to '*effectively complete their project*' should take note and manage by using Lao Tzu's 81 chapters of the *Tao Te Ching*. Translated literally, Tao Te Ching means – the '***how*** (Tao) things ***happen*** or ***work*** (Te) ***book*** (Ching). Pheng (1995) indicates that '*Tao is simply the Way of Life. It is about living naturally, effortlessly, spontaneously and correctly*'. He also points out that '*unfortunately management in the construction industry is often reduced simply to the use of barcharts, networks and resource allocation programmes*'. Recently in the West, authors (Coleman et al., 2002) described emotional intelligence as part of the required management competencies necessary to lead. A comparison has been performed between the Eastern style of management, advocated by the introduction of Lao Tzu's teachings, and the work by Coleman et al. (2002:39) on emotional intelligence and the required management competencies. The correlation between the two is immediately noticeable and can be seen in Table AP.A-2.6 in Appendix A. The reciprocal emotional bond between the leader and the led, as well as between the team members themselves, has also been stressed by Harvey (1999) who indicates that there should be attachment and connection.

The management style of the '90s had a participatory approach, which dictated a flatter / broader structure on the company side, setting up cross-functional teams in order to serve the customer, however, the role continues to evolve and the manager is now becoming more of a coach (Johns, 1995). The avoidance of rigid management controls and the persuasive powers of the PM, who aims to synthesise and mobilise a transient organisation of human elements, plays a very important role. This is also highlighted by Blackburn (2002) who proposes that the mobilisation of an evanescent organisation, which comprises human and non-human elements in an actor-network, is enhanced by the PM's managerial, personal and learning skills. Recent research into communities facing complex and uncertain challenges (Gosling, 2006) shows that '*the most effective leaders are those with a sense of repose – a tolerance for uncertainty coupled with self-aware creativity*'. Therefore, instead of the PM being viewed as an orchestra conductor, we should consider her/his leadership using the jazz metaphor (Harris, 2006). The jazz metaphor of management style is closer to the real world view, with its uncertainty, required flexibility and understanding of the environment.

For the transformational leadership style (see Table AP.A-2.1), which runs so close to the jazz metaphor, Partington (2003) indicates that it relates to the leader's charisma, inspiration, consideration and stimulation of the individuals being led, as opposed to the transactional style (see table AP.A-2.1) which gives more emphasis to a mechanistic approach of '*goals, tasks and performance*'. Expanding on the transformational style, '*the leader creates a compelling narrative about the missions of his/her organisation or polity; embodies that narrative in his/her own life; and is able, through persuasion and personal example, to change the thoughts, feelings and behaviours of those whom s/he seeks to lead*' (Gardner, 2006:7). Partington (2003) points out that although the transformational 'move' started by focusing on the few business leaders who exhibit the characteristics mentioned previously, it has been found that when leading organisational change, middle-level leaders with sapiential authority, are those who display a more 'extraordinary vision of the future' and initiate and lead changes. However, in projects, those with sapiential authority are frequently ignored (Moore, 2002). The middle-level leaders, usually PMs, live in a company environment that is governed by internal narratives which dictate their career paths (Green, 2006), depending on the prevailing power group. Management styles could be easily influenced by current as well as future/evolving narratives. Company narratives of course cannot be ignored and PMs, apart from being aware of this, will need to consider the future and their career progression. Rejecting standard tools and techniques (Green, 2006) and considering what the future attributes are (Gardner, 2006) should constantly be in the PM's mind.

In describing the five minds of the future – disciplined, synthesising, creating, respectful and ethical, Gardner (2006) highlights the fact that we need to decide '*which minds are crucial, which to prioritise, and how to combine them within a single organisation* (organisation narrative), *as well as within a mind*'. Therefore, in terms of projects, PMs need to consider how to lead, how to select the team members and how to combine these minds into a team as ultimately, it is the minds that will deliver the project. Gardner (2006) proposes that leaders should consider how to mobilise peoples' skills so that the whole team remains up-to-date continuously. Therefore the leadership style, when it involves interdisciplinary work, is critical as it aims to combine the different minds (Gardner, 2006).

Turner (1993) indicates that leadership, organisational structure, the evanescent and changing nature of projects and peoples' behaviour are intricately connected. The element of the management of change, apart from being included in the definition of leadership, by Senge et al. (1999), is also included in the definition of project management. For the latter it signifies the fact that PMs will need to consider that a component of the change to be managed is peoples' resistance to change, as well as the management of the 'break-up' period of the project (Moore, 2002). Therefore, proposals are made for the management style to include various traits which will reduce people's resistance to change (Yoram Wind and Main, 1998). However, there is a particular view (Harvey, 1999) that the concept of resistance to change is inappropriate and that peoples' behaviour during change should be considered as one that is affected by the '*anaclytic depression blues*'. The definition for anaclytic depression given by Harvey (1999) is that it is '*a form of melancholia that we often experience when the individuals, organisations or belief systems that we lean on or are dependent on for emotional support are withdrawn from us*' (Harvey, 1999:112). One could envision the relevance and effect of '*anaclytic depression*' on project personnel working in the transient nature of the project environment.

Thomas and Mengel (2008), in an extensive review of project management education material, highlight that very little is currently covered regarding the management style to be followed when dealing with complex adaptive systems such as teams. In particular, they state that there is concern that PMs are not educated on transformational leadership and that there is a need to equip PMs so that they are able to sense the prevailing conditions and lead / act accordingly. From a different viewpoint Busby and Hughes (2004) indicate that there is an incremental insensitivity towards the project idiosyncrasies.

In terms of the management style followed, a number of fundamental questions are raised which require investigation:

- Is there a prevailing management style currently followed by practitioners?
- Is there one or more than one management style being followed?
- Who decides on the management style to be followed?
- Who identifies the leadership style requirements for the specific project, and how is this done?
- Is the management style affected by other project management processes?
- Is management style considered to be an instrument for managing complexity?
- Are complexity characteristics considered when deciding on the management style to be followed?
- How much complexity / uncertainty stems from the PM's leadership style; especially in the case when the style of the person/PM does not 'fit' the project environment?
- Would PM practitioners agree with the literature review findings regarding management style affecting project outcome?

Some of the questions outlined above have also been raised recently by other authors. For example:

- Makilouko (2004) indicated that there is a people-oriented approach,
- Lee-Kelley et al. (2003) highlighted the fact that almost half of their sample had a relationship-oriented approach,
- Keegan A, and Den Hartog (2004) established that there was no significant link between the PM style implemented and the transformational approach,

However,

- Thamhain (2004a) demonstrated that the role of the PM as a leader is very important and more significantly confirmed the influence it has on the project team and the impact that the working environment has on project success.
- Cheng and Dainty (2005), after a detailed investigation, identified team leadership as one of the 12 core behavioural competencies which support effective project management performance.

The above also emphasise the issue of having to identify a viable means of measuring objectively the project management outcome; an issue which will be addressed in the following section.

## 2.4 Measuring Project Management Outcome

For any profession to have a theoretical basis it requires axioms and premises (Gorog, 2006). One of the three axioms proposed by Gorog (2006) is the role that projects play in organisations and in particular the fact that the long-term success of the organisation is dependant upon projects being successful.

In the project success context, under the machine metaphor presented by Gorog (2006), consideration is given only to the financial success of projects. This has been the case in project management for the past fifty years and also the reason for which time, cost and quality - '*two best guesses and a phenomenon*' (Atkinson, 1999) - have remained in the driving seat for so long. However, project success is a topic where there is very little agreement (Liu and Walker, 1998). A particular point that is raised in the literature is that the PMs' leadership style and competencies are not considered as a contributing factor to project success (Turner and Muller, 2005), even though he/she leads transient organisations through streams of disturbances (Wild, 2001) and is involved in dealing with pathogens (Busby and Hughes, 2004). This does not agree with the general organisation management literature (Handy, 1993; Senge et al., 1999).

Another issue outlined by Liu and Walker (1998) regarding project success, which was initially highlighted as far back as the 1970s by Murphy et al. (1974), is that success is a matter of perceptions and therefore it should be termed '*perceived success*'. Additionally they accept that aggregating perceptions would always remain a problem and therefore we can only evaluate individuals whose perceptions '*could be reasonably common*'. Some of the major issues raised by Liu and Walker (1998) regarding project success are:

- Individuals' perception of success;
- Transferability from one project to another;
- Incorporating peoples' satisfaction; and
- Using an explicit definition for performance.

An issue that is raised in the field is that of the distinction between project success and project management success. As a result of an extensive study, Cooke-Davies (2002) described this distinction as one that is measured against overall project objectives for the former and one measured against the traditional cost, time and quality for the latter. Another extensive empirical study by Collins and Baccarini (2004) indicated that project management success is subordinate to product success, but it exerts great influence on the latter. However, they indicated that both product and project management success are components of project success criteria. They also differentiated between project success criteria and success factors by indicating that the former measures success, whereas the latter acts as a facilitator (Collins and Baccarini, 2004). Figure 2.1 below depicts Collins' and Baccarini's (2004) description of Project Success Criteria and in particular details on the Quality of the Project Management process. Project success criteria similar to those in Figure 2.1 are proposed by Nicolini (2002) as project determinants, and by Kendra and Taplin (2004) as dimensions of project success and these are shown below in Table 2.7. Wateridge (1995) also indicated that the primary success factors for a '*happy team*' are leadership, motivation and the management method.

Comparing the project success criteria of Collins and Baccarini (2004) (Figure 2.1), Nicolini (2002) and Kendra and Taplin (2004) (Table 2.7), it can be seen that these incorporate / express, to a certain degree, the views of the B-P-O framework described by Liu and Walker (1998).

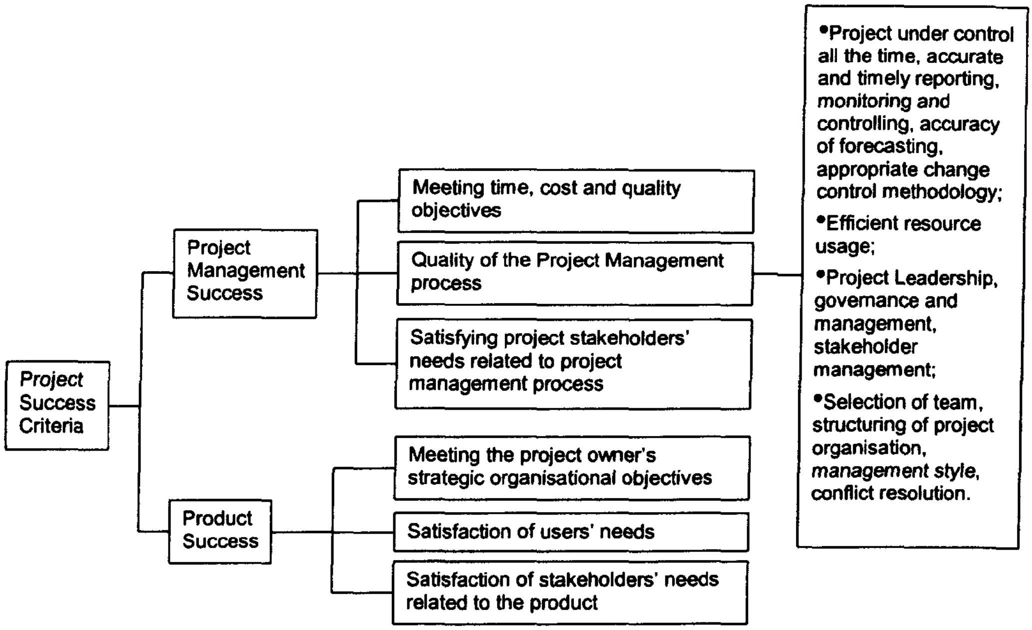


Figure 2.1 Diagrammatic representation of Collins and Baccarini (2004) description of the breakdown of project success criteria and further breakdown of the quality of the project management process variables

Table 2.7. List of project chemistry determinants and dimensions for project success from Nicolini (2002) and Kendra and Taplin (2004) respectively.

| **Project chemistry determinants (Nicolini, 2002)** | **Dimension of project success (Kendra and Taplin, 2004)** |
|---|---|
| • *Team selection and composition;*<br>• *Team development process;*<br>• *Quality of leadership;*<br>• *Boundary management and empowerment of team; and*<br>• *Involvement and well being of whole project community* | • *The Project Manager's skills and competencies;*<br>• *Organisation structure;*<br>• *Measurement systems; and*<br>• *Management practices that represent an organisation's culture'.* |

Therefore, in terms of measuring project success, there is an evident shift from the pure control paradigm to the behavioural. Liu and Walker (1998) attempted to instigate this transformation by proposing the adoption of the Behaviour-to-Performance-to-Outcome (B-P-O) model of organisational psychology in order to evaluate the construction project outcomes. They suggested a two-tier model which is dependant on project success (first tier) and which in turn is highly dependant on participant satisfaction (second tier). The latter is fundamental and will need to consider determinants such as self-efficacy, project complexity, commitment, expectancy, rewards, goals and environmental variables.

It should be noted that Cooke-Davies (2002) indicated that from the 12 project success factors identified, none are concerned with 'human factors'. In reality very little is known about '*the relations between human factors and project outcome*' and, more interestingly, whatever measures do exist, these only address the very high levels of the project organisation (Nicolini, 2002). Nicolini (2002) also indicates that there is a need to focus at the social and human processes at the 'micro-level'.
In addition to allowing for the human factor, construction projects need to consider the evaluation of project success as a continuous process (Collins and Baccarini, 2002) and one that needs to be cultivated at all project levels and throughout the project lifecycle (Nicolini, 2002).

## 2.5 Summary

In this chapter, a review of the status of project management and other current issues was conducted, these being the principal factors within which PMs perform and project management processes are performed.

The practice of project management is in a state of flux and requires a shift from the control paradigm to the behavioural one. Its main actors – the PMs – have to consider issues ranging from professional status, redundant metaphors and new paradigms, which can be used to describe alternative perspectives and allow for a change in the mind set. Additionally, advances in technology, the type of 'wicked' problem with which PMs have to deal, and the need to consider complex adaptive systems exert a higher educational demand, for which there is no provision. Therefore, starting from the basics, a new definition for project management is derived for this thesis, one which contains the elaborate demands on the PMs.

An attribute considered very important when delivering projects, which will be investigated in this research, is that of the management style followed by the PM. The review identified the need for a move from the current transactional style to the transformational, as well as a need to consider emotional intelligence as part of the management competencies. However, research has identified that this is an area in which PMs are neither educated nor equipped to a level that will enable them to make sense of the prevailing conditions and lead accordingly.
A number of questions have been raised regarding the management style to be adopted, which will need to be examined in order to establish the current approach and the management style followed by the PMs. These are:

- Is there a prevailing management style currently followed by practitioners?
- Is there one, or more than one, management styles being followed?

- Who decides on the management style to be followed?
- Who identifies the management style requirements for the specific project, and how is this done?
- Is the management style affected by other project management processes?
- Is management style considered to be an instrument for managing complexity?
- Are complexity characteristics considered when deciding on the management style to be followed?
- How much complexity / uncertainty stems from the PM's management style; especially in the case when the style of the person/PM does not 'fit' the project environment?
- Would PM practitioners agree with the literature review findings regarding management style affecting project outcome?

Finally, as every output requires measurement, a review is conducted of the approaches taken to measure the success of the project management outcome. Progress is being made towards the inclusion of behavioural criteria for evaluating project outcome and in particular the inclusion of processes such as those investigated by this research.

In the next chapter, and as required by the first research objective, a review is conducted of the project management sub-process for selecting project team members, which is part of the concept of 'how we organise projects'.

# Chapter 3 – Team selection

## 3.1 Introduction

In this chapter various areas of the basic project management sub-process of selecting team members are examined in order to establish the basic thinking and the required approach for performing the sub-process as well as findings from earlier research conducted on the topic. Thus, one of the two sub-processes considered in the first objective of this research is addressed.

The following three sections will elaborate on issues about 'Teams', 'Individuals' and the 'Environment / Organisation'. On the first subject a comparison is conducted between groups and teams and the role of the individual in teams is examined. In terms of 'individuals', the current techniques for selecting team members and the individuals' behaviour are reviewed. The role of the environment / organisation is also examined in terms of the culture and behaviour of the organisation, discussing points raised by Belbin (2000) and others as well as by Morgan (1997). The effect of the project and the company's organisational structure is also reviewed with regard to points raised by Mintzberg (1979), Newcombe, et al. (1990), Galbraith (1973) and Moore (2002). This section will close with a review of the environmental influences on this specific sub-process. Finally, the chapter raises a number of concerns from earlier investigations regarding the status of the sub-process within construction.

## 3.2 Teams

The power, the impact and the contribution of teams to a project's success (Pells, 2007) and the importance of the PM's role in fusing together the team(s), has been highlighted by a number of authors (Moore 2002; Thamhain, 2004a; Turner and Muller, 2005; Mishra, 2007). Rahman and Kumaraswamy (2002) indicate that implementing '*relational contracting principles*' whilst promoting teamwork and improved relationships, contributes to the reduction of transaction costs. Nicolini (2002) describes how '*project chemistry*' contributes to a successful project outcome and references the work done by Anderson and West (1996, 1998) who developed a model to improve the team climate - '*team climate inventory*'.

Selection of team members, formation of teams and style of work have been areas widely analysed in other industries and the general management field with authors such as Osburn, et al. (1990), Wellins, et al. (1991), Handy (1993, 2000), Parker (1994), Maxwell (2001), Coleman et al. (2002), Belbin (2000 and 2004) and Liker (2004), demonstrating the importance of these processes. Kozlowski and Ilgen (2006) also point out that team designers *need to know exactly what is important to team members, understand that teams need to be* adaptive and flexible and that the design should support the goals. However, construction has not advanced much in this field (Donovan, 1996; Moore, 2002; Green, 2002 and 2006) and has remained very enclosed, still following the traditional fragmented ways. In particular, Donovan (1996) indicates that, even though during the 90's 'self-directed work teams' in other industries had increased dramatically, the construction industry has hardly moved despite the fact that the proposed structural arrangement has been hailed as *'a natural evolution from the various types of ad-hoc problem-solving teams of the '80s'*.

### 3.2.1 Groups Vs Teams

Literature frequently uses the words 'group' and 'team' interchangeably. However, in construction, teams are considered to be the evolutionary step for groups, with individuals being brought together and developed into teams during the project lifecycle (Moore, 2002). A comprehensive and project-oriented definition of a team is given by Cohen and Bailey (1997), 'a *team is a collection of individuals who are independent in their tasks, who share responsibility for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems, and who manage their relationships across organisational boundaries*'. Belbin (2000) also stresses that there is a profound difference between team and group and that the word *'teamwork has become a fashionable buzzword – one commonly applied to any group that needs to be presented in a favourable light'*. Belbin (2000) identifies six differences between teams and groups and these are shown in Table 3.1.

Table 3.1 Differences between teams and groups (from Belbin, 2000, Figure 3)

| | Group | Team |
|---|---|---|
| **Size** | Medium to Large | Limited |
| **Selection** | Immaterial | Crucial |
| **Leadership** | Solo | Shared or Rotating |
| **Perception** | Focus on Leader | Mutual Knowledge Understanding |
| **Style** | Convergence, Conformism | Role spread, Coordination |
| **Spirit** | Togetherness, Persecution of opponents | Dynamic interaction |

On the practical side Mishra (2007) indicates that the characteristics of a high-performing team are:

- *Sense of purpose*
- *Trust and mutual respect*
- *Effective working procedures*
- *Building on differences*
- *Flexibility and adaptability*

He continues by highlighting the fact that team leaders need to identify a set of behaviours which will be adhered to / adopted and expectation will be defined by words such as '*timeliness, commitment, availability*'.

In addition to the distinct differences highlighted above, another relevant area that has also been investigated and authored widely is that of the differences of thinking and functioning between groups and teams. Manz and Neck (1995) initially and then Walker (1996), Moore (2002) and Reid (2003) have outlined the important differences when thinking of groups and teams, now commonly known as 'groupthink' and 'teamthink' respectively and the comparison of their descriptions and 'symptoms' are shown in Table 3.2.

Table 3.2. Description and symptoms of groupthink and teamthink (Manz and Neck, 1995)

| **From Groupthink** | **To Teamthink** |
|---|---|
| Description | |
| Group members striving to agree with one another; overwhelms adequate discussion of alternative courses of action. Defective decision making results. | Groups engage in effective synergistic thinking through the effective management of its internal dialogue, mental imagery, beliefs and assumptions. Enhanced decision-making and team performance result. |
| Symptoms | |
| • Direct social pressure against divergent views.<br>• Self-censorship of concerns<br>• Illusion of invulnerability to failure<br>• Illusion of unanimity<br>• Self-appointed mind guards that screen out external information<br>• Collective efforts to rationalise<br>• Stereotyped views of enemy leaders<br>• Illusion of morality | • Encouragement of divergent views<br>• Open expression of concerns / ideas<br>• Awareness of limitations / threats<br>• Recognition of members' uniqueness<br>• Recognition of views outside the group<br>• Discussion of collective doubts<br>• Utilisation of non-stereotypical views<br>• Recognition of ethical and moral consequences of decisions |

With regard to this investigation some of the most important points that should be highlighted in terms of teams are:

- The criticality of the selection of team members;
- The dynamic interaction that needs to exist;
- The recognition of the members' uniqueness;
- The discussion that needs to exist; and
- The acceptance that there is enhanced decision-making and team performance.

Calling a work group a team and giving them duties and decision making responsibilities is not really the right start (Donovan, 1996). As individuals, we develop patterns / habits in our thinking. Manz and Neck (1995) indicate that the three techniques that influence these patterns are:

1. Belief and assumptions, which we frequently use to manage / deal with problems, e.g. phobias, bad habits, and which with Teamthink are challenged and tested all the time;
2. Internal dialogues (self-talking); and
3. Mental images.

Thought patterns can be produced by combining the three techniques, which can be triggered by events or situations, or even simply become forms of habit. These can then deliver the teamthink – '*a synergistic combination of members' knowledge and cognitive abilities*' (Manz and Neck, 1995). Manz and Neck suggest that to create teamthink a balance should be sought between cohesiveness and team and the '*focus and value should be placed on each individual*'. They also stipulate that it must be accepted that groupthink threatens effective group decision-making. This highlights the case and the importance of teams / teamthink versus groups / groupthink. In an environment such as that of construction, which is transient, dynamic and requires the management of complex adaptive systems/agents, creating a team means allowing for the bringing together, at all levels, of individuals who will combine their efforts to deliver a project. Training individuals and building their skills in working together by instilling '*adaptive team behaviours*' will increase the '*team threshold*' thus improving the capacity to increase resilience (Benton, 2006). This is also confirmed by Thamhain (2004a) who notes that '*today's complex business world requires fast and flexible <u>project teams</u> who can work dynamically and creatively toward established objectives in a changing environment*'. He continues by stating the importance of the PM as '*a social architect who understands the <u>interaction of organisational and behavioural variables</u>, facilitates the work process and provides overall project leadership for developing multidisciplinary task groups into unified teams, and fostering a climate conducive to involvement, commitment and conflict resolution.*' (Thamhain's italicised words have been replaced here by underlining.)

To create an empowering team environment and establish clusters, serious changes will be required in the wider system (Belbin, 2000). Thus there will be the need to:

- Consideration to be given at organisational strategy level (Pells, 2007),
- Identify the management and operational 'system' (Walker, 1996),
- Examine the structure, the jobs, measures and rewards (Donavan, 1996),
- Develop the team objectives and charter (Misra, 2007),
- Make sure that communication, conflict resolution and problem-solving are managed effectively (Donovan, 1996),
- Develop behaviours and skills (Donovan, 1996).

This will then create the necessary *interdependence and autonomy that is the glue for teamwork* (Donovan 1996). To establish and maintain all this requires time and effort, which can pose a challenging task for construction because of the short term / duration of projects. In order to support the setting up of a team environment, at company level and in terms of selecting partners, the Construction Industry Council (2005) has published the Selecting The Team (STT) guide which describes in three stages how companies should proceed.

In terms of the lower organisational levels, and from the general as well as project management literature (Galbraith et al., 1993; Walker, 1996; Turner, 1999; Moore, 2002; Liker, 2004), it can be deduced that there are five key steps in the selection of teams and team members. These can be summarised as follows:
Step 1: understand the project needs;
Step 2: identify and appoint the right project manager;
Step 3: select team members that meet the needs of the project;
Step 4: supplement the team with experts to cover gaps in project needs; and
Step 5: monitor team performance.

Donovan (1996) defined in detail three steps, six principles and several processes, behaviours and roles that need to be developed for training and instilling a team environment. Tuckman's (1965) four stages – forming, storming, norming and performing - are widely used and referenced, however, for the case of project teams Turner (1993) added a fifth one - 'mourning', which happens at the end when the project is nearing completion and the team is disbanded. Taking a similar approach and specifically for construction projects, Moore (2002) identified six stages - Collection, Entrenchment, Resolution, Synergy, Decline and Break-up. In addition to the steps required and as part of selecting team members and forming teams, Belbin (2000 and 2004) indicates clearly that consideration of personal characteristics is crucial. PMs need to consider the make-up of the personalities in the project teams (Turner, 1993) and issues such as, fragmentation, complexity, diversity of players, stakeholders and changing of boundaries between Client and Project Management roles, require solid investment in project teams (Thompson, 1996).

In defining leadership, Senge et al. (1999) indicate that it grows from '*the capacity to hold creative tension*'. Therefore, in the evanescent and turbulent nature of construction projects, where creative tension needs to be established very quickly, selection of project teams and team members must be one of the most fundamental sub-processes for all levels of the project structure and not only at the management level. However, the problem with the UK construction industry is that it is fragmented and operates through transactional arrangements between various parties, companies, even individuals, who come together under considerable 'environmental' pressures. Additionally, construction technology was, and remains in some cases, the problem with setting up a team environment, which is the reason behind the industry focusing on sequential rather than reciprocal interdependencies (Thompson, 1967). There is no attempt, from within the construction companies, to establish a true, integrated, team-working approach. Turner (2003) points out that organisations became sceptical of the whole process of selecting team members because it was poorly understood, it did not provide results very quickly and it was considered to be too costly. This has been hindered further by the fact that selection of teams and team members became an industry fad where '*to proclaim a belief in teamwork became a safe way for those in middle management and in personnel functions to gain general approval*' (Belbin, 2000).

## 3.2.2 Individuals in Teams

Teams are built and shaped by individuals, thus the significance of the behaviours, characteristics, stimuli and contribution of these people is paramount. The importance placed on the persons can be seen in the model followed by Toyota (Liker, 2004) which takes two years to form a team. Individuals, who are independent in their tasks (Cohen and Bailey, 1997) but come together to form teams, are adults whose personality, behavioural choices and characteristics have been shaped by a number of factors, e.g. education, upbringing and experiences, to mention but a few. From the team's standpoint and in terms of the individual's characteristics, it has been found that when selecting team members they should be:

- Creative, open minded and 'forward looking' (Thompson, 1996),
- Good team players, '*collaborate as members of team*' (Thompson, 1996),
- Using '*judgement*', (Thompson, 1996),
- Well respected among peers, stakeholders, and other business leaders, and
- Having the '*ability to adapt to change*', (Thompson, 1996).

However, from the individual's position, personality, career aspects, professional interest(s) even networks play a particular role. There is a need to understand these issues and support the individual(s) who are to form a team. The importance of understanding personality and how / what are its core components are clarified by Benton (2006) who indicates that the intricacies of personality can be analysed by using Jung's approach (Jacobi, 1973) whereby personality is described in terms of preferences rather than traits. Preferences are generated from '*complex interactions of the fundamental personality structures – attitudes and functions*' (Benton, 2006). Seeing personality as a combination of attitudes – extroversion and introversion, and functions – thinking, sensing, intuition and feeling, allows for the building of '*eight Jungian attitudinal functions which shape the personality preferences*', e.g. extrovert thinking, introvert thinking (Benton, 2006). It has been argued (Manz and Neck, 1991) that behavioural choices and experience of life largely reside in the mind, and that each person sets up standards, evaluation processes and rewards/punishments systems. Therefore, it can be deduced that preferences generate behavioural choices. Understanding the prevailing preferences allows for the mapping of their impact on activities and interactions and thus allows for the overcoming of impediments.

Turner (1993) indicates that different factors affect the team and its members, with perhaps higher levels of pressure concerning personal and career aspects in particular. Whereas, in the past, personnel would strive to prove themselves to their management, now there is no single target. Career development - i.e. personal growth and learning - is the factor that individuals use to judge their development (Turner, 1993). With the rapid development in communications technology and the Internet, individuals in projects are networking in a much wider range of topics - professional and technical interests and projects (Pells, 2007). Views are exchanged and individuals are influenced by a much wider world. Communicative relationships and credibility have become more important and central to the shaping of organisational life (Winter and Smith 2006). Therefore, understating individuals' stimuli becomes a bigger issue.

Lao Tzu, who refused to set his ideas in writing because he believed that written words might solidify into formal dogma, highlighted in his principles the importance of the individual and how they operate within the team (Pheng, 1995). Pheng goes on to confirm that the main focus of Lao Tzu's 'Tao Te Ching' is man and his operation in society. By looking at things with an open mind and forgoing prejudices and biases, individuals can understand what is happening (Pheng, 1995). Some of the principles in Lao Tzu's 81 chapters, although keeping the leader as a central figure (in Pheng's case, the PM), clearly show that there is an equal share of focus on the individuals that form the team. For example:

- *'Knowing how polarities work, the wise PM does not push to make things happen but instead allows processes to unfold of their own accord'.* Here, by using the word '*polarities*', Lao Tzu (Pheng, 1995) highlights the different push-and-pull factors within the team.
- *'The wise PM who understands when to listen, when to act and when to withdraw can work effectively with nearly everyone, even with the most difficult and sophisticated team members'.* Whilst emphasising the need for the PM to understand when to listen, act and withdraw, Lao Tzu (Pheng, 1995) indicates that the mixture of individual characters, which make up a team, can vary vastly.
- *'The intelligent PM knows how other people behave'.* This further confirms the existence of different behaviours between team members and the importance of understanding these behaviours.
- *'The rigid PM may be able to lead repetitive and mechanical exercises but he will never be able to cope with lively team processes. As a rule, whatever is fluid, soft and yielding will overcome whatever is rigid and hard. What is soft is strong'.* The fluidity / flexibility that needs to exist within team members enables stronger teams which can overcome difficulties.

These proverbs can easily be applied to all levels of management, from team leaders to PMs, highlighting the diversity within teams and the requirement for, one could say, character flexibility. Thompson (1996) indicates that '*behavioural understanding*', in addition to other attributes, is considered as a key factor for successful project management. Cerny (2006) also suggests that high project dynamics influence individuals' emotions and therefore leaders will need to be able to understand their effect on project success and manage them successfully.

The importance of the role of individuals in teams was highlighted by Antoniadis (1998) who argued that, when selecting team members, every opportunity must be taken to embody critical dimensions of the environment to every element of the organisation. Project units, whether that is a team member, a team, or a section, must become a gyroscope – the gyroscope paradigm – understanding the environment and feeding back to the team. Manz and Neck (1991) and Benton (2006) also point out that the diversity and uniqueness of individuals affect teams, structures and the quality of the output. The most productive and content team environments are created by ensuring the clarity of the individual roles as well as by selection based on skills and interests (Sommerville and Dalziel, 1998; Belbin, 2000). Identifying team roles, as part of selecting team members, is a very important process and Belbin (2000) has developed nine basic roles that need to be filled in when setting up the team (see Table 3.3). Belbin (2000) argues that individuals should not be placed in a team *'just because they have a particular background but should be selected on the type of contribution they are likely to make'*.

Table 3.3 Belbin roles and description of contribution:

| **Belbin Name** | **Contribution** |
|---|---|
| Coordinator | Coordinating the team's efforts |
| Shaper | Imparting drive |
| Plant | Creating ideas |
| Resource investigator | Exploring resources |
| Motivator evaluator | Evaluating options |
| Implementer (Comp worker) | Organising the work |
| Completer / Finisher | Following up on detail |
| Teamwork | Supporting others |
| Specialist | Providing expertise |

### 3.2.3 Selecting Team Members

The three best known selection and personal profiling tools / techniques are Belbin's roles, shown in Table 3.3, the Myers Briggs Type Indicators and the 16 Personality Factors (16PF). Whereas Belbin's roles are required to set up a successful team, Myers Briggs and 16PF are aimed mainly at the individual as a member. In particular, the Myers Briggs profile is a good predictor of how individuals think and interact in most situations and with most people (Lawrence and Martin, 2001). Additionally, if team members are aware of each other's profiles then teams can operate more effectively. The 16PF technique defines the individual's basic, underlying personality, without particular attention to how or within which environment it is applied. The underlying personality is there all the time, but the way individuals view it is affected by their intelligence, and by their upbringing and education, which may have taught them either to emphasise or suppress aspects of personality (Cattell and Schuerger, 2003). However, if individuals can better understand their personality, they will be able to make better use of the strengths it gives, and make allowances for the resultant weaknesses (Cattell and Schuerger, 2003).

Baiden et al. (2006) indicate that there are a number of challenges that need to be faced and overcome in terms of selecting and forming integrated teams. These are, traditional drivers for project success, project culture, behavioural change and measurements of integration. For the behavioural change, Baiden et al. (2006) suggest that the various fragmented parties have to see themselves as members of the team and to treat each other as '*equal stakeholders*'. The parallel of a dogsled team, including the dogs, can be considered as a paradigm of how each party has a role for which it has been selected and fits the structure that will deliver the task (Hunter, 2006). Another example is given by Harris (2006) who uses the selection of musicians for a jazz group as a paradigm for selecting team members.

Belbin (2004) identified that the importance of considering personal characteristics, in terms of setting up successful teams, stems from the fact that in successful teams there was a distinct absence of highly dominant individuals. This is contrary to the current perception in construction which continues to drive towards a more autocratic / assertive individuals. In support of the fact that teams of high flyers (in terms of intelligence) performed badly, Belbin (2004) indicates that these teams only had the otherwise good characteristic of '*proposing – opposing*', giving too much emphasis to analysis and counter-analysis. These characteristics are indeed required when teams are facing problems, however, these teams fail to consider '*using resources, collecting and exchanging information, recording what is known, coordinating plans and actions*'.

Lawler (1993) proposes six themes and eight practices to be followed when selecting project team members so that expectations are understood and the right attitude, ability and motivation exist. Some selection of personnel for certain levels/roles is currently performed in construction, based on job-task and behavioural competencies, however, Cheng et al. (2005) emphasise that it is important to understand that competencies are an attribute of both the job holder and the job itself. Interestingly, Newcombe (1996) indicates that there should also be a drive from the bottom upwards and project team members must also realise that with increased participation and greater power-sharing comes the responsibility to think bigger and manage better. The sub-contractor mentality must go, along with the label.

Thompson (1996) also indicates that the traditional time- and cost-oriented approach causes 'dilemmas in selecting the team members'. Budgets will restrict the recruitment of expensive and highly skilled personnel for long periods. Similarly, highly structured teams could push away 'free thinkers' with creative / innovative capabilities, which is why Thompson (1996) suggests that this could cause dilemmas and pose a major challenge. It is not surprising then, as indicated by studies involving construction projects, that the appointment of personnel is still performed in a subjective manner (Thompson, 1996; Ogunlana et al., 2002) and that it is race-biased (Hinds et al., 2000). Construction continues to employ a command and control approach (Green, 2002) as opposed to empowerment and commitment despite the fact that, organisationally, has been identified as '*a poor path to performance*' (Senge et al., 1999). Egan (2005) also established that, despite general knowledge and understanding of selection and team formation techniques, managers did not present a selection process that could be described as systematic with regard to team leader priorities for team member selection. Additionally, Green (2002) and Pells (2007) highlight weaknesses in the traditional construction human resource and administrative systems. Policies and procedures for hiring, firing, reassigning and rewarding people need to be revised (Pells, 2007). This is important, if not critical, when considering that project complexity influences the selection of project inputs (Baccarini, 1996).

The findings indicate that, apart from selection of team members, concepts such as group sentience (Walker, 1996), pooled, sequential and reciprocal interdependencies (Thompson, 1967), which can also be applied to team members (Walker, 1996), and even sapiential authority (Moore, 2002) are not considered. Despite all the literature and the bodies of knowledge such as APMBoK, (APM, 2006) and PMBoK (PMI, 2000), one must question the level of application of team selection techniques at the project level in current practice.

## *3.3 The significance of Individuals*

Further to a number of points made above, there is a need to cover various additional points in terms of the contribution of individuals towards the performance of the project organisation, the effect of developments in individuals and the near future requirements as well as the importance of behaviours.

It has been established that the performance of project organisations depends on the people working in them (Turner, 1993; Moore, 2002; ICB, 2006). In addition to the individual's competencies, the ICB (2006) indicates that the project manager will have to consider also '*the personality of the individual and the fit with other team members*'. However, this advice is not followed (Green, 2002; Ogunlana et al., 2002; ICB, 2006) and conflicting personalities continue to cause a number of problems in the performance of some teams. Belbin (2004), having held workshops, emphasised the importance of the selection of individuals who will be able to '*take the tension out of the situation*'. The significance of Belbin's team-roles to construction and the need to build on an individual's strengths was identified earlier by Sommerville and Dalziel (1998). Motivating individuals, monitoring their performance and making sure that they have the required training, tools and information is a PM's responsibility (Jaafari, 2003). The behavioural, motivational and ethical approach towards individuals in teams was also highlighted by Lao Tzu (Pheng, 1995).

Both technological and social changes are affecting the role(s) and the individuals who need to come together to deliver projects (Edum-Fotwe and McCaffer, 2007). In particular, as management layers are thinned out, front-line workers will be required to take on more responsibilities (Thorpe et al., 1998) and will need to understand and perform '*a full range of technical, administrative, ...and predominantly human and social oriented skills*' (Edum-Fotwe and McCaffer, 2007). By resolving organisational and behavioural issues and empowering individuals, performance of both individuals and teams improves (Kanter, 1993; Liden et al., 2000; Courtney and Winch, 2003; Slevin and Pinto, 2004). In particular, Dainty (2002) and Loosemore (2003) indicate that, in a project-orientated structure, empowered working provides a theoretically suitable context where it can be implemented.

The shift towards the importance of behaviours and individuals cannot be stressed more than by giving project management a definition which focuses purely on the management of behaviours. Such a definition is given by Johns (1995) who says that project management is a '*system for managing behaviours needed by people who work together in teams to satisfy the needs of the customer*'. However, what has to be considered is that '*human behaviour operates on a probabilistic not a deterministic* model' (Belbin, 2000).

## *3.4 Environment / Organisation*

Individuals and project teams influence and are influenced by the project environment, the culture, the relationships and the structure of the organisation (Moore, 2002; Pells, 2007) as each project involves hierarchies and networks of teams. These areas are expanded upon below.

### 3.4.1 Culture / Behaviour

The change from the 'control' to the 'commitment' mentality and the required emphasis on the understanding of human behaviour, culture, patterns and situations (Winter and Smith, 2006; Edum-Fotwe and McCaffer, 2007) indicates the importance placed upon individuals and project teams to understand, cope, act and manage effectively such issues. This is not something new, indeed it can be seen from Lao Tzu's statement, '*The intelligent leader* (PM) *knows how other people behave*' (Pheng, 1995). Reflecting on the *participatory approach* of the 90's and the required behaviours articulated by Drucker and Deming, Johns (1995) describes a system that can be used by individuals for understanding patterns and managing behaviours under the acronym COST, which reflects the following:

**C**: Customer focus behaviours;

**O**: Ownership behaviours;

**S**: System for planning, leading and controlling work;

**T**: Teamwork behaviours.

For each behaviour, Johns prescribes the use of a set of standard / existing tools. For example under **S**ystems, he indicates that the behaviours shown in Table 3.5 can be created.

Table 3.5 Use of management tools to create certain behaviours (Johns, 1995)

| **Management Tool** | **Behaviours Created** |
|---|---|
| Objectives | Concurrence, agreement |
| WBS | Control |
| OBS | Accountability, ownership |
| Schedule | Communications |
| Baseline (budget) | Control – Coaching through *measuring, evaluating and acting* |

The proposed five tools are some of the basic elements of the Project Execution Plan (PEP), or the Project Control Handbook (PCH). However, using tools to determine - and, even further, to control - human behaviour is based on the assumption of perfect rationality (Nash, 1950).

Myerson (1999) proposed that '*applied social theorists should find it useful to scrutinise social institutions under the assumption that every member of society will act, within the domain of control, to maximise welfare as they evaluate it, given the predicted behaviour of others.*' The question asked of PMs and project team leaders in construction projects, is if they consider both sides of this statement. That is whether they consider their own position as well as the position of others on their project(s), including stakeholders.

Considering Myerson's statement above from the construction point of view, it could be paraphrased to read as follows (Myerson's statement shown in italicised characters and the authors underlined):

'*every member of* <u>the project</u> *will act, within their domain of control, to maximise welfare* – <u>to deliver the project and during the process get paid, or get promoted, or use it as a step towards promotion -</u> *as they evaluate it* <u>– as this fits their career plan, ambitions, style of living, financial demands, etc.,</u> *given the predicted* <u>- what do they see as -</u> *behaviour* <u>- response, reviews, style of leadership, style of management,</u> *of others* <u>- stakeholders, Clients, managers</u>'. Therefore, the '*Nash equilibria should be a fruitful part of the critical analysis of almost any kind of social institution*' (Myerson, 1999) and one of the most intricate social institutions is the project.

In terms of cultures, a number of authors (Harrison, 1972; Hofstede, 1980; Deal and Kennedy, 1982; Hofstede et al., 1990; Morgan, 1997; Handy, 2000) described various cultures and how these affect individuals and organisations. In particular, Morgan (1997) identified eight organisational metaphors, which help understand and manage organisational change and the forces which shape the organisation. Hofstede et al. (1990) indicate that the six basic organisational culture construct characteristics are *'a) holistic, b) historically determined, c) related to anthropological concepts, d) socially constructed, e) soft and f) difficult to change*. These are linked closely to the four manifestations of culture defined by the authors, 'symbols, heroes, rituals and values'. Values are considered as invisible and unconscious, whereas the other three can be described as 'practices'. Considering the last four characteristics as the ones closest to the subject under review and so particularly relevant to the construction industry, it can be accepted that these characteristics have a fundamental influence on the implementation of processes for the selection of team members. However, the PM and the project team have to be aware of and understand the main cultural challenges (Andersen, 2003), since cultural values could be used as sources for employee resistance to team work (Kirkman et al., 2000).

### 3.4.2 The Effect of Structure

The importance of individual and team behaviours to the structure of the team / organisation was reflected on by Mintzberg (1979) who indicated that behaviour should be formalised by rules, where rules describe how employees behave in situations that arise - who reports to whom, when, or who does what. Mintzberg (1979) proposed different types of behaviour formalisation for the five structural configurations. Also, Galbraith (1973), within the mechanistic approach of structuring matrix organisations, highlighted the need for groups and interpersonal skills in order to make lateral relations effective. Thus, even within the machine metaphor, the importance of behaviours and interpersonal skills, and therefore individuals, is identified as a significant element of the team environment.

From an open system type of approach to structuring project organisations, Newcombe et al. (1990) describe how the social processes create the social structures, which are actually not designed but evolve as a response to individual needs. The effectiveness of the social structure is dependent upon the efficiencies of the informal groups which could be driven by Maslow's (1954) hierarchy of needs and influenced by the following factors: nature of work; individuals' attitudes, values and beliefs; leadership styles; communication and the time available for interaction.

The problem with the established theory of project organisational structure is fitting the hierarchical structure approach of core work (Belbin, 2000) to the modern day worker (Thorpe et al., 1998) and the ever-increasing interfaces between individuals, teams and parties to the project. The discrepancy between core work, what the management considers when defining the structure, and additional work, what the jobholders consider also to be part of work, causes the creation of interfaces that require management. Attempts have been made by forward thinking practitioners (BAA HET programme of works) to focus on team members and team interactions and establish a project structure where core and additional work are delicately balanced and agreed and interfaces are managed, however, these could not progress to implementation due to lack of support.

Moore (2002) investigated construction organisational theory and behaviour by taking macro- and micro-views of organisations and indicated that, when designing the structure of the project organisation, one has to consider processes that focus on individuals and teams. Team dynamics and structure have to be set within the organisational structure. It has also been confirmed that the matrix structure, which is '*running on sapiential authority and has the problem of requiring mature people*' (Moore, 2002), does not apply to projects any longer since there are so many organisations involved (Moore 2002; Pells, 2007). Demarcation and transactional relations between project teams mean more coordination (Yuan and Pheng, 1992) and an increase in conflicts, with individuals following prevailing narratives (Green, 2006) and accepting that their allegiance lies with their employer and not the project team and the project objectives.

Complex and dynamic environments, such as those in construction, require transformational organisations and have a significant advantage in overcoming problems; the reason being the role of the individuals within this type of organisation (Turner, 1993; Moore, 2002; Jaafari, 2003). Establishing versatility instead of specialist roles was the approach that Toyota adopted by setting up communities in the organisation (Moore, 2002; Liker, 2004). The role of the individual in transformational organisations is much more elevated and in the case of construction provides the best ground for team work and career advancement (Turner, 1993).

### 3.4.3 Environmental Influences

Reciprocity exists between projects and their environment and 11 factors have been identified by Hughes (1989). These factors allow project teams to identify stability, certainty, simplicity and mitigability of the project environment and take appropriate action(s). As a result the quality of the people involved plays a much more important role than the systems (Thompson, 1996). Mintzberg (1979), Lansley (1994) and Shirazi et al. (1996) propose that prior to selecting team members and structuring the project team, leaders should review the project environment in terms of three sets of variables:

1. Simple Vs Complex
2. Static Vs Dynamic
3. Friendly Vs Hostile

An appropriate classification of the project environment allows for the appointment of team members with the relevant strengths.

Contractual agreements and transactional relationships (legal factors, (Hughes, 1989)) which aim for minimisation of conflict, improvement of output and achieving the performance plateau at a much earlier stage could have detrimental effects in the relations between team members and the delivery of the whole project (Turner, 1993; Walker, 1996). Additionally, weaknesses in the traditional construction organisation machinery and the company policies do not allow for any flexibility in meeting the needs of the current project teams (Pells, 2007).

## *3.5 Current Status*

In closing the review of the issues regarding the selection of team members and the importance of teams, it should be noted that human interaction and team formation are complex phenomena (Dal Forno and Merlone, 2005). This interaction, together with the very short period contractors have to put the team together, does not help the process of selecting project team members. Usually, and up to contract award, only the PM would be identified based on subjective assessment (Ogunlana, et al., 2002; Raiden et al., 2004). The remainder of the team below the PM level would be represented as a lump sum of money (Green, 2002) and the 'system' would not consider issues relevant to project staffing (Thompson, 1996; Ogunlana et al., 2002; Raiden et al., 2004; Egan, 2005).

Concerns are raised regarding the lack of implementation of team selection and formation processes, mainly because a number of social systems, in the form of micro-worlds, have to come together to '*make sense*' (Green, 2006) and deliver the project. '*Perhaps of greatest concern is the development of a transient multi-tiered workforce comprising a myriad of different employment arrangements*' (Green, 2006). He concludes that we should be concerned that whatever scripts the main contractor PMs perform, in terms of managing the project, these actually has very little influence upon those who do the work. This is disquieting if one is to consider implementing teamwork principles, unless of course the team is only considered to be the units at the management system level (Walker, 1996).

A number of questions are raised regarding the process of selecting project team members, which will require investigation. These are:

- Are practitioners aware of the techniques available and do they know how to implement these correctly?
- Do companies support the implementation of selection techniques?
- What is the current status of implementation of the process in the construction industry?
- Are the processes implemented and down to what organisational level?
- What other processes for the selection of team members are implemented?
- What factors affect the process?
- Do project management practitioners consider the effects of complexity when implementing the process?
- Are the effects of interconnections considered when selecting project team members?

## 3.6 Summary

This chapter addressed the significance of the sub-process of selecting project team members and the powerful tool available to PMs in the construction industry when teams have been formed.

The importance of individuals in teams and the various steps and techniques available for selecting team members have been reviewed and the advantages of teamthink over groupthink have been described. In addition, the benefits and the factors affecting the sub-process, such as structure, behaviour, culture, technology and complex adaptive systems, have been established.

The review has indicated that ample and tested material exists which can support project management practitioners in carrying out the sub-process of selecting team members. However, concerns have been raised regarding its implementation as well as the way in which construction industry lags behind other industries in terms of empowering personnel, establishing robust interdependence and team interactions, allowing for self-directed teams and understanding complex adaptive systems.

A number of questions are proposed for investigation, thus allowing for an informed decision to be made regarding the status of implementation of the sub-process and the consideration given to the effects of the complexity of interconnections. These questions are:

- Are practitioners aware of the techniques available and do they know how to implement these correctly?
- Do companies support the implementation of selection techniques?
- What is the current status of the implementation of the process in the construction industry?
- Are the processes implemented and down to what organisational level?
- What other processes for selection of team members are implemented?
- What factors affect the process?
- Do project management practitioners consider the effects of complexity when implementing the process?
- Are the effects of interconnections considered when selecting project team members?

With the plethora of results available in the existing literature, in terms of the current status, it will be possible to triangulate the research findings of this against existing ones.

The next chapter reviews the second part of 'how we organise projects' by examining the project management sub-process of structuring project teams.

# Chapter 4 – Structuring the Project Team

## 4.1 *Introduction*

In this chapter a review of the second sub-process of organising projects, that of structuring project teams, is conducted in order to establish the basic thinking and the required approach for defining the organisational structure of projects. The aim is also to establish findings from earlier research conducted on the implementation of the sub-process and thus address the first objective of this research.

The importance and benefits of structuring construction projects have been described by the APM (2006) and PMI (2000) Bodies of Knowledge as well as the IPMA Competence Baseline (2006). Current literature on the subject suggests empowerment, a fractal structure (Breuner, 1995), self-organisation (Donovan, 1996), a chaordic structure (Senge et al., 1999), project gene (Moore, 2002) and an inverted structure (Liker, 2004). Also, various proposals have been made regarding other issues that have to be considered when structuring project teams, for example, culture, technology, diffusion and codification of information, power distance and uncertainty, the project environment (Hughes, 1989) and procurement methods (Moore, 2002). However, there is very little indication of wider consideration and implementation of the latest thinking within the construction industry. The potency and possible benefits of implementing the theory to the lowest levels of project teams have yet to be investigated.

The review of this sub-process will cover the existing theories and, in particular, those concerning construction projects; the influencing factors, the latest thinking / developments and finally the problems that affect the sub-process and cause concern.

## 4.2 *Existing Theories*

Due to the extensive material available, the literature review of existing organisational structure theories will concentrate on works by Mintzberg (1979) for general theory, Galbraith (1973) as part of the information view and Newcombe et al. (1990), together with some more recent literature, as part of the construction view of organisational structure.

### 4.2.1 General theory of organisational structure

Mintzberg's (1979) approach to designing an organisational structure revolves around a set of four groups and nine design parameters, which '*organisations use to divide and co-ordinate their work in order to establish stable patterns of behaviour*'. Organisational structure is not just about the positioning of boxes but rather involves dealing with the '*established forces of habit and tradition, and of power as well*' (Mintzberg, 1979). The four groups and the nine design parameters are shown in the Table 4.1.

Table 4.1. Mintzberg's organisational design groups and parameters (Mintzberg, 1979:67)

| Group | Design Parameter |
|---|---|
| *Design of Position* | *Job Specialisation, Behaviour Formalisation, Training and Indoctrination* |
| *Design of Superstructure* | *Unit Grouping, Unit Size* |
| *Design of lateral linkages* | *Planning and control systems, Liaison devices* |
| *Design of decision-making system* | *Vertical decentralisation, Horizontal decentralisation* |

In terms of decision-making, which defines the systems of authority, Mintzberg (1979) identified two organisational systems, those of vertical and horizontal decentralisation. Delegating power down the line of command is termed vertical decentralisation, whereas extending the decision process to 'non-managers' is labelled horizontal decentralisation. A combination of the two may exist where:

- Vertical decentralisation with horizontal centralisation gives power to first-line supervisors,
- Horizontal decentralisation with vertical centralisation keeps power high up in the hierarchy.

Both, as will be shown below, are used extensively by the construction industry by means of trade or sub-contracts. The summary of Mintzberg's five types of decentralisation is shown below in Table 4.2.

Table 4.2 Continuum of types of Decentralisation (Mintzberg, 1979:208-210)

| | |
|---|---|
| *Vertical and Horizontal Centralisation* | *Formal and informal power in the hands of one person* |
| *Limited Horizontal Decentralisation (Selective)* | *Bureaucratic organisations with unskilled tasks that rely on standardisation of work processes for co-ordination. Structure centralised in the vertical dimension.* |
| *Limited Vertical Decentralisation (Parallel)* | *Organisation divided into market units, or divisions, where managers are delegated (in parallel) a good deal of formal power to make decisions concerning their markets.* |
| *Selective Vertical and Horizontal Decentralisation* | Combination of selective decentralisation in two dimensions. *In the vertical dimension power for different types of decisions is delegated to work constellations of various levels of the hierarchy. In the horizontal dimension, these constellations make selective use of the staff experts, according to how technical are the decisions they must make.* |
| *Vertical and Horizontal Decentralisation* | *Decision power here is concentrated largely in the operating core, because its members are professionals whose work is co-ordinated largely by the standardisation of skills.* |

Mintzberg (1979) developed the pentagon of the basic structural configurations, which are shown in Table 4.3 together with other authors' parallel categories of organisations as summarised by Lansley (1994)

Table 4.3. Parallel categories of organisation (Lansley, 1994)

| Set | Category of Organisation | Reference |
|---|---|---|
| 1 | Ideal bureaucracy | Sadler and Barry (1970) |
| | Professional bureaucracy | Mintzberg (1983) |
| | Task culture | Handy (1976) |
| 2 | Organic | Burns and Stalker (1961) |
| | Simple structure | Mintzberg (1983) |
| | Power structure | Handy (1976) |
| 3 | Mechanistic | Burns and Stalker (1961) |
| | Machine bureaucracy | Mintzberg (1983) |
| | Role culture | Handy (1976) |
| 4 | Anarchic | Sadler and Barry (1970) |
| | Adhocracy | Mintzberg (1983) |
| | Person culture | Handy (1976) |
| 5 | Divisionalised Structure | Mintzberg (1979) |

In terms of agility, Breuner (1995) suggests that there are two ways to make an organisation more agile and that is to either centralise under one unique charismatic individual, or decentralise by means of:

a) Empowerment, distributing decision making to lower levels,
b) Re-engineering, reducing repetition and / or superfluous activities, automating processes. Keeping only the necessary central processing,
c) Partnering and outsourcing. Thus allowing the business to focus on core competencies.

For the last decade the construction industry in the UK and in Client and Contractor organisations, have implemented 'b' and 'c' above.

### 4.2.2 The information view

Galbraith (1973) identified a weakness of the hierarchical system of communication in its inability to deal with the handling of information and indicated that organisations must find new ways to supplement rules and hierarchy. It should be noted that project communication and project information management systems are still issues that are revisited by researchers and other authors (Jaafari and Manivong, 1998; Pritchard, 2004).

Based on the principle of 'structure follows strategy', stated by Chandler (1962), the basic proposition that Galbraith (1973) makes is that there is a direct proportionality between the levels of uncertainty of the task and the required amount of information to be processed. Thus, uncertainty is the key variable and information is the key concept; the lower the uncertainty of the task, the lower the level of information required, especially during the execution of the task. Therefore, different organisation designs will have different capacities to process information. In order to administer the amount of information managed, organisations should change their strategy and either reduce the need for information processing or increase the capacity to process more information (Galbraith, 1973; Jaafari and Manivong, 1998). Organisations are not restricted to developing strategies in either, or even both, of the ways, for which Galbraith (1973) identifies four potential methods. For the first two, the organisation could invest in vertical information systems and/or create lateral relations, and for the last the organisation could create slack resources and/or self-contained tasks. The four proposals are:

- By investing in vertical information systems companies should look carefully into investing in information systems which enable decision making, and which do not overload the decision makers with either problems of generating the information or too much of it;
- The creation of lateral relations enables managers and/or units to have direct contact in order to resolve problems or issues raised;
- An organisation could choose the costly approach of introducing 'slack resources' so that it can reduce the need for information or the creation of 'exceptions';
- The creation of self-contained tasks shifts the emphasis from one of input to one based on output.

### 4.2.3 The construction view

Within a project, the set up of a team (the organisational structure), or at least what is required of the set up, is one of the most fundamental prerequisites (Manz and Neck, 1991).

Following the systems theory, Walker (1996) proposes the separation of the organisation into the management and the operational systems. Newcombe et al. (1990) earlier indicated that in construction the organisation should be seen as a system where inputs are processed to generate outputs. The inputs of age and size, operations, environment and stakeholders (the contingency factors – Mintzberg, 1979) are considered through the three main processes 'Structural', 'Social' and 'Power' to generate 'Authority', 'Social' and the 'Power' structures respectively (Newcombe et al., 1990). The authority structure, usually depicted in the project organisational charts, emerges either by accident or is designed by managers. The social and power structures evolve as a response to individual needs (Newcombe et al., 1990). Newcombe et al. (1990) point out that the more efficient the process and the feedback for corrective actions, the more effective the operation of the organisation. Each input influences the type of organisation that is to be formed.

Mintzberg (1979), Lansley (1994) and Shirazi et al. (1996) explored and proposed types of organisational structures that should be considered when more than one environmental continuum and dimension are affecting the process. In particular Mintzberg (1979) developed a two dimensional matrix by combining two environmental factors - Stable to Dynamic and Simple to Complex, and proposed the required organisational settings. These are shown below in Table 4.4.

Table 4.4. Organisational settings against relevant types of environment (Mintzberg, 1979)

| | Stable | Dynamic |
|---|---|---|
| **Complex** | Decentralised Bureaucratic (standardisation of skills) | Decentralised Organic (mutual adjustment) |
| **Simple** | Centralised Bureaucratic (standardisation of work process) | Centralised Organic (direct supervision) |

Lansley (1994), having considered the three dimensions of organisation structure - control, integration and boundary regulation - proposed various structures in 2D matrices. The suggested structures have been organised and shown in a 3D form in Figure 4.1 below. Table 4.5 gives a brief description of Lansley's organisation dimensions.

Table 4.5. Dimensions of Organisation Structure and brief descriptions (Lansley, 1994)

| Dimension | Definition |
|---|---|
| Control | The extent to which the activities of individuals are laid down by higher authority and prescribed by procedural rules, or are decentralised, less formal and left mainly to the discretion of the individual. |
| Integration | The extent to which the activities of individuals are closely coordinated in relation to the firm's objectives, for example, its markets or projects rather than its internal functions. |
| Boundary Regulation | The extent to which the activities of the management system of the firm are concerned with managing its relationship with the environment or controlling the internal affairs of the organisation. |

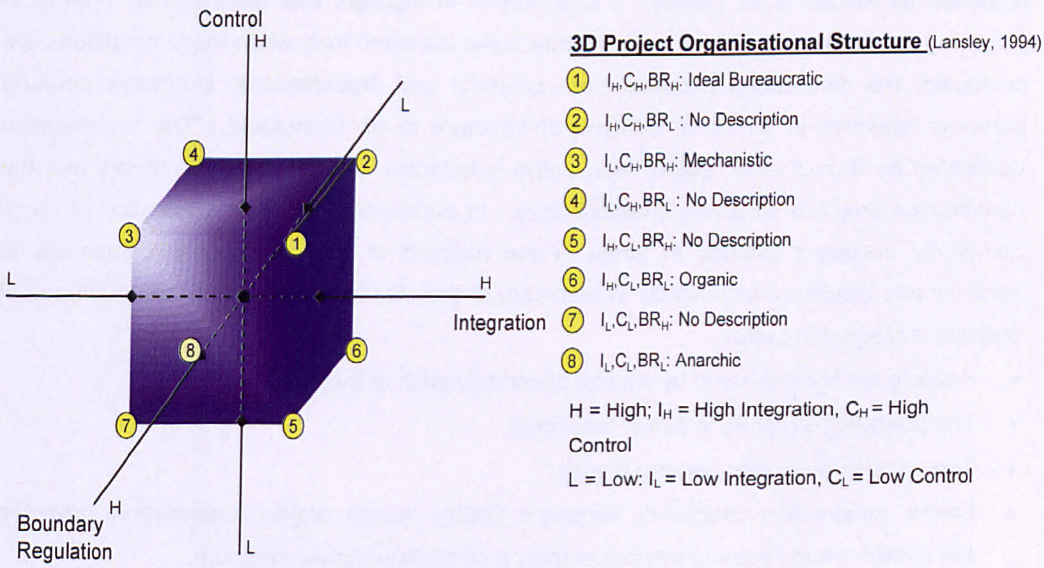


Figure 4.1. 3D graphical representation of Lansley's 2D work on organisational dimensions

Table 4.6. Theoretical construction organisational structures proposed by Shirazi et al. (1996)

| | |
|---|---|
| Environment: **Stable to Dynamic** | |
| **Description:** These could cover areas such as, variations in the client's requirements, resource limitations (human) and the economy. | A stable environment will require the project organisation to have standard procedures with formalised work and therefore rigid structure. |
| | A dynamic environment will require the project organisation to have an organic structure. |
| Environment: **Simple to Complex** | |
| **Description:** Clarity of work, number and similarity of environmental factors that need to be considered during decision making, number of parties (subcontractors), type of activity, client interference (direct of indirect through agents), level of programming and control required. | A simple environment will require the project organisation to have centralised control. |
| | A complex environment will require the project organisation to decentralise decisions and delegation of authority. |
| Environment: **Friendly to Hostile** | |
| **Description:** Predictability of work, speed of response, competition, inter-party relations, industrial relations, location of project, even adverse weather conditions. | A friendly environment will require the project organisation to encourage differentiation and use selective centralisation vertically and horizontally. |
| | A hostile environment will require the project organisation to form temporary centralisation and tight coordination and control. |

Shirazi et al. (1996) also investigated how the construction environment influences the prevailing type of organisation of projects and in addition to the dimensions used by Mintzberg (1979) and Lansley (1994) they introduced a third set - friendly to hostile. Table 4.6 provides an indication of the possible theoretical structures of each single continuum / dimension proposed by Shirazi et al. (1996). It is important to highlight that Shirazi et al. (1996), in reviewing the above continuums in singularity, have accepted that, when these conditions are combined, the dimensions become more powerful and organisational structures demand particular attention in terms of the type of structure to be formulated. The investigation conducted by Shirazi et al. (1996) identified a substantial variation between theory and the construction project's structural characteristics. In particular, there was a rejection of some commonly accepted findings in terms of the reaction of the construction companies to dynamic and hostile environments. A summary of their findings in terms of the structuring of projects is presented below.

- Projects are characterised by vertical decentralisation of the core,
- The prevailing structure is that of functional,
- The creation of smaller primary groups,
- Larger construction companies employ a flexible, matrix project organisation, however, the smaller trade / sub-contractors employ a centralised power structure,

- The industry at the lower levels is looking for flexibility and an organic approach to carrying out the tasks,
- In the case of technical certainty, which, according to theory and the author's hypothesis, should lead to '*breaking down of tasks into routine*' and to a more bureaucratic system, the hypothesis was not supported,
- Formalisation usually occurs through the use of three basic operating procedures / manuals on: planning and information control, subcontract management and Health and Safety procedures.
- There is an intertwining of formal and informal methods, indicating, on the one hand acceptance of the formality of structure, but on the other hand that extreme formalisation is behaviourally unacceptable,
- The employment of Contracts Managers who are looking for the '*most effective arrangements for efficiency and control*',
- The presence of specialists who allow for horizontal decentralisation.

However, the most important finding from this study was that of the systems approach to project management, as described by Walker (1996), which differentiates between the managing and operational systems.

It should be noted that the matrix organisation, referenced by Galbraith (1973), Newcombe et al. (1990) and Shirazi et al. (1996), has the interesting characteristic of two organisational elements; the bureaucratic, which is the functional departmental that provides the specialist resource, and the organic, which is the individuals who are the resources in the project teams (Moore, 2002). This type of organisation is '*running on sapiential authority*' and has the problem of requiring mature people (Moore, 2002). What is necessary is the specialisation that has been built through experience and enables problems to be solved quickly. It is also based on individuals that are not '*fixated on playing politics*' (Moore, 2002).

In terms of the three processes considered by Newcombe et al. (1990), which are used for the structuring of organisations, the only one that can be influenced is that of the structural process. Two major forces are used to shape the organisation: differentiation and integration (Lawrence and Lorsch, 1967). The former is necessary in order to respond to the external and internal influences that the organisation is exposed to, whilst the latter is created as a response to the former and is the one that carries the co-ordination element of the organisation's activities (Newcombe et al., 1990). The more complex and highly differentiated the organisation, the more difficult it becomes to co-ordinate. Therefore, when designing a project organisation a fine balance must be drawn between these two forces. Baccarini (1996) indicates that the greater the differentiation, the more complex the organisation. Indeed various organisations are attempting to minimise the effects of organisational complexity (Baccarini, 1996) through the introduction of long term partnerships, frameworks, alliancing and other similar procurement methods.

Shirazi et al. (1996) indicate that construction organisations were mainly found to deal with the '*coordination of specialised and differentiated tasks*'. At the lowest levels of supervision, competence, acquired through experience, replaces vertical differentiation and the formation of small groups and informal relationships removes interdependence issues. When exposed to complex tasks, there is informal / personal, cross-boundary liaison between the different parties to the project as well as '*mutual adjustment*' (Shirazi et al., 1996). With regard to the current status of the construction industry, a recent case study (Panas, 2006) on a medium-sized construction company identifies the following points:

- Overall the company was portrayed as a machine-type organisation with a bureaucratic style of monitoring, communication and central support,
- As a subsidiary of a major construction company, it is part of a diversified / divisionalised and decentralized organization,
- Internally, the company has a flat management structure,
- *Apart from the official organisational chart, there is an informal organisational structure running in parallel, which consists of informal work groupings, informal channels of communication, informal power and status differentials among the team members.*
- The team's effectiveness was affected by the amorphous type of power structure, which encompassed all 'theoretical' forms of decentralisation.

The above do not differ from the findings of Shirazi et al. (1996) on the variation between theory and the construction project structural characteristics.

## 4.3 Influences

Various factors influence the structure of organisations and, more particularly, the project organisations. The literature identifies some of these as age, size, technical system, power relations, codification and diffusion of information, culture and external environment, ethics and knowledge. These factors will be described in summary below in order to provide a cogent picture of the issues that PMs should consider when deciding on the structure of the project.

### 4.3.1 Contingency factors

Based on the contingency factors of age and size, technical system at the operating level, environment and power relations, Mintzberg (1979) developed two hypotheses: congruence and configuration. The former confirms the need for matching between situation and structure and the latter confirms the interdependence of design parameters and the requirement for logical configuration. In general, Mintzberg indicates that the contingency factors affect different levels of the organisation. So the technical system, affects primarily the operating level and age and size affect the middle line, the environmental factors affect the strategic apex and the power factors selectively affect all three levels. However, although these were basic principles set up 30 years ago, one has to consider them in the light of developments and, in particular, the current tendency of 'flattening' organisations (Thorpe et al., 1998).

### 4.3.2 Technology

The results from the investigation into 18 projects, conducted by Shirazi et al. (1996), indicate that technology has a more significant and stronger impact than size on the span of control. In particular, the results point to the fact that the involvement of trade contractors and specialists requires horizontal decentralisation in order to have smooth coordination by '*mutual adjustment*' and vertical decentralisation so that activities can be supervised by expert managers. These findings support the proposition made by Thompson (1967) that construction organisations link technology and organisation structure in order to minimise coordination cost (Shirazi et al., 1996). However, the advancement of technology and the introduction of virtual teams (Edum-Fotwe and McCaffer, 2007) establish additional complications which will need to be reviewed in terms of interconnections.

### 4.3.3 Diffusion, Codification and Culture

Lansley (1994) conducted an analysis of construction organisations and identified the various structures as these are shaped from the work by Boisot (1987) on the level of diffusion and codification of information. Figure 4.2 shows the structures for the respective high and low levels of codification and diffusion.

| | | |
|---|---|---|
| High Diffusion (Associated with High Integration) | Market (Mechanistic) | Clan (Anarchic) |
| Low Diffusion | Bureaucracy | Fief (Organic) |
| | High Codification (Associated with High Control) | Low Codification |

Figure 4.2. The diffusion-codification relationship in organisational structures (Lansley, 1994)

Hofstede (1980), who defined culture as '*the collective mental programming of people in an environment*', generated a model to show how the individual's cultural background affects the understanding and the expectations of an organisation. He determined four criteria by which individuals' national cultures differed. These are, '*Power distance*', '*Uncertainty avoidance*', '*Individualism - Collectivism*' and '*Masculinity - Femininity*'. Two criteria were identified as being of vital importance to structuring organisations, power distance and uncertainty avoidance. The respective definitions, given by Hofstede (1980) are:

- Power distance; '*the extent to which a society accepts the fact that power in institutions and organisations is distributed unequally*'.

- Uncertainty avoidance; '*the extent to which a society feels threatened by uncertain and ambiguous situations by providing greater career stability, establishing more formal rules, not tolerating deviant ideas and behaviours and believing in absolute truths and attainment of expertise*'.

The cultural models created and the respective organisational structures are shown below in Figure 4.3 (as shown by Lansley, 1994).

| Uncertainty Avoidance (Formalisation) | Power Distance (Centralisation): high | Power Distance (Centralisation): low |
|---|---|---|
| high | *Pyramid*<br>(centralised and formalised)<br>**France Japan** | *Family*<br>(centralised but not formalised)<br>**India Hong Kong** |
| low | *Well oiled machine*<br>(formalised, not centralised)<br>**Germany Austria** | *Village Market*<br>(neither formalised, nor centralised)<br>**UK USA** |

Figure 4.3 Hofstede's cultural models and organisational structures (Lansley, 1994)

Andersen (2003) established that the project dominant culture is that of 'task' and that, amongst the other points, '*people collaborate when their joint contribution is needed to perform the task*'. He also identified three areas where the highest variances exist regarding the ideal task culture:

- Implementation of a task culture is restricted by the barriers set from project hierarchies,
- There is a hierarchical structure in project decisions,
- Similarly, there is a hierarchical implementation of control and distribution of information.

Andersen (2003) also identifies two more characteristics. First, that even though culture affects project results, it is not imperative that it has to be a task-oriented culture. The second point concerns the fact that PMs must have a clear knowledge and understanding of the existing culture and prevailing conditions because, without these, they will not be able to set up the appropriate structure for the project or make any '*definite changes to the culture*'.

### 4.3.4 Environment

A factor that has to be taken into consideration when designing project organisations is the ability and flexibility of the organisation to respond to change and environmental influences (Hughes, 1989). Uncertainty, stemming from change, precedes instability. The management of project teams must be able to assess uncertainty factors and detect the first signs of uncertainty created in the environment so that they can react before it becomes crisis (Moore, 2002).

Hughes (1989) identified reciprocity between projects and their environment and defined 10 factors / constraints with five levels of variability – definition, stability, certainty, simplicity and mitigability. He suggests that the planning of the project organisation will be enormously benefited should these environmental factors be reviewed in terms of being favourable, moderate or unfavourable. Moore (2002) indicates that the '*extent of the project's openness to its external environment can have considerable effects to its internal environment and system organisation*'.

### 4.3.5 Procurement, power and other factors

As mentioned previously, Newcombe et al. (1990) indicated that, in structuring the construction organisation, the power process creates a power structure. The major factor that influences the 'power' within an organisation is the type / style of decision-making. Centralisation or decentralisation vertical, horizontal or geographical, or a combination of the two, will result in the development of different ways in which individuals or groups can influence decision making and this creates power structures. Newcombe et al. (1990) describe the outcomes for the construction industry from these combinations as:

- Power at the level of site managers will require *vertical decentralisation with horizontal centralisation,*
- Power to senior personnel will require *horizontal decentralisation with vertical centralisation,*
- For senior management to retain power, the organisation will need to centralise both vertically and horizontally,
- Finally, decentralisation - both vertically and horizontally - will mean wide distribution of power.

Obviously, decision-making, and therefore power, depends on the involvement, or not, of others in the processes of gathering information, journalising, selecting appropriate options, authorising and executing. Therefore, the more these processes are interfered with, or depend upon others, the more the power available is dispersed. In a similar manner a centralised organisation can have a decentralised power structure (Newcombe et al., 1990).

Relevant to the power scenarios in projects is the maturity of the different organisations which come together to deliver the project through the procurement process. This also is another factor that needs to be taken into account when structuring a project organisation (Moore, 2002).

Maintenance activities (Miller and Rice, 1970), such as procurement, recruitment, training, and motivation, must also be accommodated when designing the project structure to avoid issues caused by '*human resource energy*'. The importance and influence that procurement routes exert on project structures through the different forms of power – reward, coercive, expert, ownership - and with at least two types of vehicles: the legal and the psychological contracts, have been highlighted (Moore, 2002). Closely linked to the latter is the level of institutional influence on the individual and the client organisations. In terms of influencing the individual, it can be said that the psychological contract commences as a calculative one – voluntary contract with an expressed rate of exchange. However, after achieving a certain status it becomes a coercive one where the emphasis is on rules and punishment, individuality is suppressed and conformity is emphasised (Moore, 2002).

Finally, knowledge, skills and the level of sapiential authority, which will be discussed in the next section, also need to be considered as any significant difference in knowledge and skills define another sub-system within the structure of the project (Moore, 2002).

## *4.4 New Developments*

The latest literature on organisational structures introduces such concepts as chaordic and fractal structures, the effects of entropy, sapiential authority, cellular automata and information processing, project organism genes and the Toyota model of the inverted triangle structure. These 'new developments', or in some cases not so new but currently finding fertile ground, will be presented below as the challenge for resolving issues regarding structuring construction projects increases.

### 4.4.1 Sapiential authority

An important concept within the more fluid and creative transformational, organisation, as opposed to that of the traditional, hierarchical, transactional one, is that of sapiential authority (Moore, 2002). Sapiential authority, depicted as the level of workers' specialist knowledge exceeding that of their leaders, will need to be considered when structuring a project organisation. Construction organisations need to understand and empower their people with sapiential rather than hierarchical / positional authority. This will allow organisations to operate more flexibly using a transformational approach thus, they will be able to utilise their resources more efficiently and tap into opportunities as these occur. In particular, Moore (2002) indicates that construction project organisations will need to become:

- *Highly decentralised with extensive numbers of autonomous groups,*
- *Highly flexible,*
- *Highly adaptive,*
- *Forming and disbanding as required to meet the needs of the permanent organisation,*
- More dependent on vision rather than relying on rules.

Transformational organisation structures operate as an open system with no boundaries, as '*a seamless organic whole*' (Moore, 2002), or, as Brodnick (2000) suggests, as '*a complex nesting of dynamic systems*' where the nesting is highly dependent on the potency and intensity of communication and interactions. Moore (2002) makes an interesting juxtaposition between transactional and transformational organisation structures by using two paradigms:

*What is in this for me?* Vs *What can we do to help achieve the objective of the whole?*

(transactional) (transformational)

## 4.4.2 Chaordic Organisation and Fractal Structures

In terms of the long-term target for the construction organisation, Moore (2002) describes how it will be possible to be influenced by change and resistance to failure by implementing a '*chaordic*' organisation, similar to that implemented in Visa by Dee Hock (Senge et al., 1999). Dee Hock (1999) designed the 'chaordic' structure, a structure that combines the maximum chaotic behaviour with the minimum hierarchical order necessary for stability (Moore, 2002); aiming and achieving an organisation that is '*infinitely malleable yet extremely durable*' (Breuner, 1995). Its structure is one that is based on fractal hierarchy where each level has similarities with the others and enables flexibility, ease of transfer of information, consistency and, in the case of a failure, one where work can be easily undertaken by the other sections. It is interesting to note that, as in a large proportion of construction operations, Visa's product is coordination and skilful use of cooperative and competitive forces to achieve effectiveness and efficiency respectively. It is the alignment of the efforts of hundreds of member institutions, leaving no one entity in charge (Breuner, 1995). People at the top do not manage operations; they manage the conditions through which growth can occur. They are not chosen for their ability to plan or execute, but for their ability to coordinate, govern, coach and judge. Breuner (1995) describes how the decentralised organisations of Visa and the Internet are fractal in nature. The shape, the format and the relationship(s) are all the same between and within the different levels and within the levels. The rules and authority of each level are the same. So we see that standardisation enables the management of information that flows between the different parts of the hierarchy. Breuner (1995) states that the fractal structure serves several purposes since it:

1. Reduces risks by insulating other subassemblies or agents from the failure of any other one;
2. Allows for information to be passed easily between subassemblies or agents since it is highly reusable given the similar structures of the others; and
3. Allows the independent entities to be loosely coupled and not over-connected, thereby providing stability.

Also, as the systems become adaptive there is transfer of knowledge and learning. '*Visa's ability to change its structure literally serves to adapt and change behaviour, enabling the organisation to evolve along with its environment*' (Breuner, 1995). This abides by Senge's

(1990) view that '*structure follows behaviour*'. Also, as Moore (2002) indicates, '*the most creative forms of project management emerge in projects operating in an environment that is on the edge of stable and unstable conditions*'. Perhaps some of the most important conclusions from Breuner's (1995) work, from which the construction industry can learn, are:

- That hierarchy does not have to be used to concentrate authority, but rather to manage the participation of autonomous agents;
- Similarly, management do not solve problems but rather choose among solutions;
- The role of those at the top of the hierarchy is not to lead with 'vision', but to enable via careful stewardship.

### 4.4.3 Entropy

The concept of entropy (second law of thermodynamics) and how this can influence organisational structures is reviewed by Moore (2002). The second law states '*The entropy of the universe tends to a maximum*' (Claucius, 1856). Moore (2002) explains that as the universe winds down, it attempts to convert low entropy, ordered systems, into high entropy, disordered, ones. Therefore attempts by projects, which are seen as open systems, to establish organisational order are almost futile, as these are affected by the universal laws. This is also reflected in Wild's (2001) paradigm of accepting projects as disturbances punctuated by crises and occasional periods of calm.

Realising the influence and effect entropy can have on structures will enable project management to understand that it needs to operate within a finely balanced borderline between order and disorder. Moore (2002) states that traditional project management will find it hard to acknowledge that project structures are not to be used as control mechanisms. Organisational relationships need to be viewed as non-linear and dynamic in order to avoid the demise of the project organisation (Moore, 2002).

### 4.4.4 Cellular Automata and Lambda

Several authors (Galbraith, 1973; Newcombe et al., 1990; Moore, 2002) have highlighted the fact that when structuring projects, a factor which needs to be considered carefully is the link between resources and important relevant information. This link, as suggested by Artificial Intelligence, is vital for the survival of an organisation and is referred to as Lambda (Moore, 2002). Lambda ($\lambda$) values, which are entities that are used to study Artificial Intelligence, are used to classify a Cellular Automata (CA) universe. CAs simulate a number of problems and, as such, the process of information processing. Studies have indicated that for values of $0.3 \leq \lambda \leq 0.5$ CAs display stable patterns and rhythms. However, as patterns become more stable near $\lambda = 0.5$, behaviours become complex and chaotic (Rennard, 2000). For values of $\lambda$ lower than 0.3 CA universes usually die because no information is processed, whereas for values of $\lambda$ greater than 0.5 unstable structures collapse quickly. Therefore, if we were to envisage a stable organisation it will require a $\lambda$ level of 0.5, however, this will mean a system that has complex and chaotic behaviours. As systems move from a chaotic to a complex behaviour it is the transition phase, the zone in between, where systems self-organise spontaneously. If PMs are to consider projects as cellular automata then they will need to recognise and appreciate when it is likely for this transition phase to happen and what measures can be taken to manage the problems.

### 4.4.5 The project organism gene

Using the gene metaphor, Moore (2002), proposes the use of the six APM BoK topics to construct the gene pattern which needs to be used by the PMs for the development of the project organism. The approach is one of acceptance / acknowledgment of the interaction between the six genes rather than rigid differentiation. Each gene then, using the sub-areas of the BoK, forms the start genome which can be used as a framework to develop specific project organisms.

### 4.4.6 Other Models

The ecological model is another model of organisational structure presented by Moore (2002). In an environment which allows for free-forming structures, members consciously or unconsciously form new organisations and these could either be new or variations from previous ones. The ecological model is made up of two types of organisations the '*generalist*' and the '*specialist*'. The former has a '*wider niche and offers a range of services*' whereas the latter has a '*narrower niche and offers fewer services*' (Moore, 2002). The width of the niche covered by the organisations provides protection from environmental changes and the narrower the niche, the higher the risk. Therefore, in the context of construction and if one could consider the possibility of allowing for the free-forming of structures, main contractors would be represented as a generalist type and subcontractors as specialists.

Toyota's organisational structure is one that, as described by Liker (2004), is designed to remove waste from every position by instilling '*role versatility*' (Moore, 2002), whereas traditional structures are building-in waste and bureaucracy. Designed in the form of an inverse triangle, Toyota put emphasis on holistic teams with members that are trained extensively and can perform all the required tasks. Teams of between 5 – 8 members are guided by team leaders who are respectively coached by group leaders who are, in turn coached by Assistant Managers. All leadership posts are internally filled in order to develop a learning organisation. Liker (2004) points out that Toyota turned Taylor's scientific management theory on its head and gave control of standardisation to the teams. The author has witnessed the implementation of the Toyota - inverse triangle - organisational structure principle in the UK construction industry for the duration of a project. The project had, according to the standards of the Client organisation, considerable success and team members had the opportunity to implement a number of technological improvements in cooperation and exchange of information.

### 4.4.7 Jazz ensemble and organisation structure

In closing this section it is considered appropriate to describe the parallelism given by Harris (2006) between the business organisation and jazz ensembles. One can experience the effect of self-organisation in a jazz ensemble, where the independent path followed by each musician comes together to create a '*coherent whole*' (Harris, 2006). Harris continues by saying '... (sound) *of course is not magic and the effect depends on having high-calibre performers, ..., improvisation in jazz works by a careful balance of rules and freedom*'. It is the flexibility in these rules - the '*pre-specified number of bars*', and the understanding between the members that forms the coherence. What is envisaged with this parallelism is work performed on projects by a number of appropriately-sized, flexible clusters that deliver assigned parts, within the overall scheme of a project.

## *4.5 Current Status*

The theory reviewed indicates the existence of an extensive and diversified theoretical breadth and depth, which could enable PMs to appreciate the variety of factors that need to be considered when setting up the project structure. However, as will be shown below, the literature review also reveals that these are not implemented in construction projects and a number of questions are raised in terms of the problem.

The construction industry does not consider how teams are to be structured in order to deal with the particular project (Moore, 2002). The transient nature of the project and its idiosyncrasies (Busby and Hughes, 2004) also are not considered when structuring the teams. The insistence of implementing transactional organisations in construction projects means placing authority in the hierarchical position, separating it from knowledge and imposing a linear approach to non-linear project systems. The industry resorts to transactional organisations as a means of establishing control and authority (Moore, 2002). Status and hierarchical position in projects are considered as more important than knowledge and expertise (Andersen, 2003). Some of the other issues raised from recent research are the existence of glass ceilings within structures (Green, 2006), unofficial structures (Panas, 2006), the structuring around nationalities (Green, 2006), and the detrimental effect that short-termism and cost demands have on the structuring of projects (Winter and Smith, 2006).

Although the industry is decentralised (Panas, 2006) and the merits are well documented, the creation of the transformational structure is almost impossible in our deeply rooted 'Western' culture where central control is a basic assumption (Breuner, 1995). This is particularly true in construction, which is essentially an engineering based industry where everything has to have a logical pattern and must be controlled (Bertelsen, 2004a), and it is thus easier to understand the use of linear methods. However, when it comes to understanding organisations, Tichy et al. (1979) argue these are much more complicated and non-linear.

Transformational structure and non-linearity are overlooked unless there is specific interest from someone knowledgeable (Busby and Hughes, 2004). Similarly, consideration is not given to research which suggests that specialism and singularity of functional role are detrimental, and an unsuitable structure for highly unstable / turbulent conditions (Moore, 2002; Bertelsen, 2005).

If, in addition to the legal and psychological contracts mentioned in section 4.3, one considers the client requirements for certain levels of competences through institutional grading, the pressures on the PM to approach the organisational structuring in a transactional way are enormous. Arguing the case for a post-contingency (transformational) cooperative (Moore, 2002) contract in a project board presentation, where most of the members represent a bureaucratic organisation, is a career-limiting exercise. However mature and responsible the PM might be, one has to consider carefully the internal environment through Morgan's (1997) metaphors of the 'Political system' or indeed that of the 'Psychic prison'.

Research in other industries (Donovan, 1996) has shown that the number of organisations implementing 'self-directed work teams' has increased dramatically since the 1990s. However, the construction industry remains tightly enclosed and still follows the traditional fragmented ways. This is happening despite the fact that the proposed structural arrangement is hailed as '*a natural evolution from the various types of ad-hoc problem solving teams of the '80s*' (Donovan, 1996).

It is possible that some implementation of forward thinking organisational structures does occur, in isolated pockets, by some progressive PMs, although this cannot be considered as an 'industry-wide acceptance' of the established principles. New concepts in terms of the organisational structure of projects have been proposed and some of those have been referenced above. Considering for example the theory of the project 'gene' (Moore, 2002), mentioned previously, there is almost nothing new / radical to what has been proposed. However, it is not apparent how much of this intelligent thinking has been filtered through to construction PMs.

Therefore, from the above, a number of questions are raised by the author that need to be investigated in terms of the current approach taken by practitioners and these will need to be confirmed or refuted. These questions are listed below:

- Down to what organisational level do Construction PMs structure their projects?
- Down to what level are they considering the organisational structure?
  - The Management team?
  - The Discipline leader level?
  - The Team leader level?
  - The Team level?

- The outsiders (support) who have direct or indirect involvement?
- Are all the levels mentioned above critical or can some of them be excluded?
- What type of structuring method is followed?
- What are the current environmental conditions in construction and are these considered when structuring project organisations?
- Are other project management sub-processes affecting the structuring of projects?
- Is complexity considered when structuring the project teams?
- Are complexity characteristics taken into consideration?

## 4.6 Summary

This chapter has addressed the sub-process of structuring project teams and its importance to the project management process, as part of the question 'how do we organise'.

Theories and basic concepts spanning the last 40 years were reviewed from multiple points of view - the general, the information and the construction. Other factors influencing the sub-process, such as the environment, diffusion, codification, culture, the contingency factors, procurement and power, were described and need to be considered when deciding the set-up of the project structure.

Further on, the review of past theories is complemented by new developments and proposals in the field of structuring teams. These are considered appropriate as they take into account the requirement for project structures to accommodate the increase in sapiential authority, the rising complexity and the benefits of fractal structures and chaordic organisations. The new developments allow for an understanding of the effect that the overall system, with its attempts to convert order into disorder, has on projects and also the importance, the patterns and criticality of operating in the transition zone of chaotic and complex behaviours ($\lambda$ of 0.5). These developments call for the implementation of a more flexible organisational structure, one that will allow for flexibility, versatility and adaptation to the prevailing conditions. The 'jazz ensemble' paradigm was given as an example that can be considered for modern organisations, those that have to consider the effects of complexity.

Finally a review of concerns raised regarding the current status of structuring teams in construction projects was presented. It is clear that the sub-process of structuring project teams is not considered and the industry insists in the implementation of a transactional approach which aims at control and authority. Glass ceilings, unofficial structures and the problems of implementing linear methods are also some of the issues discussed. Self-directed teams, although recognised as the appropriate approach for construction, are not being implemented.

A number of questions are posed for investigation, which will allow for an informed decision to be made in terms of the status of the sub-process of structuring project teams as well as the consideration given to the effects of complexity of interconnections. These questions are:

- Down to what organisational level do Construction PMs structure their projects?
- Down to what level are they considering the organisational structure?
    - The Management team?
    - The Discipline leader level?
    - The Team leader level?
    - The Team level?
    - The outsiders (support) who have direct or indirect involvement?
- Are all the levels mentioned above critical or can some of them be excluded?
- What type of structuring method is followed?
- What are the current environmental conditions in construction and are these considered when structuring project organisations?
- Are other project management sub-processes affecting the structuring of projects?
- Is complexity considered when structuring the project teams?
- Are complexity characteristics taken into consideration?

With the plethora of information available in the existing literature, in terms of the current status, it will be possible to triangulate the research findings against the existing ones.

The next chapter reviews the topic of complexity and, in particular, the complexity of interconnections.

# Chapter 5 – Complexity

## 5.1 Introduction

A review of the current status of project management was conducted in Chapter 2 and as described the project management theory is challenged in terms of the understanding of projects and how it is based on Newtonian principles and linearization rather than working with 'living', non-linear / dynamic organisms in multi-dimensional / multi-order forms. Construction project management should be perceived as a complex system operating at the edge of chaos (Bertelsen, 2002a; Moore, 2002; Thomas and Mengel, 2008). Therefore, there is a need to understand:

- What complexity is;
- How it is defined;
- How is it classified / categorised; and
- What is proposed in terms of managing its effects.

In order to address the second objective of this research, this chapter will review all the above questions with regard to general and basic principles. Complexity will also be reviewed from the construction project point of view together with the issue/importance of the interconnections and the questions that should be raised by the construction industry.

## 5.2 Various Theories and Basic Principles

For the past 50 years traditional project management theory has focused on control and chains of command (Davidson Frame, 2002), despite calls for a shift towards a more behavioural approach (Applebaum, 1982) and to consider projects as living organisms. Since the early days the focal point has been compliance, rather than self-regulation and self-control, and inappropriate rewards and incentives instead of motivation from within (Jaafari, 2003). Perhaps the cause of this was the inability to understand and work with non-linear and constantly-changing/living systems, which are '*inherently messy*' (Davidson Frame, 2002; Thomas and Mengel, 2008). This is one of the reasons that prompted researchers to investigate stochastic rather than deterministic behaviours. The research led into what mathematicians refer to as 'chaos', or 'chaos theory'. The definition of chaos given at an international conference by the Royal Society in London in 1986 (Stewart, 1997:12) is that: Chaos = Stochastic Behaviour in a Deterministic System.

By analysing the words 'stochastic' and 'deterministic' in the above definition, Stewart (1997:12) describes chaos as '*Lawless Behaviour Governed Entirely by Law*', or as it was first coined by Gleick (1987) '*There is order in disorder*'.

A concise definition of both chaos and complexity theory is given by Sim and Van Loon (2004). The authors indicate that chaos theory emphasises the inherent propensity of systems to become unpredictable when changes occur in their initial conditions; whereas complexity theory maintains that '*spontaneous self-organisation*' enables '*physical systems*' to evolve to higher levels of development. The common base for both chaos and complexity theory is that they are '*part and parcel of the theory of non-linear dynamics*' (Stewart, 1997).

Various different views have been expressed on the topic of chaos and complexity theories. With regard to the former, Meyer et al. (2002) described it as one of four types of uncertainty. On the complexity side, several concepts are described as either 'core' or 'triggers'. Some of these are emergence – the whole is greater than the sum of the parts – (Stewart, 1997; Rennard, 2000), self-organisation and self-steering (Phelps and Hase, 2002), unforeseen feedback loops (Perrow, 1984) and even the potential of space – with fold and heteropia – (Kornberger and Clegg, 2003). The effect and the criticality of the initial conditions on general processes as well as projects has also been highlighted as causes of complexity by Eve et al. (1997b), Moore (2002), Phelps and Hase (2002) and Busby and Hughes (2004) who, in terms of projects, described these as pathogens and incubation periods.

From the above it can be seen that complexity is a theory undergoing a healthy 'dialogue' between academics searching for some universal concepts and axioms.

Burns (2005), having conducted an extensive literature review on complexity theory, points out that, despite the presence of extensive theory and contradictory views on the subject, implementation has not moved further than being used as a metaphor. However, when Lissack's (1999) description of complexity is complemented by the three key additions of Stacey's et al. (2002), together they cover most of the common ground and provide an overall acceptable picture of the subject. Lissack (1999) describes complexity as the dealing of dynamic patterns which could be underlined by simplicity and which '*can be discovered by the use of software and analytical, logical and conceptual developments*'. Stacey et al. (2002) then indicate that there are essentially three key theories that cover the whole spectrum of complexity - '*chaos theory, dissipative structures and complex adaptive systems*'. The former two - chaos theory and dissipative structures - remain at a high level of the overall system and use mathematical modelling to explain and decipher complex systems, whereas the latter – complex adaptive systems (CAS) - deals with the lower level and the interactions between the sub-systems which construct the overall system.

Davidson Frame (2002) also concurs that a consensus is emerging, suggesting that complexity is closely tied to the adaptive behaviour of systems. The rule seems to be that flexible, sophisticated systems have the edge in this competitive world. Earlier, Lucas (2000c) had highlighted the fact that complexity is a '*true transdisciplinary endeavour*' that covers the middle ground operating in the '*realm of systems having many interacting parts - too complex for deterministic mathematical solutions, too simple for averaging by statistics*'. It is generally accepted that complex behaviour is much more difficult to define and measure whereas chaotic behaviour is easier by using the Liapunov exponent (Moore, 2002). In particular it is the region between the two, where systems self-organise, which is of interest to researchers.

## 5.2.1 Some chaos and complexity concepts

The mathematical interpretation of a number of concepts within chaos theory, using computers, and in particular graphics, enabled the popularisation of concepts such as fractals, attractors, bifurcations, self-organisation, complex adaptive systems and others. Some of these concepts are even used as metaphors during lectures (Murray, 2003). For familiarisation purposes some of these will be expanded below.

**Complex Adaptive Systems**

As one of the three key theories covering complexity (Stacey et al., 2002) complex adaptive systems (CAS) *are of particular interest to a number of industries, and in particular* to construction. Although the theory behind CAS is based on systems thinking, some of its findings are pointing beyond that framework. It is based on the properties of learning and adaptation to a changing environment exhibited by systems with many independent parts which are highly interconnected and interactive (Breuner, 1995). CAS could easily resemble human interactions, however, it is important to note that these can only be used as analogies to human actions rather than applications (Stacey, 2001). It is the '*process of interaction that provides this analogy*' (Stacey, 2001) and it is this analogy that is sought to be established by various authors in organisational theories.

**Attractors**

Stewart (1997) indicates that '*the most important property of a dynamical system is its long-term behaviour*'. Mathematics has proved that in the long-term, a dynamical system settles down/evolves into an attractor. An attractor is defined to be the smallest/unbroken phase space subset to which the system settles down and which could be a point, a curve, a manifold or a fractal structure. Stewart (1997) describes attractors as '*some portion of the phase space such that any point which starts nearby gets closer and closer to it*'. A term used frequently is that of "strange attractor" and which simply describes an attractor which has '*non-integer dimension or if the dynamics on it are chaotic*' (Wikipedia.org, 2008). Sim and Loon (2004) describe the strange attractor as '*the underline force that controls any given system*'. Strange attractors are unstable to parameter changes, so, as these form complex/multiple interesting attractors, it is very possible that they could be changing each other's parameters (shapes). This interaction causes the systems to 'flip' from stable to unstable and the vice-versa. Ultimately the system self-organises to achieve dynamic balance (Lucas, 2005).

Attractors are also used to describe social phenomena and depict the intricacies of social systems (Lucas, 2005). For example, the '*dense strange* attractor' represents the standard social system, whilst the *'disjoint dense'* strange attractor represents two cultures with incompatible viewpoints and even the human propensity to over-complicate things can be seen in the *'tracery'* strange attractor. A pictorial view of the three strange attractors mentioned here can be seen in Appendix B. Lucas (2005) also stresses the fact that it is possible to have more than one attractor interacting, in which case there will be changes in the parameters and a co-evolution mode.

**Bifurcation**

Bifurcations, otherwise known as phase transitions, in a purely mathematical context, are described as the points where two identical, or near identical, entities are split due to the sensitivity of the initial conditions (Stewart, 1997). The important factor in the concept of bifurcations, as noted by all authors in the field (Gleick, 1987; Lorenz, 1997; Stewart, 1997, Phelps and Hase, 2002), is the sensitivity to the primary conditions, commonly referred as the 'Butterfly Effect'. The minute and perhaps unidentifiable difference(s) in the starting conditions amplify exponentially the effects of all other variables encountered. In addition, the feedback given to the system provides the cause(s) for even more deviation resulting in very different paths. Generally, bifurcations result in new and more complex stabilities and can *'evoke significant changes in outcomes'* (Phelps and Hase, 2002).

**Self-organisation**

Moore (2002) describes self-organisation as the simple fact of teams taking the responsibility of organising themselves without any external instructions in terms of *'hierarchy or definitions of internal relationships'*. In terms of complexity theory, it is seen more as the team(s) changing and modifying their structure, otherwise known as perturbed equilibrium (www.wikipedia.org ), so that they will adapt to the prevailing environment and grow and develop. Systems which go through states of instability usually self-organise after they have reached a critical point. It is important to note that those critical points are usually bifurcation points (Stacey, 2003). A typical example of self-organisation is a learning organisation (Moore, 2002).

### 5.2.2 On Sources, Types and Characteristics of Complexity

Analysing, categorising and understanding the effects of complexity will enable improvement of the management of complexity, a response with appropriate actions, a decision-making process, an improvement of output and, above all, improvement of confidence in the appropriateness of the process. A number of authors have suggested sources, proposed characteristics and facets and described tools and techniques to manage the effects of complexity. In order to understand the current thinking, a number of views in terms of types, characteristics and tools proposed will be described below. Five types of complexity have been described by Gidado (1996) and Girmscheid and Brockmann (2008) – task, social, operative, cultural and cognitive, the definitions are given below.

- *Task* complexity is defined as the '*density*' of tasks that need to be performed in the time and space frame;
- *Social* complexity relates to the multiplicity of parties involved;
- *Cultural* complexity concerns the background of the parties involved in terms of their '*history, experience, and sense-making processes*';
- *Operative* complexity relates to the interdependency of the parties involved in terms of operations and goals to be achieved; and
- *Cognitive* complexity, which is highly dependent on the individual or the group in terms of self-reflection, emergence and sense-making.

Gidado (1996) also determined four sources of complexity, employed resources, environment, level of scientific and technological knowledge required and number of interactions of different parts in the workflow.

Geraldi (2008a and 2008b), using Williams' (2002) typology of complexity, proposes that complexity in projects should be seen not as singular characteristics but holistically as '*patterns of complexity*' which are described by units of complexity ($\gamma$) that are the result of the product of the weight (w) and the intensity ($\lambda$) of each complexity characteristic ($\pi$). Through the concept of '*patterns of complexity*', Geraldi (2008b) indicates that there are three types of complexity – faith, fact and interaction. '*Complexity of faith*' refers to the situations where something new / unique is worked with – be that a new problem or dealing with high uncertainty. '*Complexity of fact*', as per Williams' (1999), structural complexity, is when dealing with a '*very large amount of interdependent information*'. Finally '*complexity of interaction*' exists between parties or '*systems / locations*'.

A number of other authors have identified various features/facets of complexity; Davidson Frame (2002) described size, variety, difficulty and change; Kallinikos (1998), on the organisation side, identified dynamism; whilst Crawford (2005) has indicated uniqueness and lack of clarity / definition of scope, goals and methods. Haas (2007) proposes seven dimensions which introduce complexity and risk on projects. These consist of time/cost, team size, team composition, competing demands, problem solution clarity, stability of requirements, strategic importance / political implications / multiple stakeholders and level of change. Phelps and Hase (2002), when considering complexity, highlight the inter-relationship between technology and behaviour and indicate that the introduction of technology as a change agent affects human behaviour and increases complexity. Similarly, Lillieskold and Ekstedt (2003) draw attention to the inter-relationship between cognitive and technical complexity. In particular they indicate that our capacity and mental capability to process information has remained constant against a rapid increase in the rate of change of technology.

The considerable shift in technological, social and economic factors and, above all, the growth of a knowledge-based society has increased the rate of change, which, according to complexity theory, occurs spontaneously as a result of an autocatalytic process (Jaafari, 2003). The rate of change has therefore affected the multiplicity of parties, which come together to deliver projects and therefore increase social complexity (Girmscheid and Brockmann, 2008). Social complexity, which exhibits such characteristics as 'open systems', 'chaos', 'self-organisation' and 'interdependence' (Jaafari, 2003), has been found to lead to an increase in self-reference at individual level and self-organisation at the group level (Geyer, 1998; Kirshbaum, 1999). At the individual level, Jaafari (2003) suggests that increasing all peoples' insight, including those at the lowest levels, increases their ability to operate and handle their environment more effectively and enables the creation of a the knowledge-based organisation.

Complexity (in organisations) will demand that managers reconsider the nature of hierarchy and the management of change (Morgan, 1997). Managers will have to take into consideration and then implement the concepts of self-organisation and master the art of achieving large effects through the use of small changes. Facets, types, features and dimensions are all lower-level 'products' that also need to be considered when dealing with complexity. However, what is required is clarity in the definition of complexity (Baccarini, 1996). Therefore, at a more elevated, indeed an all-encompassing, level the application of complexity theory is to enable the systematic review of the inter-connections (Davis and Sumara, 1997; Lucas, 2000a). Complexity can be defined as the study of the interconnections of systems and change, '*it is the interactions of structures that are important not which objects are interacting*' (Lucas, 2000a).

Considering complexity from the position of complex adaptive systems, Lucas (2000b) identified 18 distinct complexity axioms by carrying out a review of the '*three strands of thought*' – systems, organic and connectionist thinking. This approach is also confirmed by Burns (2005) who emphasises the need to deal with complexity at the lowest organisational level, the interactions between the systems and the formulation of '*rules of interactions*'. Therefore, Lucas' (2000b) axioms can be considered as the analytic approach that can provide a starting point for providing PMs with the tools to manage complexity. A detailed description of these axioms is shown below in Table 5.1.

Table 5.1. Complexity axioms (Lucas, 2000b)

| Axioms | Lucas' Description of complexity axioms |
|---|---|
| Autonomous agents | *Complex systems are generally composed of independent or autonomous agents (not the identical parts often assumed in science). All of these agents are regarded as equally valuable in the operation of the system.* |
| Instability | *Over the long term stepped evolution or catastrophes will exist (similar to punctuated equilibria). Sudden swaps between attractors become possible as the system parameters approach the boundaries of the attractors.* |
| Non-equilibrium | *Energy flows will drive the system away from an equilibrium position and establish semi-stable modes as dynamic attractors.* |
| Non-linear | *Complex system outputs are not proportional to their inputs. Taking the properties of each part and adding them will not give a valid solution ... the whole is different than the sum of the parts.* |
| Attractors | *Self-organization relates to the presence in the system of dynamical attractor. Each attractor occupies a relatively small area of the overall state space. The system is expected to contain multiple alternative attractors, giving several different possible behaviours for the same system.* |
| Co-evolution | *The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment.* |
| Self-modification | *Parts can change their associations or connectivity freely - either randomly or by evolved learning procedures.* |
| Self-reproduction | *Systems have an ability to clone identical or edited copies, ... copying errors permit new system structures to become available, allowing open ended evolution and self-generation.* |
| Downward Causation | *The existence and properties of the parts themselves are affected by the emergent properties ... of the whole which form boundary conditions on the freedom of the constituents.* |
| Mutability | *Random internal changes (mutations) or innovations typically occur in these systems. New configurations become possible due to part creation, destruction or modification.* |
| Non-uniform | *Each part evolves separately, giving a diversity in rule or task space.* |
| Emergence | *The properties of the overall system will be expected to contain functions that do not exist at part level.* |
| Phase changes | *Feedback processes lead to phase changes, sudden jumps in system properties.* |
| Unpredictability | *In such interacting systems a chaotic sensitivity to initial conditions can occur.* |
| Non-standard | *... initially homogenous systems will develop self-organizing structures dynamically.* |
| Undefined values | *The meaning of the system's interface with the environment is not initially specified and this must evolve.* |
| Fitness | *...fitness to the landscape,... identifying all the possibilities open to the system and not just the current actuality.* |
| Fuzzy functions | *The overall function of the system is not known but is created by co-evolutionary methods.* |

## 5.3 Complexity in Construction

Project management in construction exists in a complex environment (Thompson, 1967; Bertelsen, 2004), most importantly '*our project management knowledge base ... does not apply to complex projects*' (Turner, 2005). Additionally the contemporary project management model has failed (Williams, 1999 and 2002; Jaafari, 2003). Complexity in the context of construction, and the work by various authors, will be expanded below in order to establish a wider perspective of the thinking developed.

The application of complexity theory is to enable the systematic review of the interconnections (Baccariní, 1996; Lucas, 2000a). The importance of this definition lies in its ability to be applied to the numerous project management sub-processes.

As described in the previous section, Gidado (1996) proposed four sources of complexity in construction projects. He investigated the concept of complexity in planning and deduced that the lack of availability of appropriate tools or techniques forces practitioners either to ignore it or use subjective means in order to incorporate its '*effects on project managerial objectives*'. Having conducted interviews, he deduced that the construction industry sees complexity from a two-fold perspective: the managerial and the technical. The former is concerned with the planning and the management of the flow of work performed by the various parties whilst the latter focuses on the technical aspects of carrying out the works. Following on from these findings and by applying a deterministic approach, he defined project complexity as the measurement of the intricacy of the planned work against project '*quantifiable objectives*'. Despite the deterministic definition, he indicated that the sources of project complexity fall into two categories '*the inherent*' and those which emanate from the '*interconnections*' between the different parts of the project. In reference to the importance of the interconnections, Gidado (1996) states: '*The varying nature of the interdependences or interfaces of roles may bring about the occurrence of any one or a number of the inherent complexity and uncertainty factors*' (Gidado, 1996:217).

From a more generic perspective, Baccarini (1996) highlights the fact that complexity should be treated as a separate dimension which consists of a number of interrelated parts and can be understood and measured '*in terms of differentiation and interdependencies*'. Even more importantly, he points out that project complexity influences the selection of project inputs, including the expertise and experience requirements of management personnel. Therefore, given the fact that complexity is categorised as inherent and something which emanates from the interconnections of the parties and systems involved, one could question the existence of simple projects. In terms of product and time constraints, Williams (2002) also identified that the increasing complexity increased structural / project complexity and both constraints affected the interdependencies, or as he calls it '*the inter-element connectivity and concurrency of tasks*'. The comparison made by Williams (2002) is basically between 'systems thinking', with its fundamental principle of interrelationship, and 'linear thinking', where everything is progressing steadily in a simple, linear, cause and effect chain (Senge, 1990). Interdependencies, as the source of complexity in projects, have been highlighted by a number of authors (Gidado, 1996; Baccarini, 1996; Williams, 1999; Jaafari, 2003; Geraldi, 2008). In addition it is crucial to understand the type of interdependencies and not just the number. For example, reciprocal interdependencies (Thompson, 1967) are those that increase complexity in projects (Williams, 1999).

The IPMA in their certification guidelines (ICRG, 2005) provide a number of characteristics that should be taken into account when dealing with complex projects. Within the characteristics described, interrelationships are identified as an area that needs to be taken into account. However, an unsuccessful description of a complex project as '*a project that requires complex project management*' (ICRG, 2005) and the persistent promotion of deterministic methods, even though these have been characterised as '*stuck in a time warp back in the 60's*' (Morris, 1994), or seen as 'passive sources of information' (Reiss, 2006), fails to illuminate the subject of complexity. Criticism is also growing regarding PMBOK, PRINCE2 and similar tools as failing to help PMs manage complexity in projects (Thomas and Mengel, 2008).

The failure of the project management '*decomposition models*', described in Chapter 2, emphasises the need for improvements (Williams, 1999; De Meyer et al., 2002). For example network models need to include stochastic effects, or to build top-down holistic models using System Dynamics, which understand and deal with feedback loops, or to utilise 'softer' ideas such as Soft Systems Methods. There is a need for greater flexibility, teamwork and for PMs to understand that they will need to deal with constant change and the fact that learning could affect the project structure (De Meyer et al., 2002). Also improvements in management techniques, management structures and style are necessary since complexity increases conflict (Williams, 1999). The required management style is one that should be based '*on elements such as integration, systemic management, simultaneous management, the use of teams and managing functional plans simultaneously and interdependently*' (Laufer et al., 1996, as quoted by Williams, 1999:270).

In describing the development of overall complexity with time, in the construction of mega projects, Girmscheid and Brockman (2008) deduce that one of the most basic ways of dealing with complexity is through departmentalisation. They also state that '*project management must decide on a coherent set of management procedures that assure efficiency under the terns of the* contract'. Particularly in the case of social complexity, this is resolved by a 'superior' delegating the work to a trusted person. However, Bertelsen (2004) criticises the use of the production paradigm in construction and indicates that the industry should be considered as a complex non-linear system. In particular he indicates that the three facets of construction - fragmentation, temporariness/transience and the non-assembly-like process - render themselves for analysis under the complexity perspective (Bertelsen, 2002a). In agreeing with Lucas' (2000a) approach to viewing complexity in terms of the interconnections, he uses three of Lucas' (2000b) 18 complexity axioms - emergence, self-organisation and self-modification - to propose a set of management techniques to manage complexity in construction. In earlier work which was implemented in a Danish project, Bertelsen (2002b) grouped 14 of the 18 complexity characteristics defined by Lucas (2000b) into three groups –

autonomous agents, undefined values and non-linearity - and established relevance against the construction process and the production and social systems.

The above again raised the question as to whether there is such a thing as 'a simple project'. The condition of a project (simple or complex) is dependant on a large number of factors which vary during the life of the project. Conditions that vary throughout the duration of the project could transform it from something that is functioning smoothly to something that is at the edge of chaos. These conditions are dependent not only on technical, contractual, organisational, environmental and systems issues, which could be the cause of complexity, but also on the behaviours and culture(s) of the players. Soft processes, such as the selection of team members, structuring the project team and the management style are considered as constants that are '*put in place to optimise through-life performance, but are later reconfigured because of short-term demands for cost-reduction and control*' (Winter and Smith, 2006). The case for a new management style, when PMs deal with complex adaptive systems, has also been demonstrated by Ivory and Alderman (2005).

In general, there are calls (Williams, 1999; Jaafari, 2003; Thomas and Mengel, 2008) for new ways of thinking about complexity in projects from both the researchers and the practitioners. In particular Thomas and Mengel (2008) question the level and adequacy of the latest drive for standardisation, certification and generally preparation of professionals to deal with complexity and the approach taken by senior company management (Crawford, 2005).

## 5.4 Project Management and Complexity Concerns

Stacey (2003), having progressively moved from the concept of organisations as chaotic systems and chaos theory to the concept of complex adaptive systems and complexity theory, advocates that the latter can only be employed if it is considered as a thought-provoking source of analogies. These analogies, between complex adaptive systems and human actions, should really be triggered by a process of assessment of the human actions and interactions against the characteristics of complexity.

Concerns regarding the PM's competency in dealing with the increasing complexity in projects are raised from two different directions. The first is from the level of the project management outcome (Jaafari, 2007b) and the second from the educational side (Thomas and Mengel, 2008). Jaafari (2007a), having reviewed studies in the project management outcome by Lampel (2000), concludes that there is a profound failure of the '*normative model of professional preparation in practice because of the rise in complexity, uncertainty and indeterminacy*'. Thomas and Mengel (2008), after an extensive review of educational material, also reached the same conclusion. Jaafari (2003) proposes that a new '*creative-reflective*' model – philosophical framework - is required. The model will enable PMs to overcome high environmental and project complexity and operate at the edge of chaos, in the phase transition stage. This will be done by following a transformational leadership style, enabling empowerment and self-organisation and relying on the competence and insights of the team members (Jaafari, 2003). However, this will result in an increase in the interconnections formed. As the number of interconnections between the structures and team members rise, complexity and the requirement for managing its effects increases. Therefore, processes such as those investigated in this research will become critical. Additionally, as construction moves more towards virtual teams, the requirement for such a model becomes more profound. Working in a virtual environment will demand greater individuality, empowerment and self-organisation, and consequently create the need for improved teamwork (Edum-Fotwe and McCaffer, 2004) and for the management of interconnections.

The review conducted on complexity has raised a number of questions which will need to be investigated. These are listed below:

- Is the definition of complexity of interconnections one that is acceptable by the project management professionals in UK?
- Could the complexity axioms described by Lucas (2000b) be considered as a means of managing complexity?
- Could the complexity axioms be deciphered to become applicable to construction project management and therefore as manageable characteristics?
- Is complexity or its characteristics considered when selecting team members, structuring the project teams or when considering the varying management styles?
- What is the effect of complexity on the project performance?
- What do construction companies consider as complexity and do they define it?
- Are any tools used to manage complexity?

## *5.5 Summary*

This chapter has addressed the basic principles, sources, types, characteristics and issues pertaining to complexity.

Having established a distinction between chaos theory and complexity, the latter has been researched more intensely. Authors have particularly concentrated on Complex Adaptive Systems (CAS), dealing with the interactions between the systems that construct the overall system. In response to earlier calls for treating complexity as a separate dimension and the need for specificity regarding the type of complexity, research has established that there are a number of different types of complexity, technical, social, cultural, operative and cognitive. A common thread from early findings is that interconnections are a source of complexity.

Various complexity theory concepts were borrowed and used as metaphors and various factors, facets and features have been defined. The review revealed a set of axioms that were specifically drawn to describe complexity of interconnections. These axioms were extracted from a review of the systems, organic and connectionist thinking and deal with complexity at the lowest level.

Complexity in construction has been a subject under review for more than a decade, with authors and institutions alike exposing the need and identifying techniques to deal with the various types. However, concerns have been raised for addressing complexity at a lower level - the interconnections - as well as improving the educational level of PMs. These calls also highlight the fact that the current normative / decomposition model of project management requires improvement and indicate that complexity theory could address these concerns.

A number of questions are raised by the author that will need to be investigated and which will allow for an informed decision to be made in terms of the current status in construction as well as the consideration given to the effects of complexity of interconnections. These are listed below:

- Is the definition of complexity of interconnections one that is acceptable by the project management professionals in UK?
- Could the complexity axioms described by Lucas (2000b) be considered as a means of managing complexity?
- Could the complexity axioms be deciphered to become applicable to construction project management and therefore as manageable characteristics?
- Is complexity or its characteristics considered when selecting team members, structuring the project teams or when considering the varying management styles?
- What is the effect of complexity on the project performance?
- What do construction companies consider as complexity and do they define it?
- Are any tools used to manage complexity?

The next chapter describes the research methodology adopted. In particular, the multi-methodology and the strategy chosen to investigate the effects of complexity of interconnections on the three project management sub-processes considered.

# Chapter 6 – Research Method

## 6.1 Introduction

This chapter will describe the philosophical rationale of this research based on the aims and objectives described in Chapter One, the questions raised from the literature review and the proposition set out below.

In the section on research strategy, the reasons, drivers and the approach considered for the implementation are described thereby enabling the author to draw inferences regarding the variables investigated. Following the research strategy are the hypotheses that will need to be proved or refuted. Having established the hypotheses and variables that will be investigated, the approach taken for sampling, the data collection and the relevant issues considered are described under the section on sampling strategy.

The chapter will close with the description of the two-phased approach, which will also provide explanation on the analysis of the data collected.

## 6.2 Proposition

From the aim and objectives described earlier, the following proposition is defined:
"Complexity of interconnections in construction projects can be managed by improving the project organisation and the management style followed."

## 6.3 Research rationale

The rationale of this investigation is that interconnections, formed between and affected by social entities in projects, give rise to complexity. The objectivist approach, undertaken to date, has not improved the processes concerned, resulting in a detrimental effect on the project outcome. In order to manage the effects of the complexity of interconnections a constructivist approach is required, one that will build upon, not only the already existing measures, but the behavioural ones and those required to manage the characteristics of the complexity of interconnections. The intricacy and novelty of the subject of complexity requires particular attention when devising the research strategy and design, as does the fact that the investigation concerns processes that are project- and company-specific. Implementing a single quantitative or qualitative research method is not expected to yield the required level of results that will be acceptable to practitioners. Therefore, a more elaborate approach needs to be undertaken.

## 6.4 Research Strategy

A number of research strategies can be designed from the questions raised in Figure 6.1 below and the two different types of questions which are raised, based on Yin's (2003) classification: investigate the 'what' and the 'how'.

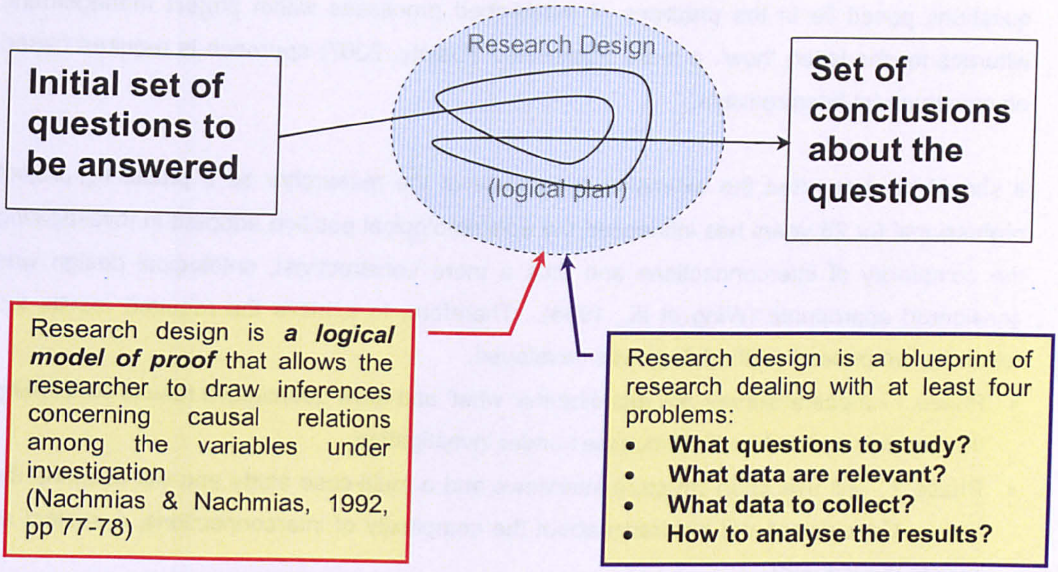


Figure 6.1. Diagrammatic representation of the definition of Research Design (Yin, 2003)

The "*what*" question calls for a survey or archival research strategy (Yin, 2003). Some of the questions raised from the objectives are:

- What is happening now in projects and in terms of the processes under investigation?
- What do the organisations and therefore the Project Managers (PMs) do?
- What are the external influences that affect the approach taken by the PMs?

The "*how*" question requires a case study research strategy and again some of the questions raised from the objectives are:

- How is complexity identified?
- How is it managed?
- How do PMs deal with the characteristics of the complexity of interconnections?
- How do PMs manage the effects of complexity of interconnections through its characteristics onto the processes under investigation?
- How does the complexity of interconnections affect the outcome?

Yin (2003) indicates that when deciding on the research strategy to be followed, one will need to consider the following three conditions:

1. *The type of research question,*
2. *The control the investigator has over actual behaviour events,*
3. *The focus on contemporary as opposed to historical phenomena.*

Exploiting these two sets of questions, as well as those raised in the literature review, requires a multi-methodology research design (Dainty, 2007). The 'what' requires a traditional positivist and quantitative method (Fellows and Liu, 2003) since the answers to the questions posed lie in the practices of established processes within project management, whereas for the latter, 'how', a more 'intertwined' (Dainty, 2007) approach is required based on constructivist interpretivism.

It should be noted that the extensive experience of the researcher as a practising project professional for 25 years has influenced the epistemological position adopted in investigating the complexity of interconnections and thus a more constructivist, ontological design was considered appropriate (Wing et al., 1998). Therefore, to achieve the required results the following two phased methodology was developed.

- Phase 1 - a postal survey, will examine the 'what' and draw quantitative results concerning the current approach to the processes under investigation.
- Phase 2 - will use open structure interviews and a multi-case study and will examine the 'how'. Conclusions will be drawn about the complexity of interconnections, a subject so new to the industry.

Figure 6.2 below provides a pictorial view of the research strategy and the phases to be implemented.

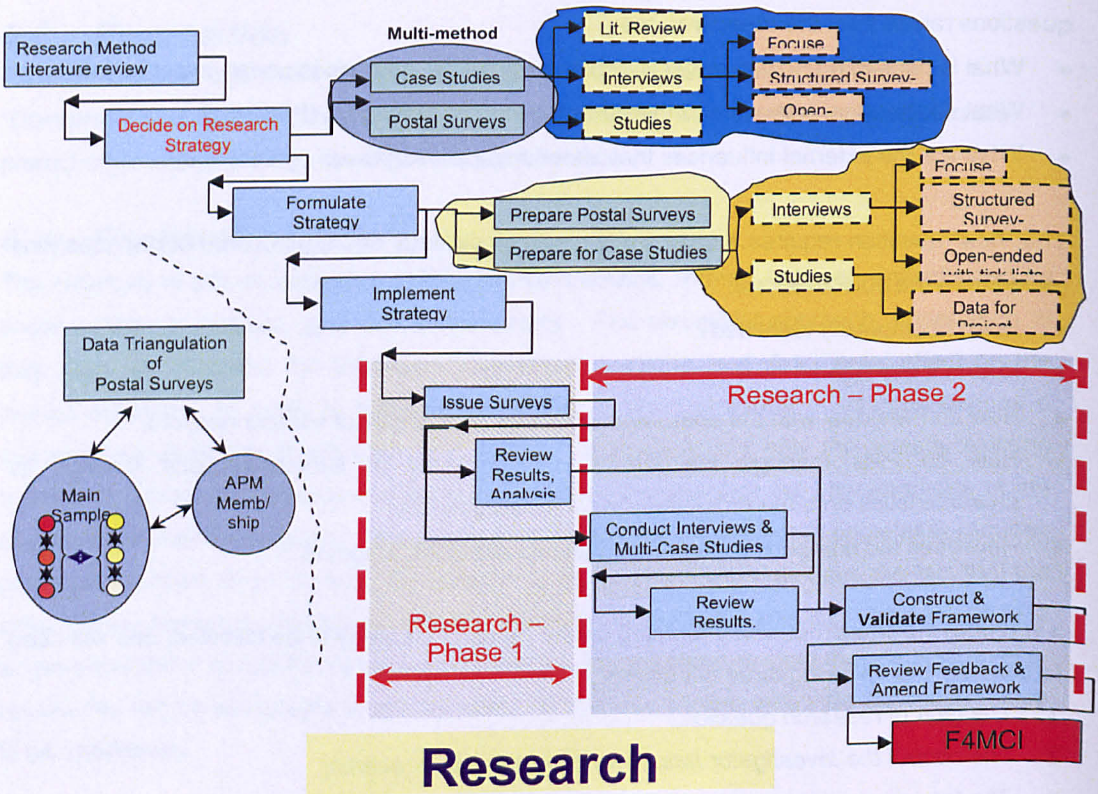


Figure 6.2. Research strategy adopted for the study

Due to the intricacy and newness, to practitioners, of the subject of complexity, it is proposed that, for an improved set of results (Stopher and Meyburg, 1979), stratified sampling is conducted for Phase 1 and then the same strata are used for Phase 2. The sampling strategy of stratification by variable sampling, which will be explained in detail below, is considered the most appropriate and beneficial because of the increased accuracy and its suitability to limited resource availability (Stopher and Meyburg, 1979). Three Client organisations and three Construction organisations, all of which are directly and continuously involved in projects and which influence heavily the UK project management environment, are selected for the stratified samples.

Thus having established the 'what' from Phase 1 – by surveying sets of organisations, the structured interviews and the multi-case studies will follow up with practitioners and a selection of projects from the same organisations in a review of the 'why' and the 'how'. Phase 2 is concluded by conducting validation interviews to saturation.

The research aim, described previously, presents the deliverable, the independent variables and the context (Fellows and Liu, 2003). However, as project management processes are interdependent, it is possible that there are a number of moderating variables which could influence the dependency between independent and dependent variables. Table 6.1, below, provides a succinct description.

Table 6.1 Description of context and variables of research aims

| | |
|---|---|
| Deliverable | The framework |
| Independent Variables | Selection, Setting-up, Management of Project Organisation |
| Dependent Variable | The Project outcome/success |
| Moderating Variables | Project Duration, Project Budget, Project Type, Procurement method |
| The Context | Management of Project Complexity of interconnections |

## *6.5 Hypotheses*

In order to perform the required investigations three main hypotheses were constructed from the questions raised in the literature review and the research objectives and these are expanded upon below.

The connection between the research objectives and the hypotheses has been indicated in Table 1.2 on page 6 and the pictorial representation of the hypotheses and how these integrate can be seen in Figure 6.3, below. Additionally and for ease of reference, a summary listing of all the questions raised in the literature review is shown in Table 6.1a, below.

Table 6.1a. Listing of questions raised by the literature review and by topic of research.

| |
|---|
| **Selecting team members** |
| • Are practitioners aware of the techniques available and do they know how to implement these correctly? |
| • Do companies support the implementation of selection techniques? |
| • What is the current status of implementation of the process in the construction industry? |
| • Are the processes implemented and down to what organisational level? |
| • What other processes for selection of team members are implemented? |
| • What factors affect the process? |
| • Do project management practitioners consider the effects of complexity when implementing the process? |
| • Are the effects of interconnections considered when selecting project team members? |
| **Structuring project teams** |
| • Down to what organisational level do Construction PMs structure their projects? |
| • Down to what level are they considering the organisational structure?<br>o The Management team?<br>o The Discipline leader level?<br>o The Team leader level?<br>o The Team level?<br>o The outsiders (support) who have direct or indirect involvement? |
| • Are all the levels mentioned above critical or can some of them be excluded? |
| • What type of structuring method is followed? |
| • What are the current environmental conditions in construction and are these considered when structuring project organisations? |
| • Are other project management sub-processes affecting the structuring of projects? |
| • Is complexity considered when structuring the project teams? |
| • Are complexity characteristics taken into consideration? |
| **Management style** |
| • Is there a prevailing management style currently followed by practitioners? |
| • Is there one or more than one management styles followed? |
| • Who decides on the management style to be followed? |
| • Who identifies the management style requirements for the specific project, and how is this done? |
| • Is the management style affected by other project management processes? |
| • Is management style considered to be an instrument for managing complexity? |
| • Are complexity characteristics considered when deciding on the management style to be followed? |
| • How much complexity / uncertainty stems from the PM's management style; especially in the case when the style of the person/PM does not 'fit' the project environment? |
| • Would PM practitioners agree with the literature review findings regarding management style affecting project outcome? |
| **Complexity** |
| • Is the definition of complexity of interconnections one that is acceptable by the project management professionals in the UK? |
| • Could the complexity axioms described by Lucas (2000b) be considered as a means of managing complexity? |
| • Could the complexity axioms be deciphered to become applicable to construction project management and therefore as manageable characteristics? |
| • Is complexity or its characteristics considered when selecting team members, structuring the project teams or when considering the varying management styles? |
| • What is the effect of complexity on project performance? |
| • What do construction companies consider as complexity and do they define it? |
| • Are any tools used to manage complexity? |

### 6.5.1 Hypotheses and Variables Structure

The hypotheses, and the investigation in general, have been constructed in such a way that the variables, in particular the independent, are consistent throughout. This will enable repeatability (Walker, 1997), propagation of conclusions and cross-referencing of deductions between and within the two strata.

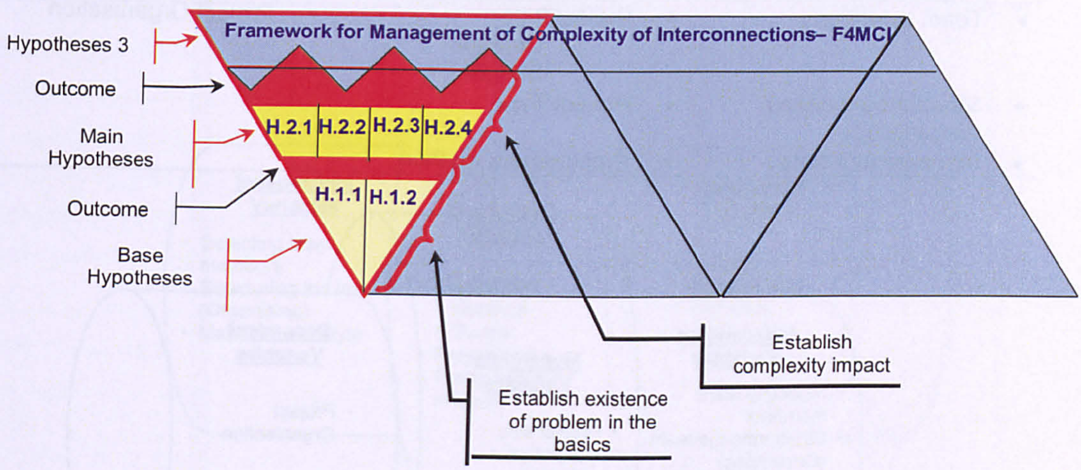


Figure 6.3. Pictorial representation of the research hypotheses concept.

### 6.5.2 Hypotheses 1 and Variables

Hypothesis 1 will be constructed in two parts. The first part will investigate the issues involved with the current techniques of selecting team members, structuring the project team and the management style that has been defined and followed. Therefore dealing with issues raised from the first objective of this research, the second part will investigate the relationship between the implementation of the sub-processes investigated and the project outcome so that they can be linked and compared against the third objective of this research.

<u>Hypothesis 1.1 (H1.1)</u>

The available techniques for setting up (selecting and structuring) project teams and the management style in construction projects are implemented down to the lowest project organisation level.

In order to simplify the set-up of the questionnaire and the quantitative evaluation of the results, the above hypothesis has been broken down into the following three sub-hypotheses.

H.1.1.1. Project team members are selected using personal profiling.

H.1.1.2. The Project Team structure is defined to the lowest level.

H.1.1.3. The Project Management style is defined down to the lowest level.

Table 6.2 and Figure 6.4 below indicate the research model and the variables developed which will test the above hypotheses.

Table 6.2. Main variables considered in the testing of hypotheses H1.1.1, H1.1.2, H1.1.3

| Independent Variables | Moderating Variables | Dependent Variables |
|---|---|---|
| • Team selection | • Project Size<br>○ Duration<br>○ Budget | • Project Organisation |
| • Structuring the team (Organising) | • Project Type | |
| • Management style | • Procurement method | |

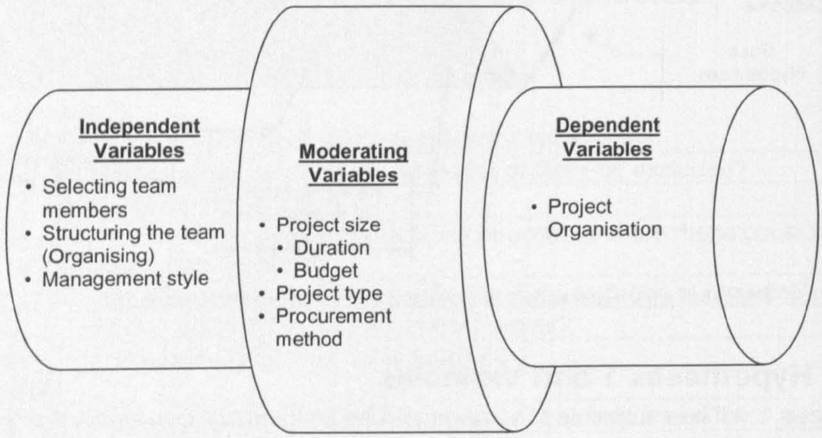


Figure 6.4. The research model for Hypotheses H1.1.1, H1.1.2 and H1.1.3

Hypothesis 1.2 (H1.2)

The implementation of selecting team members and structuring the project team processes down to the lowest project organisation level and the management style are positively correlated with improved project management outcome.

The most comprehensive work on measuring project outcome that is relevant to this research was conducted by Collins and Baccarini (2004), as described in Chapter 2. This will be expanded upon and used, throughout the testing of the hypothesis, in order to request the respondents to evaluate the outcome of their projects as well as become a link to the investigations for the third objective of this research.

Table 6.3 and Figure 6.5 below indicate the research model and the variables developed which will test the above hypotheses.

Table 6.3. Main variables considered in the testing of Hypothesis H1.2

| Independent Variables | Moderating Variables | Dependent Variables |
|---|---|---|
| • Team selection | • Project Size<br>○ Duration<br>○ Budget | • Project Management Outcome |
| • Structuring the team (Organising) | • Project Type | |
| • Management style | • Procurement method | |

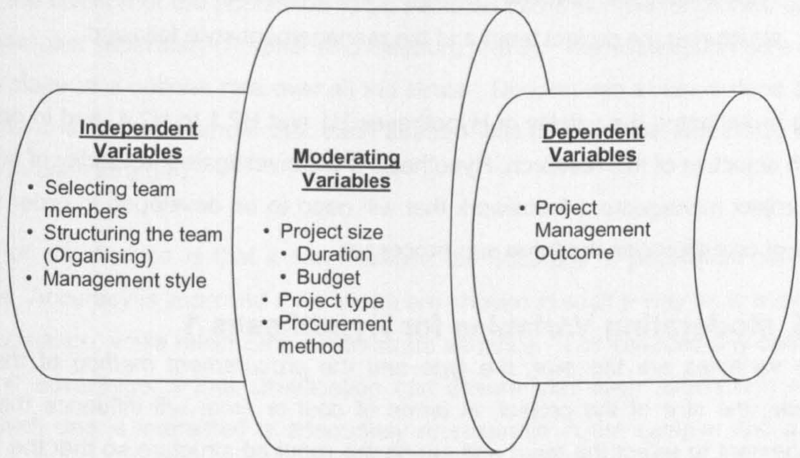


Figure 6.5. The research model for Hypothesis H1.2

### 6.5.3 Hypotheses 2.1, 2.2, 2.3 and 2.4

Defining complexity as the interconnections between structures and in order to address the second objective of this research, which investigates if the complexity characteristics are considered when carrying out the sub-processes of selecting project team members, structuring the project team and the management style followed, the following hypotheses have been formulated.

<u>Hypotheses 2.1, 2.2 and 2.3 (H2.1, H2.2 & H2.3)</u>

H.2.1 Complexity characteristics are considered when selecting project team members.

H.2.2 Complexity characteristics are considered when structuring the project team(s).

H.2.3 Complexity characteristics are taken into account when considering the management style to be followed on a project.

Furthermore, the effect of complexity of interconnections to the project performance will be tested by Hypothesis 2.4 and therefore address the third and fourth objectives of this research.

<u>Hypothesis 2.4 (H2.4)</u>

H.2.4 Complexity of interconnections is inversely correlated to the project performance.

In order to elaborate further on the above statement, it should be noted that project complexity, as defined above and introduced by the processes of selecting the project team members, structuring the team and the management style followed, is inversely correlated with project performance.

### 6.5.4 Hypothesis 3

H.3.0 A framework is required to be developed for managing the effects of complexity of interconnections caused by the sub-processes of selecting team members, structuring the project team and the management style followed.

Having investigated the validity of Hypotheses H1 and H2.1 to H2.4, and in order to address the fifth objective of this research, Hypothesis 3 will investigate the validity of and requirement for a project management framework that will need to be developed in order to manage the effects of complexity on the three sub-processes.

### 6.5.5 Moderating Variables for Hypotheses 1

These variables are the *size*, the *type* and the *procurement method* of the project. For example, *the size* of the project, in terms of cost or time, will influence the time given to management to select the team and set up the required structure so that the team can carry out the work. Similarly, *the type* of the project and the *procurement method*, e.g. major works with extensive external stakeholders and/or financial risk to the company, fixed price lump sum, etc., could influence the selection of the team and the setting up of the project team process as the company puts more effort and allows more time for these activities to be performed. It is possible that these will become issues that are discussed at Project Board level with the management team presenting proposals. An approach to establish any relationship will be to ask the respondents to indicate if these variables influence the independent variables, in order for them to be considered during the quantitative analysis.

## *6.6 Sampling Strategy*

In addition to the conditions mentioned above - the newness and intricacy of the subject of complexity - a number of other factors had to be considered when structuring and planning for the sampling strategy. These factors were:

- The importance of continuity with regard to the two-phased approach,
    - Understanding current practices by testing Hypothesis 1 during Phase 1,
    - Establishing an understanding of complexity characteristics and testing Hypotheses 2.1, 2.2 and 2.3 during Phase 2 – part 1,
    - Carrying out six case studies and testing Hypothesis 2.4 during Phase 2 – part 2.
- Minimising non-response,
- Maximising the use of the time and resources available.

Therefore, a general random-sampling approach was considered insufficient and uncertain in terms of yielding the required response (Moura and Teixeira, 2006). The literature review, in terms of sampling techniques (Stopher and Meyburg, 1979; Dietrich, 2001) and the extensive contacts with Client and Construction organisations available to the author, assisted in making a swift decision to adopt the stratified sampling approach.

### 6.6.1 Simple Stratification Sampling

Stratification is the division of the population to be sampled into a number of blocks, each of which is to be sampled separately (Stopher and Meyburg, 1979). The assumption here is that sampling takes place at a uniform rate over all the strata. Division into strata is done before sampling and there is no requirement that each stratum should be of the same size or the number of units in each stratum.

The advantage of stratification is that it can increase the accuracy of population estimates from the sample. Accuracy is improved if the strata are chosen in such a way as to maximise between-strata variance, while minimising within-strata variance. This reduces any sampling error. A second advantage is that stratification can ensure that each subdivision of the population in which one is interested is adequately represented in the sample, and a third advantage is that it allows, if required, the use of different surveying or sampling methods within each stratum. However, a drawback to stratification is that unless the population is known it can produce erroneous results regarding the reduction of random-sampling error.

Stopher and Meyburg (1979: 32) indicate that '*one may reconstruct the sampling frame into separate frames for each stratum and select each stratum's sample at random in the usual way*'. The sampling strategy followed, reflects this point by the stratification of the population into 'Client' and 'Contractor' strata with each stratum then being separated respectively into three frames, which represent some of the biggest Client and Contractor organisations in the UK. Samples within the frames are then selected randomly.

As described by Stopher and Meyburg (1979), the key in stratified sampling is a '*sufficiently large ... sample*'. Therefore, the sampling strategy will be to obtain a large random sample from each organisation so that each organisation is represented in the correct proportion. Additionally, the fact that the selected organisations represent an extensive and continuous workload in the Southeast, establishes the representation of the construction market. Considering the limited resources and time available for this research any other random or completely independent selection of companies would not be able to produce a representative construction sample.

Stratification with variable sampling fractions was also considered as an approach to increase the accuracy of the results. However, Stopher and Meyburg (1979:38) suggest that '*the method should be used only when both the between-strata and the within-strata variances are* *substantial*'. In terms of the heterogeneity of the strata, Dietrich (2001) states that '*stratified random sampling is most beneficial when data are .... heterogeneous across strata*'. The research strategy has identified two major elements in the construction industry as the main elements that require sampling, namely, the Client organisation and the Constructor organisation and these have substantial variances. Within the strata then, there will be three distinct organisations where substantial variances exist. Furthermore the research will cover and review practices from both sides of the project management spectrum thus reducing the risks of criticism from either side regarding the areas of investigation and the deductions and final conclusions made in the outcome of this research. Stratification will also enable the identification of any major variances between the two strata and the respective frames in terms of the Project Management processes and the Outcome of Project Management (Collins and Baccarini, 2004). Similarly it will be possible to investigate and inform on variances within the strata of the Project Management processes followed. Therefore, stratification by variable sampling would be the most appropriate and beneficial approach, especially with the limited resources available.

Clustering of the units within the frames will also have great advantages as has been indicated by Stopher and Meyburg (1979). Clustering in this research will be implemented in terms of taxonomies and typologies, as shown in Table 6.7 below. It is cheaper and much easier to control clustering rather than random sampling and, when combined with stratification, there is a remarkable decrease of the cluster sampling error (Stopher and Meyburg, 1979).

### 6.6.2 Minimising sampling error

In addition to the above, the author had to consider the minimisation of the random sampling error.

Stratification allows for the reduction of the level of '*variability of the units that contributes to the random-sampling error*' (Stopher and Meyburg, 1979). Therefore, and as expected, stratification sampling should have smaller '*standard errors and therefore require a smaller sample size for a given required standard error of estimate*'. Dietrich (2001) also confers that '*for balanced sampling, each sample strata contains an equal number of observations and .... for small samples the balanced strategies have the lowest failure rates*'.

Reduction of sampling error by stratification has also been agreed by Yates (as quoted by Stopher and Meyburg, 1979: 29) who constructed seven indicative rules for reducing the random-sampling error, of which the following three are relative to the approach undertaken in this research:

1. '*The use of stratification ...can generally be expected to improve the accuracy of the survey results*'.
2. '*Although stratification will generally increase accuracy, it will only do so substantially when there are highly significant differences between the strata*'. This has already been described above.

3. *'In stratification, it is necessary to have at least one unit in each stratum. So for small samples, stratification may be undesirable or ineffective, since, for a given sample size, strata will have to be fewer and larger. However, in large samples, more detailed stratification is possible with a consequent rapid increase in accuracy'.*

### 6.6.3 Comparison of methods

Despite the uncertainties faced with regard to random sampling, it is acknowledged that although stratified sampling minimises the sampling error, it will not be as representative of the construction industry in Great Britain as random sampling would be. Therefore when data collection commences, relative information will be sought which will enable comparative analysis of the results.

### 6.6.4 Sample Selection – The Approach

*'The primary interest of the analyst is to be able to make statements about the whole population'* (Stopher and Meyburg, 1979). Stopher and Meyburg indicate that there are five basic defects that should be avoided when deciding on a sampling frame. These are:

1. *Inaccuracy*
2. *Incompleteness*
3. *Duplication*
4. *Inadequacy*
5. *Being out-of-date*

All the above mentioned defects were considered carefully during the setting up of the strategy and the preparation of the postal survey sampling frame.

In terms of the choice of sampling units, it was decided to select two strata in order to cover divergence in the project management field and include the most disaggregated of the possible units, as this will allow for aggregation at a later stage (Stopher and Meyburg, 1979). The two strata will be those of Client and Contractor organisations, thus covering both sides of the project management, that of the leader and that of delivering the construction project. It was decided to investigate three of the most persistently high capital expenditure Client organisations, which are highly regulated, with extensive five year construction plans, representing the largest Utilities and Infrastructure Clients in the Southeast and UK, and with well-established project management processes. These were BAA, Thames Water and Southern Water. In selecting the construction organisations, it was decided to investigate three of the largest, well-established, construction companies in the UK, which have an extensive portfolio of construction projects and well-established processes. These were AMEC (now known as Morgan Est), Balfour Beatty and Laing O'Rourke. Therefore, the stratified sample will represent all PM practitioners for both Client and Contractor for the South East UK. As the South East UK is the biggest construction industry sector (Construction Statistics Annual, 2007) the sample can easily represent the whole UK population of construction PM practitioners and relevant statistical data will be retrieved and analysed for comparison. Also using statistical formulae, an inverse extrapolation will be carried out and from the response received, the representative population of PM practitioners will be established

The research has also considered, as a sample, only large construction Companies and Clients and avoided small companies in order to minimise bias which would come from professionals not performing a pure Project Manager's role, which is usually the practice in smaller construction companies. It was also decided that it would not be appropriate to consider Project Management Consultants because:

- They do not normally and persistently have large enough teams allocated to projects,
- They operate mainly as advisors,
- They tend to focus in keeping the cost down,
- They do not ordinarily drive construction projects. Their usual commissions are to represent the Client and present proposals.

### 6.6.5 Unit of analysis

The Project will be used as the unit of analysis of the postal survey, in order to avoid the common errors of logic, ecological fallacy and reductionism (Fellows and Liu, 2003).

### 6.6.6 Non-response

When preparing the research strategy and the questionnaires the issue of non-response was considered carefully. Lessons learnt by Moura and Teixeira (2006) were taken into account in order to minimise the risk of non-responding. Furthermore, in order to reduce the usual 70% non-response (Henry, 1990; Dainty, 2007), it was decided to approach the Project Management population through Board Directors of the selected organisations. The approach used to distribute and monitor response to the postal survey is explained below.

### 6.6.7 Respondents' Dilemmas

Other points considered whilst deciding on the structure of the questionnaire and the approach to carrying out the postal survey were the limitation of effects such as 'observer and observant' (Nial Bohr) and the Traveller's Dilemma (Basu, 2007). The former is very well known and will not be mentioned further in this Thesis. However, the latter is a recently-developed theory and explores the irrational choices made by people when they have to choose for their own benefit, or represent their own work, as opposed to the benefit of the organisation for which they work. Basu has been investigating since 1994 and supports the argument that the '*assumption that rationality is common knowledge*', which is the basic principle in the Nash equilibrium, '*is the source of the conflict between logic and intuition and that, in the case of the Traveller's Dilemma, the intuition is right and awaiting validation by a better logic*' (Basu, 2007).

Based on Basu's theory and extrapolating this to the surveys conducted, if a Project Manager is asked to select from a choice of ratings about the success of his/her project, the expectation, according to the Traveller's Dilemma, will be that s/he will select either "total success" or the ratings very near the top value, irrespective of the true outcome. By asking for data that will prove the rating of the outcome, and which can only be based on past project performance criteria, e.g. time, cost, baseline information etc., it will be impossible to understand / identify if the data given were not 'selected' purely for reporting purposes. Also, projections of the expected outcome, for live projects, will be influenced by the PM's intuition rather than rational decision.

Considering all the above, extensive time was allocated to preparing for Phase 1 of the research strategy, the preparation of the questionnaire and material which was to be used for introducing the context and content of the research to the organisations. This will be explained in the sections that follow.

## *6.7 Phase 1*

Phase 1, which comprises a quantitative postal survey, will test Hypothesis 1.

### 6.7.1 Postal Survey

Having worked out the detailed hypotheses and in order to implement the research strategy, a postal questionnaire was developed that comprised five parts structured around the areas under investigation. A postal survey note accompanied the questionnaire explaining the context of the survey and giving definitions, where required. The final version of the note and the questionnaire can be seen in Appendix C-3.1.

The five parts were as follows:

- Part 1 – General/Demographics. This consisted of nine questions requesting respondents to complete details such as the type and size of the organisation they work for, their job title, years of experience, academic and professional qualifications and the project size the organisation deals with.
- Part 2 – Selection of project team members. In this section, respondents were asked to consider questions regarding the selection of project personnel. Questions covered areas such as awareness, knowledge and implementation of personal profiling techniques; an indication of the project prevailing conditions; the criteria used for selecting PMs and Project team members as well as the lowest organisational level at which team members were selected.
- Part 3 – Structuring of project teams. In this section, respondents were asked to consider questions regarding the structuring of their project teams. Questions covered areas such as, requests to indicate the lowest level at which the project structure is defined, as well as who defines the appropriate levels and how the various project teams were organised.
- Part 4 – Management Style. In this section, respondents were asked to indicate if a decision was made with regard to the management style to be followed and consider other

questions regarding the management style adopted in their projects. Respondents were also asked to indicate the management style adopted at different levels within the project structure.

- Part 5 – Project Outcome. In this section, respondents were asked to consider questions regarding the project outcome and give their views on some generic statements. It is important to note that, throughout the previous three sections of the questionnaire, respondents were asked to reply to questions regarding '*their most recently completed project*'. The aim was to establish a link between the responses on the three processes under investigation and the project outcome for their most recently completed project. The Collins and Baccarini (2004) criteria were used for evaluating the quality of the outcome of the project management process.

Questions regarding the moderating variables were positioned at the end of each part and, using Likert 5-level scales, respondents were asked to indicate the level of influence each variable exerted on the independent variable considered. Also in Part 5, Likert scales of 5 and 10 levels were used in order to establish respondents' feedback on project outcome. It is important to indicate, in particular regarding questions of Part 5, that both levels of Likert scales produce similar statistical characteristics (e.g. mean, variance, skewness, etc) (Dawes, 2008).

During the development of the questionnaire and apart from ensuring that the questions cover the topic under review, a number of additional factors were considered (Hague, 1993):

- Ease of completion,
- Ease of understanding of questions,
- Portraying a real-life environment and not a purely theoretical approach,
- Addressing the various company levels,
- Ease of codification.

**<u>Data Entry and Information management</u>**

In order to simplify laborious and time consuming data entries and transfers, a set of tools was developed to electronically transfer questionnaire responses to a common base. An MSExcel Macro was developed which codified and transferred data entries from MSWord questionnaires to MSExcel and then imported the data to SPSS. This enabled:

- Human intervention to be kept to a minimum;
- Complete removal of possible data-entry errors; and
- Reduction in time and resource requirements.

### 6.7.2 Piloting

After an extensive review of the questionnaire content, a pilot study was conducted over a period of three weeks in order to validate the questionnaire, establish appropriateness and minimise the causes of *inadequate* or *no-response* (Fellows and Liu, 2003). The draft questionnaire was issued to ten people from four companies, all at different levels, thus simulating the sampling strategy and representing 5% of the expected stratified sample population. Due to the differences between the organisations and after discussion with the respondents, job titles were *'normalised'* to enable appropriate grouping. Table 6.6 below provides general information about the piloting sample.

Table 6.6. General information about the pilot sample.

| | | | | | |
|---|---|---|---|---|---|
| **Type** | 70% | Client | **Normalised Job Titles** | 20% | Project Director |
| | 20% | Contractor | | 40% | Senior Project Manager |
| | 10% | Consultant | | 30% | Project Manager |
| | | | | 10% | Assistant PM |

Feedback from the piloting was used to extensively revise the questionnaire and its final length was reduced by a third. A number of questions were revisited and / or simplified according to comments from the respondents and the aims of the research. Each question was measured against its contribution to the outcome and the final questionnaire included 43 questions with approximately 190 variables.

### 6.7.3 Managing the distribution of postal questionnaires

Having revised the postal questionnaire according to the findings from the pilot, the next task was to get in touch with the organisations and persuade them to participate in the process. A presentation was prepared, containing the research aims, objectives, details of the targets, the Phases involved and the schedule of activities by strata and Phase. The purpose of the presentation was to achieve endorsement at the most senior level within the companies. This was to be accomplished by describing in detail the research purpose and process and at the same time handing out the material ready for the Directors to circulate to their PMs / companies. Therefore, in addition to the questionnaire and the questionnaire note, a general email was prepared for them so that it could be circulated immediately by the Directors to the respondents. Information was provided in both hard copy and CD forms.

In addition to the six organisations and after discussions with the Association for Project Management (APM), a request to participate in the survey was published in the July 2007 issue of the Network magazine, the monthly APM circular to members. The aim was to establish data triangulation in addition to the triangulation gained through the literature review. The request was also published on all the APM Thames Valley Branch event flyers during the months of June to August 2007, in order to extend the promotion of the research for a longer period of time. APM members were asked to access the questionnaire and the note through the researcher's website (see http://www.danton-progm.doc.uk). The decision to approach only APM membership was based on the fact that it is the only Association that primarily represents PM practitioners and not Engineering or other discipline(s). Also another reason was that APM developed the Project Management Book of Knowledge.

In order to establish objectivity and cross-correspondence (Fellows and Liu, 2003; Gillham, 2000) between the respective groups and organisations, and using the typologies and taxonomies established, it was possible to group respondents by grade and years of experience as listed in Table 6.7 below. This approach made the data more manageable and visible so that it was easier '*to detect patterns and possible dependencies / causalities*' (Fellows and Liu, 2003). Furthermore the lower management level of Site Manager was introduced as a means of internal triangulation of replies as well as obtaining feedback from the organisational level above the 'doers' – design / site team members. Also the issue of interpretivism (the interpretive paradigm) was addressed by breaking down the research design into categories and sub-categories, as described above (Fellows and Liu, 2003). Variance, which occurs when analysing data, was minimised by establishing '*typologies and taxonomies*' (Fellows and Liu, 2003, referencing Hammersley and Atkinson, 1983).

Table 6.7 Typologies and taxonomies / groups of sample

| | |
|---|---|
| Experience | <5, 5<x<10, 10<x<15, 15<x in years |
| Management Levels | Project Director,<br>Senior Project Manager (SPM),<br>Project Manager (PM),<br>Assistant Project Manager (APM) |
| Academic Qualification | (HNC, HND, Degree, Post Grad) |
| Professional Qualification | CEng, Member of Institution, None |
| Project Management Certification level | APMP, ...., CPM |

### 6.7.4 Managing data collection of postal questionnaires

Due to the extent of direct involvement, presentations, workload of respondents, etc., it was decided to allow a three month period for data collection. During the presentations the Board Directors were advised that they would be kept informed of the progress made throughout the period of three months through overall weekly reports. Furthermore, all companies were allocated a code which was known only to the Directors who also knew which other organisations were participating, thus attempting to introduce a degree of inter-organisation competitiveness between Directors.

The questionnaire completion period was managed as a project, more accurately as a 'charity project' as it was largely dependant on the goodwill of others to contribute. However, it did have much tighter restrictions. For example, charity events cannot be organised as these could be seen as influencing the outcome. By issuing overall progress reports, the main 'Stakeholders' (the Directors) were continuously informed, which meant they could see how their company was performing against the other companies. Another tactic used was to establish early direct contact with the Directors' Personal Assistants who on many occasions became the drivers, thus applying more pressure to respond to the survey.

## 6.8 Phase 2

As described above, the research strategy was structured in two phases. The significance of Phase 2 was the exploration of the subject of complexity of interconnection in construction projects and the applicability of complexity axioms (Lucas, 2000a). This was considered very intricate, especially when investigating the three processes of selecting team members, structuring the project team and the management style followed, which are more behavioural rather than control-oriented. For this reason, Phase 2 was divided into two parts.

Part 1 of phase 2 – Conduct 51 interviews with project management practitioners identified by the Board Directors of the stratified samples of Phase 1 in order to investigate Hypotheses 2.1 to 2.3. The interviews were open structured with most questions having a closed response for consistency of replies (Hague 1993). The sample size - 51 PM practitioners - represents 22% of the anticipated response from Phase 1 and was considered representative and manageable within the research the time available.

Part 2 of Phase 2 – The multiple-case study - explanatory rather than descriptive (Yin, 2003) - was to be conducted by selecting projects from the same organisations.
In order to investigate Hypothesis 2.4, and for all the stages of the project life-cycle, the Directors were requested to consider an experienced PM (with more than 10 years experience) who manages a live project and which could be at any of the three different stages of the project life-cycle – feasibility, construction and commissioning. Thus, the aim was to be able to conduct two case studies per project phase and each case study to last nine weeks (a minimum of two monthly reporting periods).

### 6.8.1 Phase 2 - Sampling Strategy

In addition to a representative sample and the large number of interviews to be conducted, the sampling strategy for Part 1 of Phase 2 had to be considered at the very early stages of formulating the overall research strategy. The reason stemmed from the intricacies of the subject, the requirement for continuity between the two phases and for enabling the strata Directors to understand the importance of the research. Therefore, a generic random sampling was not considered to be the appropriate approach but instead a choice-based sampling approach was selected.

A choice-based method of sampling was considered appropriate and as Stopher and Meyburg (1979:42) state '... *other procedures of sampling may not offer the most appropriate method because of the cost of sampling or the difficulty in finding the sample ... Choice-based sampling is carried out by identifying the decision group of interest and then choosing individuals by random sampling*'. Dietrich (2001) also, having performed Monte Carlo simulations for nine sampling techniques, points out that '*choice-based sampling with proportional strata allocation will not introduce any additional bias to the small sample*'. Furthermore, stratified random sampling with balanced strata sizes and choice-based sampling outperforms the other sampling strategies (Dietrich, 2001). In spite of this, it is accepted that, by implementing a choice-based sampling, the results can only describe the selected and studied population (Stopher and Meyburg, 1979). However, the number of interviews (51) expected to be conducted is considered adequately large to represent normal responses in open surveys.

Thus, having identified the strata and the frames (the six representative organisations) individuals who would be interviewed were randomly selected by the Directors who also identified the PM that would perform the case study. This was considered as the most appropriate method because of the intricacy of the subject matter involved and because of the necessity of obtaining feedback directly from practising construction PMs. Additionally, and as will be explained below, conducting the case studies required a fastidious approach as the issue of the intricacy of the subject needed to be addressed.

### 6.8.2 Multiple-case studies

Case studies, as described by Yin (2003), are the preferred strategy when:

- 'HOW' or 'WHY' questions are being posed;
- The investigator has little control over events;
- The focus is on a contemporary phenomenon within some real-life context too complex for surveys or experiments; and
- There is need to understand complex social phenomena.

Multiple-case studies also allow the investigator to create multiple strategies (Dainty, 2007) in combination with other research techniques, such as surveys, interviews, observations, etc. (Yin, 2003). This is exactly the expected, holistic (Yin, 2003), environment of the multiple-case studies that will prove or refute Hypothesis 2.4 for all three major stages of the project life-cycle. However, multiple-case studies remain one of the most challenging of all social science endeavours and should serve a specific purpose within the overall scope of an inquiry (Yin, 2003). The importance of implementing multiple-case studies, and in particular two case studies per project life-cycle stage, lies in the fact that:

- Fears of uniqueness and artificial conditions surrounding the case(s) are minimised;
- Literal replication logic (Yin, 2003) is being followed; and

- Managing six cases, with the time and resources available, was considered the best possible approach.

Yin (2003:10) depicts three popular / traditional prejudices against the Case Study Strategy. The first one is lack of rigor and sloppiness; the second one is that '*case studies provide little basis for scientific generalization*', and the third one is that case studies are time-consuming, ending up been massive and unreadable. The first and third can be managed by the researcher. For the second, Yin (2003) states '*Case studies, like experiments, are generalisable to theoretical propositions and not to populations or universes. ... in doing a case study your goal will be to expand and generalize theories (analytic generalization) and not enumerate frequencies (statistical generalization)*'. Following this concept, a part of this research is to prove or refute, through Hypothesis 2.4, the heuristic fact that 'as complexity increases performance drops'. Rephrasing, this research will therefore attempt to explain that 'performance is inversely proportional to complexity' in terms of the complexity characteristics and provide a framework for dealing with complexity. If the case studies enable this to be achieved, it will be considered much more successful than providing a statistical generalisation. In addition, the outcome of the case studies and the proposed framework will be validated by holding a workshop with a randomly-selected audience from the construction industry.

The case studies will be use a closed design (Yin, 2003). However, the feedback/reporting mechanism will remain adaptive and flexible in order to minimise the imposition of extra workload and resource demands on case study participants and accommodate the variability of strata and frames/organisations.

Finally, it was considered that the number of case studies is apposite because, as Yin (2003: 32) states, '*if two or more cases are shown to support the same theory replication may be claimed and results will be considered more potent.*'

### 6.8.3 Phase 2 Part 1 - Interviews

Open-structured interviews with closed responses were set up in order to collect data from the 51 Project Management practitioners (see Table 6.8 below). Due to the uniqueness of the subject the author prepared a brief explanatory introduction which was followed by a two part interview based on the main hypotheses being investigated. The structure of the interviews ensured consistency of approach with questions addressing the complexity characteristics being asked in the same order. The aim of the interviews was to prove or refute Hypotheses 2.1, 2.2 and 2.3; therefore explaining and enabling comprehension of the concept(s) was paramount.

Table 6.8. Number and level of interviewees by strata and frame.

| | Interviews | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Client Group | | | | Contractor Group | | | |
| Level \ Code | G1.1 | G1.2 | G1.3 | Total | G2.1 | G2.2 | G2.3 | Total |
| Director | 1 | 1 | 1 | **3** | 1 | 1 | 1 | **3** |
| Senior PM | 2 | 2 | 2 | **6** | 2 | 2 | 2 | **6** |
| PM | 2 | 2 | 2 | **6** | 2 | 2 | 2 | **6** |
| Assistant PM | 2 | 2 | 2 | **6** | 2 | 2 | 2 | **6** |
| Site Manager | 0 | 0 | 0 | **0** | 3 | 3 | 3 | **9** |
| **Total** | **7** | **7** | **7** | **21** | **10** | **10** | **10** | **30** |

Two different questionnaires were prepared (see Appendices C-3.2 and C-3.3).

The generic complexity questionnaire.

This questionnaire addressed general questions regarding complexity including those raised in the literature review and shown in Table 6.1a, agreement or not with the definition proposed by Lucas (2000b) and if any measures are taken in terms of dealing with complexity in the three areas under investigation.

The complexity characteristics questionnaire.

This questionnaire was structured around the 16 complexity characteristics identified by Lucas (2000b) and their relevance to the sub-processes being investigated. Lucas (2000b) combined three generic theories: systems, organic and connectionist thinking, and defined the 18 axioms of a Complex System. However, whereas it might be possible to treat these as self-evident, for general complexity, it will not be appropriate to transfer them to the field of project management. It will be more appropriate to consider them as postulates dealing with specific subject matter. Bertelsen (2005) also has indicated that these can be taken as characteristics of complexity in project management.

In the current research, 16 of the 18 characteristics will be interpreted in terms of a project management perception and explained / discussed during interviews with 51 Project Management professionals (from Director to Site Manager level). The interpretations given, which can be seen in Appendix C-3.4, will be discussed with interviewees together with the parallels drawn for the day-to-day activities in the three project management topics investigated: selection, structuring and management style adopted. It should be noted that, although the two characteristics, fitness and fuzzy functions, are not included in the research investigation, these are still considered in the overall approach. For the former, the interviewer and the interviewees will consider all the possibilities open to the approach and for the latter, the system interface is created by the co-evolutionary method used.

The process of identifying and accepting relevance with Project Management, through the interviews, and then testing appropriateness by interpreting and using it as reasons for delay in the case studies, will be used for accepting these as characteristics of the complexity of interconnections in project management rather than as axioms.

To improve understanding, each characteristic was described extensively (see Appendix C-3.4) and examples were given during the interview. Each question provided a tick list of actions required to be undertaken in order to manage the effect of the characteristic. The lists had an innate flexibility to expand accordingly and interviewees were encouraged to add more actions if considered necessary. The details of the questions and the actions proposed can be seen in Appendix C-3.3. Generic scalable scores were generated to allow for ease of measurement of responses given by the interviewees. A table was also prepared presenting the correlation between the complexity characteristics, the areas under investigation and all the quality of project management outcome processes (see Appendix C-3.4).

In addition to supporting the investigation of the Hypotheses (H2.1, H2.2 and H2.3), the questionnaire also served the following purposes:

- To establish the level of the current actions taken by the interviewees to minimise or maximise the effects of the complexity characteristics on their projects in terms of the project management sub-processes reviewed in this research.
- To produce a consistent output, from all six organisations, and allow for the production of various radar graphs in order to draw overall conclusions as well as comparisons for the different strata – types of organisations, frames – companies and grade levels.
- To establish the base for a tool that will be used to enable the management of the effects of complexity of interconnections when implementing the sub-processes investigated.

### 6.8.4 Phase 2 Part 2 – The Multiple-case Studies

The multiple-case studies will prove, or refute Hypothesis 2.4.

As described above, each contributing organisation was requested to put forward a case study project. Directors were briefed on the requirements at the very beginning of the research period and were asked to consider projects at the three different stages of the project lifecycle - feasibility, construction and commissioning - and PMs with 10 or more years of experience. In order to coordinate all six contributors, before deciding which project would be used for the multiple-case study, a very brief discussion took place between the Senior Manager and the researcher.

The case study PMs were briefed extensively on the purpose and the process to be followed. They were asked to provide general information about their project and a number of meetings between the researcher and case study PMs were arranged for the nine-week the case study.

The preparation and set up of the multi-case studies had to consider the following factors:

- Very simple monitoring process, in terms of:
    - Usability:
        - Provision of performance log templates,
        - Simple pick list,
        - Predefined codes,
    - Understanding the importance and thus achieving continuous support from the participants throughout the period of nine weeks,
    - Reducing the risk of filtering information (Pritchard, 2004; Antoniadis et al., 2006);
    - Avoiding/minimising non-availability or missing data; and
    - Ease of extraction and use of information fed back at the end of the period.
- Keeping the process almost effortless by using existing project information/reports as much as possible and adding as few further activities as possible to the already stretched workload of the PMs;
- Common process for both strata in order to establish:
    - Cohesiveness of information obtained,
    - Universal and regular reporting between the six different organisations and PMs.
- Covering two reporting periods.

Considering all the above, it was decided that the most appropriate method to investigate the hypothesis would be to monitor and record the reasons for delay of the activities to be performed in the predefined time. The tool to be used would be the project programme. Progress would have to be monitored weekly by the PM and either the Site Manager or the appropriate Team Leader and reasons for delay would be picked from a pick list already provided. Working programmes would have to be at the appropriate level of detail so that the length of delay can be reasonably recorded and reported weekly. Pre-arranged meetings with the researcher would enable clarification of any queries, checking clarity of data recorded in the performance log (see Appendix C-3.8) and ascertaining whether the process was being followed correctly.

An extensive list of 'reasons for delay' was provided, focusing essentially on the three areas under investigation. Each reason was linked to one or more of the 16 complexity characteristics (see Appendices C-3.5 and C-3.6). All 'reasons for delay' were generically coded, for ease of use by the case study PMs, and also coded against the 16 complexity characteristics for ease of de-coding and analysis. Reasons for delay(s) due to issues/causes raised in the past were also available from the pick list. In such case(s) where the reason for the delay was due to events in the past, the PMs were asked to elaborate during the pre-arranged meetings. Particular interest was paid to those issues since, in most cases, for the areas under research, it is earlier problems – incumbent pathogens (Busby and Hughes,

2004) - that are not properly resolved and which cause increase in complexity. Reasons for delay were grouped by complexity characteristic under the main headings defined by Antoniadis, et al. (2006). The groups and coding were as follows:

- **Conditional** characteristics were coded from C100 to C500. Codes from C600 to C999 represented 'conditional' reasons from the day-to-day PM activities.
- **Developmental** characteristics were coded from D100 to D800. Codes from D900 to D999 represented '*developmental*' reasons from the day-to-day PM activities.
- **Behavioural** characteristics were coded from B100 to B300. Codes from B400 to B999 represented '*behavioural*' reasons from the day-to-day PM activities.

During the initial meetings, PMs were requested to provide their current working programme. Activities to be performed during the case study period were brought to a level that could be monitored and reported. Electronic copies of the completed performance logs were collected weekly either via email or during the pre-scheduled meetings.

### 6.8.5 Methodology for monitoring performance

Using project information recorded in the 'performance log' template (see Appendix C-3.9), data regarding decrease in performance was gathered from the columns '% Delay' and 'Cumulative % Delay'. An example of the final performance sheet for case study G1.1.4 is shown in Appendix C-3.10.

In order to determine the instances where complexity had a compounding effect, the following points, which included a combination of the recording of the weekly delay reported and the reasons selected were considered.

- If the reason for the delay remains the same and the increment of delay does not change, then there is no compounding effect,
- If the delay increases and the reason for the delay remains the same, then the reason stated has a compounding effect on the activity,
- If the delay increases and the reasons also change, then there is a compounding effect from the complexity characteristics,
- If the delay does not change but there is a new reason, then again there is a compounding effect deriving from the existence and continuation of complexity.

In terms of the approach taken to measure the performance on the case study projects, two views were considered:

- The simple method. With this method, performance of activities is calculated simply on the basis of: (Duration Planned * Performance reported) and Total Performance is: ($\Sigma$ of Duration Achieved / $\Sigma$ of Duration Planned) irrespective of the time elapsed for the activity to be completed.

- The time elapsed method. This method is more elaborate as it takes into account the time elapsed to complete the activity and it does emphasize the effect of time lost, under-utilisation of resources (idle time) and strain put on subsequent activities.

The former method will be used to calculate performance. An example for each method is shown in Appendix C-3.7.

### 6.8.6 Analysis of evidence

All the techniques identified by Yin (2003) in terms of the multi-case study analysis of evidence will be employed. Table 6.9 presents the approach to be followed against the techniques specified.

Table 6.9. Techniques and methodology used for analysing case study evidence

| Analysing Case study evidence Technique (Yin, 2003) | Research methodology approach implemented |
|---|---|
| 1. Pattern matching | A set of graphs will be created from each case study and pattern-matching will be investigated not only for the projects that are in the same project stage, e.g. construction, but also for the case studies where the projects are in different stages |
| 2. Explanation building | Using the reasons for delay, explanations will be built regarding the effect(s) of the 16 complexity characteristics on project performance |
| 3. Time-series analysis | Case study data will be collected and analysed for a period of nine weeks – two project reporting periods |
| 4. Logic models | Logic models will be built from the effects of complexity on project performance. In particular, to investigate the compounding effect of complexity through time-series analysis |
| 5. Cross-case synthesis | As described above, analysis will be performed between the six case studies and deductions, together with information from the survey and the interviews, will enable, apart from proving or refuting the hypotheses, the development of a framework that will allow the management of complexity and improve the project performance. |

## *6.9 Hypotheses acceptance criteria*

The acceptance criteria of each hypothesis are described in the following sections. For ease of presentation, and following the multi-methodology research strategy, each main hypothesis and its sub-hypotheses will be grouped and acceptance criteria will be presented by group. (Note: The notation of hypotheses in this section is as follows: all research hypotheses are indicated by the subscript 1, e.g. $H_1$, and all null hypotheses are depicted by the subscript 0, e.g. $H_0$. Each hypothesis number is indicated as a superscript, e.g. $H^{1.1.1}$).

### 6.9.1 Acceptance criteria for Hypotheses 1.1 and 1.2

The two hypotheses are tested by carrying out quantitative research, postal questionnaires. The postal questionnaire data will be ordinal or nominal and associations will be sought between one dependent variable and more than two independent variables. In this research, the parametric technique to be used will be the chi-squared test (Kerr et al., 2002) with a conservative confidence level of 95%. Therefore, to accept a hypothesis, the value of the Pearson chi-square will have to be less than 0.05 ($p < 0.05$). The recorded frequency of response will also be used to accept or refute the hypotheses. This will be presented in the form of tables or histograms and the response with the highest frequency will be accepted. The criteria for the significance of the response obtained from a frequency chart will be as follows:

- Above 75% the frequency will be considered significant;
- Above 55% the frequency will be considered acceptable;
- Between 50% and 55% the frequency will be considered noticeable, however, results will need to be considered carefully in terms of their impact;
- If none of the frequencies exceeds 50% (as in the case of three variables examined, e.g. 'Yes', 'No' and 'Don't Know') then the results will not be acceptable, but could be commented upon.

<u>Hypothesis 1.1 (H1.1) states:</u>

The available techniques for setting up (selecting and structuring) project teams and the management style in construction projects are implemented down to the lowest project organisation level.

In order to simplify the setting up of the questionnaire and the quantitative evaluation of the results the above hypothesis has been broken down to the following three sub-hypotheses.

$H_1^{1.1.1}$ Project team members are selected using personal profiling

$H_0^{1.1.1}$ Project team members are not selected using personal profiling

Frequency response outputs as well as the Pearson chi-square test will be applied to assess the hypothesis, using the criteria stated above.

$H_1^{1.1.2}$ The Project Team structure is defined to the lowest level

$H_0^{1.1.2}$ The Project Team structure is not defined to the lowest level

The Pearson chi-square test will be applied to assess the hypothesis, using the criteria stated.

$H_1^{1.1.3}$ The Management Style to be adopted is defined down to the lowest level

$H_0^{1.1.3}$ The Management Style to be adopted is not defined down to the lowest level

The Pearson chi-square test will be applied to assess the hypothesis, using the stated criteria.

<u>Hypothesis 1.2 (H1.2) states:</u>

The implementation of selecting team members and structuring the project team processes down to the lowest project organisation level and the management style are positively correlated with improved project outcome.

An extensive Pearson chi-square test will be applied to assess the hypothesis, using the criteria stated above.

## 6.9.2 Acceptance criteria for Hypotheses 2.1, 2.2 and 2.3

The three hypotheses are investigated by conducting interviews.

Hypotheses 2.1, 2.2 and 2.3 (H2.1, H2.2 & H2.3):

$H_1^{2.1}$ Complexity characteristics are considered when selecting project team members.

$H_0^{2.1}$ Complexity characteristics are not considered when selecting project team members.

Frequency response outputs from the interviews will be applied to assess the hypothesis, using the criteria stated above. For the interviewees' response regarding actions taken to manage the effects of complexity when selecting project team members to be deemed acceptable, the average weighted effectiveness of the actions will need to exceed a level of 75 points on a scale of 100.

$H_1^{2.2}$ Complexity characteristics are considered when structuring the project team(s).

$H_0^{2.2}$ Complexity characteristics are not considered when structuring the project team(s).

Frequency response outputs from the interviews will be applied to assess the hypothesis, using the criteria stated above. For the interviewees' response regarding actions taken to manage the effects of complexity when structuring the project team to be deemed acceptable, the average weighted effectiveness of the actions will need to exceed a level of 75 points on a scale of 100.

$H_1^{2.3}$ Complexity characteristics are taken into account when considering the management style to be followed on a project.

$H_0^{2.3}$ Complexity characteristics are not taken into account when considering the management style to be followed on a project.

Frequency response outputs from the interviews will be applied to assess the hypothesis, using the criteria stated above. For the interviewees' response regarding actions taken to manage the effects of complexity when considering the management style to be deemed acceptable, the average weighted effectiveness of the actions will need to exceed a level of 75 points on a scale of 100.

## 6.9.3 Acceptance criteria for Hypothesis 2.4

The hypothesis is investigated by conducting case studies.

Hypothesis 2.4 (H2.4) states:

Complexity of interconnections is inversely correlated to the project performance.

To prove the relationship between the project performance and complexity, and in particular for the 16 complexity characteristics, the data from the multi-case studies will be analysed by establishing a number of relationships. The relationships will be established by plotting a number of graphs. These graphs will be:

1. Simple % drop in performance and weekly number of coded reasons for delay against time,
2. % drop in performance and cumulative number of coded reasons for delay against time, using the time-elapsed method,
3. Simple % drop in performance against time,
4. % drop in performance against time using the time-elapsed method,
5. Frequency of occurrence of coded reasons for delay,
6. Frequency of complexity characteristics causing delay.

The results from the case studies will be deemed acceptable if replication is established between two or more cases (Yin, 2003).

### 6.9.4 Acceptance criteria for Hypothesis 3

The results from the validation of the framework will prove or refute Hypothesis 3.

Hypothesis 3 (H.3) states:

A framework is required to be developed for managing the effects of the complexity of interconnections caused by the sub-processes of selecting team members, structuring the project team and the management style followed.

## *6.10 Validation of results*

The analysis of the research results will have proved or refuted the hypotheses developed and the acceptance or rejection of the framework by PM practitioners will prove or refute Hypothesis 3. Therefore, a two stage validation process will need to be conducted, one for validating the interview results and the second for validating the framework. The steps below describe in detail both stages of the validation process:

- Conduct saturation interviews, in terms of the responses obtained, with PM practitioners who have not participated in any of the two phases. However, a minimum of five interviews, or 10% of the intended interviewee population during phase 2, will be sought;
- Each interviewee will be given a presentation of the research aims, objectives and findings from the research results;
- A presentation of the objectives, the framework developed and its outputs will follow;
- Interviewees will be requested to complete a short questionnaire (see Appendix F_6.1) where, using five-level Likert scale, interviewees will be requested to:
    - Consider the research results and indicate acceptance or rejection;
    - To consider the framework and confirm that:
        - It achieves its aim and objectives;

- It provides a tool which will enable the PM and other project team leaders, within the project, to manage the effects of complexity of interconnections through the sub-processes of selecting project team members, structuring the project team and the management style to be followed;
- Its ease of understanding, applicability and use;
- Its applicability to construction organisations.

- Responses with a level above 3 on the Likert scale will be considered as a positive feedback and will be deemed as accepting the statement made. The overall output will prove or refute Hypothesis 3.

The brief for the framework interviews, which is also to be handed out, can be seen in Appendix F-6.2.

As the validation process reflects two different stages of this research, validation of results and validation of the framework, the results will be presented in two chapters. The former will be presented as part of the Analysis Chapter and the latter as part of the Recommendations. The reasoning behind the two-stage presentation is that the framework can only be recommended as a result of the analysis and discussion of the research findings, therefore, all relevant activities, e.g. its validation, analysis of validation results and presentation of the output will be included in the Recommendations Chapter.

## 6.11 Summary

The literature review established that the topic of complexity of interconnections in UK construction was an area that required further research. This is underlined by the sparse literature dealing with its effects upon the three project management sub-processes of selecting project team members, structuring the project teams and the management style adopted. Therefore, it is proposed that the complexity of interconnections in construction projects can be managed by improving the project organisation and the management style adopted

The rationale of this research is that interconnections formed between, and affected by, the social entities in projects give rise to complexity.

In order to conduct this research and due to the intricacy of the subject, a multi-methodology has been designed which will include quantitative as well as qualitative techniques. The research strategy is made up of a two-phase approach. The first phase will be conducted through a postal questionnaire and will provide quantitative results on the current status of the processes under investigation. The second phase will comprise two parts, open structure interviews in part one and a closed multi-case study in part two, thereby examining in depth the effect of the complexity of interconnections on the sub-processes and the project outcome.

Three hypotheses and acceptance criteria were formulated in order to investigate the research propositions in the UK construction industry. Initially, the current status of implementation of the three project management sub-processes of selecting team members, structuring the project team and the management style adopted will be examined - phase 1. Then an investigation will be conducted into the subject of general complexity and the approach taken by the construction industry, which will be followed by an examination of the actions taken by practitioners to manage the effects of the complexity of interconnections on the three sub-processes investigated - part 1 of phase 2. Finally, the effects of the complexity of interconnections from the inappropriate implementation of the three sub-processes upon the project performance will be examined - part 2 of phase 2.

The intricacy and newness of the subject of the complexity of interconnections in construction and the requirement for a high level of response from the industry - both client and contractor project management practitioners - led to the stratified sampling technique being selected in order to maximise the response and minimise the sampling error. Two strata will be formed – client and contractor – and each stratum will be represented by three organisations. From the client side, the three organisations - frames - represent some of the UK's largest infrastructure capital expenditure organisations. From the contractor side, the three organisations - frames - represent the UK's largest contractor organisations. Within each frame, the samples will be randomly selected.

A five-part questionnaire was developed and piloted for phase 1, the quantitative part, with the relevant approach for the management of the distribution and data entry. For part 1 of phase 2 - the 51 interviews - a two-part questionnaire was developed. For part 2 of phase 2 - the closed multi-case study - six projects from the same organisations representing all the stages of the project life-cycle were selected and processes for monitoring and selecting case study information on a weekly basis were developed.

The next chapter describes the research results obtained from the implementation of the multi-methodology.

# Chapter 7 – Results

## 7.1 Introduction

This chapter comprises eight sections which cover details of the approach taken to implement the research method in addition to information extracted from the responses obtained. The approach adopted for the implementation of the research method and the data collection process is described in Section 7.2 below. The research findings from the postal survey, the interviews and the case studies are presented in three sections with some minor explanatory comments. Results for the hypotheses testing, the effect of moderating variables and correlations and other significant statistical results are also presented in respective sections.

Section 7.3 focuses on the results from the postal questionnaires; for clarification, these mirror the five parts of the questionnaire: demographics, selecting the team, structuring the team, management style and project outcome.

Section 7.4 focuses on the results from the interviews which were conducted using two distinct questionnaires. The first covered questions regarding general complexity. The second covered questions regarding apposite actions taken to minimise or maximise the effect of the 16 complexity characteristics, in particular whilst performing the three project management sub-processes.

Section 7.5 presents the results from the five case studies.

Following the presentation of results, Sections 7.6 and 7.7 introduce statistical results for the effect of the moderating variables as well as general statistical correlations that will be used in the Analysis chapter and the overall discussion of results. Where appropriate, throughout this chapter, results are presented in summary form with the more detailed tables and figures residing in sections within Appendix D.

## 7.2 Implementation & Data Collection

The approach taken for the implementation of the research method and the data collection process is described in the sections below.

### 7.2.1 Implementation

The implementation of the multiple research strategy required detailed planning and preparation. The initial duration allocated for the two phases was as follows:

- Postal survey, three months, starting from May 2007 and finishing July 2007,
- Interviews were planned to commence in October and complete in mid-December 2007, allowing for briefing Directors during September 2007,
- Case Studies were planned to commence from the beginning of January and complete in early March 2008.

Thus, a research period of seven months was to be covered in 10 calendar months in order to accommodate the resource limitations, communication with the Directors of participating companies and, obviously, respondents' availability, especially for Phase 2. Electronic copies of the postal questionnaires were issued to the Directors who, by return, provided information about population size within their Division. The information submitted is shown in Figure 7.2 below with each company identified by a code, allocated for reporting purposes.

In September 2007 and following on from the completion of Phase 1 – postal questionnaires – Directors were briefed about Phase 2 and were asked to randomly select PMs who would participate in the interviews for part 1 of Phase 2, as per the initial briefing, shown in Table 6.8. A number of changes in three of the six participating companies, which will be explained below, partly affected their participation resulting in a reduced number of interviews, from 51 to 31, and the loss of one of the case studies.

Table 7.0 shows the distribution of the interviewees by company / frame within the strata and their job title.

Table 7.0. Number of project management professionals interviewed per company

| Company / Job Title | Client Strata | | | Contractor Strata | |
|---|---|---|---|---|---|
| | **G1.1** | **G1.2** | **G1.3** | **G2.1** | **G2.2** |
| Director | 1 | | 1 | 1 | 1 |
| Senior PM | 2 | 1 | 2 | 2 | 1 |
| PM | 2 | | 2 | 2 | 4 |
| Assistant PM | 2 | | 1 | 2 | 1 |
| Site Manager | | | | 2 | 1 |
| **Total** | **7** | **1** | **6** | **9** | **8** |

With the significant changes affecting the research implementation programme and in order to maintain the overall duration, the interview period was overlapped with the case study period for those organisations and individual PMs who were ready to commence. In order to accommodate losing one of the case studies and following discussions with all the Directors regarding the issue, it was decided to conduct two case studies with contractors working for organisation G1.1. However, even these plans did not materialise and another contractor was not able to provide an appropriate project for the case study. Thus, for Part 2 Phase 2, five studies were conducted as shown below in Table 7.1.

Table 7.1. Case study contributors by project stage

| Company – Case Study | Project Stage | Description |
|---|---|---|
| G1.3 | Feasibility | Waste Water Treatment works |
| G1.1.2 | Design / Early Construction | Forecourt extension |
| G1.1.4 | Construction | Redevelopment of Lounge |
| G2.1 | Construction | Building – 28 luxury flats |
| G1.2 | Commissioning | Chemical removal plant |

The initial strategy of conducting two case studies per project life-cycle stage could not be implemented as there was only one case study for feasibility and commissioning respectively. However, it was decided to continue with both case studies and extract appropriate deductions and correlations.

## 7.2.2 Data Collection

**Phase 1 – Postal questionnaires – sampling statistics**

As described in Section 6.6 – sampling strategy – the approach followed with the postal questionnaires is that of a stratified sample selecting from both sides of the project, the Client and the Contractor. Additionally, in order to consider the wider implementation of the findings, comparisons are made of the sample selected against the wider construction industry in terms of employment levels and construction total output for all the regions of Great Britain (GB). All the information is extracted from the DTI publication *Construction Statistics Annual Report 2007* and cross-checked against the Annual Abstract of Statistics from the Office of National Statistics, 2007. These statistical comparisons are shown in the tables in Appendix D and a number of other points are addressed in the Analysis Chapter.

During the three month period allowed for the data collection from the postal questionnaires, there were 99 responses. Table 7.2 below provides a breakdown of the responses in terms of expected and actual. The expected figures were, as described above, provided by the Directors of each frame, apart from the expected figure from APM which was more of an anticipated figure on behalf of the researcher, as this was directed to the wider APM membership through various means. The anticipated number of responses from APM was based on accepting that from the 2,648 members who have indicated that they are working in the construction industry, approximately 40% will be working as construction Project Managers and therefore, from those, only 20, or approximately 2%, will respond. It should be noted that the APM membership numbers quoted above were provided from the APM Membership Department and reflect the records held as of March 2007.

Table 7.2. Postal questionnaire response by strata.

| **Strata code** | **Response** | | **% response** | **Total by Strata** |
|---|---|---|---|---|
| | **Expected** | **Actual** | | |
| G1.1 | 45 | 17 | 38% | |
| G1.2 | 35 | 18 | 51% | |
| G1.3 | 35 | 17 | 49% | **52** |
| G2.1 | 30 | 21 | 70% | |
| G2.2 | 20 | 10 | 50% | **39** |
| G2.3 | 15 | 8 | 53% | |
| G3.1 / APM | 20 | 8 | 40% | **8** |
| **Total** | **200** | **99** | **49.5%** | |

Further details and the breakdown of the responses received will be provided in the Demographics section below.

Figure 7.1 provides some more details in terms of the statistical feedback given to the Directors of each frame on a weekly basis. Apart from the company's actual response against the target, the report also provided a percentage for the company contribution to the overall research target for the expected and the actual responses. The report also indicated the overall percentage achieved.

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| | G.1.1 Company | G.1.1 Company Contribution to the Total | G.2.1 Company Total | G.2.1 Company Contribution to the Total | G.3.1 Company Total | G.3.1 Company Contribution to the Total |
|---|---|---|---|---|---|---|
| Expected num. of respondents | 45 | 23% | 30 | 15% | 20 | 10% |
| Actual response to date | 17 | 17% | 21 | 21% | 8 | 8% |
| Company Actual against Target | 38% | | 70% | | 40% | |

| | Research Total |
|---|---|
| Expected response | 200 |
| Actual response | 99 |

| | G.1.2 Company Total | G.1.2 Company Contribution to the Total | G.2.2 Company Total | G.2.2 Company Contribution to the Total |
|---|---|---|---|---|
| Expected num. of respondents | 35 | 18% | 20 | 10% |
| Actual response to date | 18 | 18% | 10 | 10% |
| Company Actual against Target | 51% | | 50% | |

| | G.1.3 Company Total | G.1.3 Company Contribution to the Total | G.2.3 Company Total | G.2.3 Company Contribution to the Total |
|---|---|---|---|---|
| Expected num. of respondents | 35 | 18% | 15 | 8% |
| Actual response to date | 17 | 17% | 8 | 8% |
| Company Actual against Target | 49% | | 53% | |

| Overall Response Performance to date: | 49.5% |
|---|---|

Figure 7.1. Statistical information about returned questionnaires and sample of weekly report to Directors during the three month period

From the 99 questionnaires received, the 91 submitted by the stratified sample were valid whereas all those received from the APM group were invalid either because whole parts were missing or the respondents were not from the construction industry. Therefore all further references and analysis of the postal survey questionnaires will be based on the 91 valid responses.

Responses from the stratified samples are statistically compared against the overall contractors' output and the employment numbers for Great Britain in order to provide an indication and a comparison for the size of the survey response. The Construction Statistics Annual Report of 2007 was used for improved accuracy (all figures used have been extracted from Fig. 2.4 p. 44 and Tables 3.4 & 3.5 p. 50-53). Firstly, a comparison is made of the contractors' output between the regions selected and where the stratified sample operates, against the overall contractors' output in GB. Table AP.D-7.3 in Appendix D provides an indication of the contractors' output (in terms of money and percentage) in the South East and London and the whole of GB. Thus, almost 30% of the total construction output occurs in the areas of the selected strata. It should be noted that one of the contractors had some minor operations in the South West. However, after discussions with the Director, these were ignored.

In terms of employment in the these regions, the figures in Table AP.D-7.4 in Appendix D indicate that 12% of the total employment in construction is occurring in the same two areas from which the stratified sample has been selected and also that the two regions are the two highest, in terms of employment, within GB. As above, the figures for employment in the South West have been ignored, as operations there were very minor. In order to extrapolate the stratified random sample of project management practitioners and reflect this against the general employment numbers, obtained from the Construction Statistics Annual Report, it was considered appropriate to obtain actual and accurate project management practitioners' employment levels from a non-participating construction organisation and use these to factorise the general statistical figures. This would result in a more realistic representation of the expected population of project management practitioners in the two regions and a better comparison of the stratified random sample against a generic random sample.

The 'control sample' – construction organisation – provided very detailed information regarding the levels of project management practitioners in their London and South East region and these are shown below in Table 7.5. The table includes all information provided, e.g. Commercial Managers and Directors, as well as Senior Managers. Operations Directors have been included as practitioners since they are involved in the running of projects, albeit in a wider role. The description of Senior Management – Projects reflects Board level members of the Division. The percentage shown in the highlighted cells in Table 7.5 represent the project management practitioners in the organisation and are used to extrapolate the research results against the generic figures obtained from the Construction Statistical Annual Report 2007.

Table 7.5. 'Typical' construction organisation actual employee numbers

| Discipline | Number of Staff | % |
|---|---|---|
| Project Managers | 58 | **4.52** |
| Operations & Project Directors | 43 | **3.35** |
| Commercial Manager & Directors | 38 | 2.96 |
| Senior Management - Projects | 6 | 0.47 |
| Other Senior Management | 6 | 0.47 |
| All other Company staff | 1133 | 88.24 |
| **Total staff** | **1284** | |

Thus PMs represent 4.5% of the typical organisation and PMs and Directors represent 7.9% of the typical organisation. The two figures are used to generate the tables below and in particular the former is used to calculate the figures under 'Estimated number of PMs', whereas the latter are those for the 'Estimated number of PMs & Directors'.

Tables AP.D-7.6 to AP.D-7.8 in Appendix D, generated from the Construction Statistics Annual Report (Tables 3.4 and 3.5, p.50-53), provide in detail an indication of the estimated number of PMs, the estimated number of PMs and Directors and the percentage of the postal survey response achieved against these overall numbers for the following:

- Total Contractors' employment in the sampled area – London and South East regions,
- Employment, less operatives, in the sampled area,
- Total employment in firms which have more than 300 staff.

For ease of reference, a summary table (see Table 7.9) has been created using the figures generated in the above mentioned tables.

Table 7.9. Contractor strata sample population response against estimated population

| **% response against Total contractors' employment in sampled area** | | **% response against Contractors' staff, less operatives, in sampled area** | | **% response against Total employment for firms with over 300 staff in GB** | |
|---|---|---|---|---|---|
| PMs | PMs & Dirs | PMs | PMs & Dirs | PMs | PMs & Dirs |
| **0.25%** | **0.14%** | **0.52%** | **0.30%** | **0.30%** | **0.17%** |

In addition to the comparison made in Table 7.9 and in order to enable analysis and extrapolation of results from the contractor stratified sample, a table is drawn comparing employment levels. The employment level of the construction strata is compared against total contractor employment in GB, the total construction employment in the sampled area and with organisations with over 300 staff. These figures are shown in Table 7.10.

Table 7.10. Comparison of contractor stratified sample representation against overall contractor employment figures in the sampled area, for firms with over 300 staff and total contractor employment in GB.

| **Stratified sample total staff** (in '000s) | **Total empl/nt in Sampled Area** (in '000s) | **Stratified sample %** | **Empl/nt in firms with more than 300 staff in GB** (in 000s) | **Stratified sample %** | **Total Contractor empl/nt in GB** (in 000s) | **Stratified sample %** |
|---|---|---|---|---|---|---|
| 9.25* | 343.3 | **2.70%** | 293.4 | **3.15%** | 1,215.4 | **0.76%** |

Note: * this figure is derived from the total staff of G2.1, G2.2 and G2.3 shown in table 7.11.

Taken from Table 7.10, the stratified sample represents 3.15% of the construction population in firms with more than 300 staff, which represents all three sampled organisations. The breakdown of figures of the stratified sample total staff can be seen in Table 7.11 below.

Table 7.11. Sampling statistics and percentage response within the strata and the frames for the stratified sample

| | Clients | | | | Contractors | | |
|---|---|---|---|---|---|---|---|
| **Company** | **Staff** | **PMs** | **Response** | **% of Total** | **Estimated number of PMs within company** | **Response** | **% of Total** |
| G1.1 | 90000 | 95 | 17 | 17.89 | | | |
| G1.2 | 8000 | 35 | 18 | 51.43 | | | |
| G1.3 | 5000 | 35 | 17 | 48.57 | | | |
| G2.1 | 5003* | | | | 310* | 21 | 6.77 |
| G2.2 (Div) | 2250 | | | | 102 | 10 | 9.84 |
| G2.3 (Div) | 2000 | | | | 90 | 8 | 8.86 |
| **Total** | **112253** | **165** | **52** | **31.52** | **502** | **39** | **7.77** |

(* Note, for Construction Organisation G2.1 the figures shown are actual ones as provided by the HR department of the organisation and these represent information published on their website for 2008.)

To compile the research statistics tables, Directors were asked to provide numbers of PMs and total staff within their division and / or company. However, whereas this was fairly easy for the Client strata, it was not possible for two of the three Contractor strata. Client Directors, possibly because of the tightness of their divisions, provided the number of staff operating as Project Managers, from Assistant level to Senior PM level. Thus, it was easy to calculate the rate of response against the total number of PMs within the Client companies. For the two Contractor strata, the typical percentage of 4.52%, shown in Table 7.5 above, was used against the total number of staff in the Construction Company or Division, in order to calculate the rate of response. Table 7.11, above, provides a detailed view of the figures provided and those that were calculated in order to establish the percentage response within the strata and the frames.

In terms of an overall figure for the construction PM population in Great Britain, both Client and Contractor, it was not possible to identify a source and establish an accurate enough basis with which to calculate the overall percent response. The only reference that was available was a statement in 2007 by the current Chairman of the APM (Shepherd, 2007) where he states that the estimated number of PMs is 300,000. However, this includes PMs in other disciplines e.g. IT, Consultants, Government, etc. Assuming that 10% of these are dealing with construction projects and from both sides then the sample population of **91** responses to the postal survey represents **0.3%** of the total population (see Table 7.12). This percentage is not far from the one calculated and shown above in Table 7.9, which represents only the construction PMs.

Table 7.12. Estimated population of PMs in GB and percent sample population

| Estimated population of PMs in GB | Estimated population of PMs dealing with Construction in GB (Client & Contractors) | Overall response to postal survey | Overall % Response |
|---|---|---|---|
| 300,000 | 30,000 | 91 | 0.3 |

However, the 10% figure mentioned above cannot be substantiated or cross referenced against an accurate source or literature. This was also confirmed from correspondence with the author of the article (Mr. Shepherd) "*it is only an estimate and it can be anything*". A more accurate approximation will be to assume that, when comparing the population of Client PMs against the Contractor PMs in GB, the number of Client PMs is much smaller and thus insignificant. Therefore in order to calculate the overall response to the survey we can amalgamate the sample population of Client PMs in the Contractor PMs. Thus, including the 52 Client PMs in the calculations performed for the Contractor PMs, shown in Tables AP.D-7.6 to AP.D-7.8, we can obtain the summary Table 7.13.

Table 7.13. Approximate overall response percentage summary table

| Total contractors' employment in sampled area | | Contractors' staff less operatives in sampled area | | Total employment for firms with over 300 staff in GB | |
|---|---|---|---|---|---|
| PMs | PMs & Dirs | PMs | PMs & Dirs | PMs | PMs & Dirs |
| **0.59%** | **0.34%** | **1.21%** | **0.69%** | **0.69%** | **0.39%** |

Therefore, from Table 7.13, it can be established that the sample population represents between 0.4% to 0.7% of the population of PMs in GB, or for the London and South East between 0.7% and 1.20%.

From simple statistical calculations (http://www.surveysystem.com /sscalc.htm #one) and PM population data in Tables AP.D-7.6 to AP.D-7.8, it can be seen that for a sample size of 91, confidence level 95% and confidence interval 10%, the population can vary from 7,500 to 150,000. Therefore it can be considered appropriate that the sample size taken represents the overall population of PMs in GB.

**Phase 2 – Interviews and Case Studies**

The data collection process for the interviews and the case studies was described previously. With regard to the interviews undertaken, it can be seen (see Table 7.0) that an almost equal sample was taken from both sides - 55% Construction PMs and 45% Client PMs. This will allow for a balanced view and analysis of data when considering the validity of Hypotheses H2.

## 7.3 *Postal Questionnaire results*

In presenting the postal questionnaire results and to enable ease of direct cross-reference the structure followed is that of the questionnaire. In terms of presenting the outcome and because of the extensiveness of the questionnaire, the detailed results will be included in Appendix D and only selected tables and figures will be included in this chapter.

### 7.3.1 Part 1 - Demographics

With regard to the demographics of the postal survey, the respondents' seniority and experience ranged from Directors (6) to Site Managers (3) with the highest population being that of the Project Managers (42) and 60% respondents had more than 15 years experience. The detailed results regarding the demographics of the stratified sample can be seen in Appendix D, Tables AP.D-7.14, AP.D-7.15, AP.D-7.16 and Figures AP.D-7.1, AP.D-7.2.

### 7.3.2 Part 2 – Selection of Project Team Members

As described in the Research Method, the questions within and between each part were interconnected in order to establish a clearer understanding, allow for more depth in the responses given, minimise subjectivity and improve repeatability (Walker, 1997).

**Prevailing conditions in projects**

In order to understand the current conditions in construction, respondents were requested to indicate, using a five-level Likert scale, the prevailing environment in terms of based on descriptions by Lansley (1994):

- More Static to More Dynamic.
- More Friendly to More Hostile.
- More Simple to More Complex.

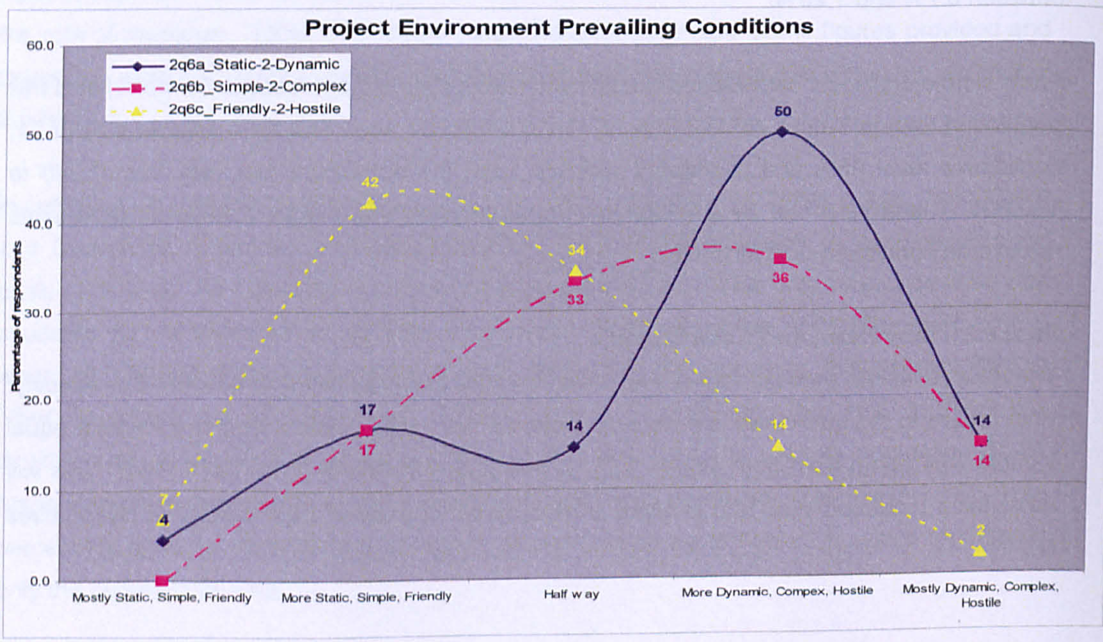



Figure 7.3. Prevailing conditions in projects

The respondents' feedback is presented in Figure 7.3 and provides an indication of the prevailing conditions. It is clear that the friendlier contracting processes of partnering and alliancing have improved conditions, however, the project environment remains more complex and dynamic. Detailed discussion of the results will be conducted in the Analysis and Discussion chapters.

The response obtained, in terms of the highest percentage for selecting team members and knowledge and implementation of known personnel profiling techniques, is shown in Table 7.17.

Table 7.17. Response regarding levels of knowledge and implementation of personal profiling techniques

| Question | Result | | | Detailed results in Appendix D Table: |
|---|---|---|---|---|
| | Reply | Highest Freq/cy | Highest % | |
| 2q1: Does your organisation offer you guidance in selecting project team members? | Yes | 62 | 68.1 | AP.D-7.18 |
| 2q2: Are you aware of any known techniques/methods of personal profiling? | Yes | 65 | 71.4 | AP.D-7.19 |
| 2q4: Please indicate for which project team members personal profiling has been carried out, within your company. | None / No | 62 | 73 | AP.D-7.20 |

Following on from the questions regarding personnel profiling, respondents were asked to indicate if profiling was used and down to which organisational level. The results in Table 7.21 provide a clear and overwhelming indication of the techniques used for selecting personnel at different project organisational levels.

Table 7.21 – Response regarding techniques used for selecting team members

| Question | Result | | | Detailed results in Appendix D Table: |
|---|---|---|---|---|
| | Reply | Highest Freq/cy | Highest % | |
| 2q5: In your company, is personal profiling considered, as part of the selection process, when appointing Project Managers to a project? | No & No to Q2 | 62 | 69 | AP.D-7.22 |
| 2q10: Do the site supervisors use any selection process techniques? | No & No to Q9 | 63 | 69 | AP.D-7.23 |
| 2q11: Indicate which of the following techniques/methods your supervisors use/consider for selecting team members | None / No | 71 | 78 | AP.D-7.24 |

The responses given in terms of the criteria used for selecting Project Managers and Project Team members are shown in Appendix D Tables AP.D-7.25 and AP.D-7.26. Responses were given using five-level Likert scale and the results are presented in terms of percentage response.

Table 7.27 provides an indication of the responses given to question 13 regarding the lowest level at which selecting team members and carrying out personal profiling is performed. The table includes responses to both parts of the question with further detail given in Tables AP.D-7.28 and AP.D-7.29 in Appendix D.

Table 7.27 Response regarding lowest level of selection of team members

| 2q13: For your most recently completed project, consider the questions below and indicate to what organisational level did you, or others on your behalf, | | | | |
|---|---|---|---|---|
| | a) Carry out selection of team members | | b) Carry out personal profiling? | |
| | **Frequency** | **Valid Percent** | **Frequency** | **Valid Percent** |
| Discipline & Team Leaders | 47 | **52** | 15 | 17 |
| Supervisors & Team Members | 34 | 37 | 6 | 7 |
| None | 10 | 11 | 66 | **76** |
| **Total** | 91 | **100** | 87 | **100** |

Results in Table 7.27 indicate clearly that no personal profiling is conducted for selecting project team members, however, some level of selection is performed at Discipline and Team Leader levels.

Further tables presenting responses regarding selection of project team members, personal profiling and team-forming techniques at lower levels (e.g. subcontractor level) are shown in Appendix D (see Tables AP.D-7.30, AP.D-7.31 and AP.D-7.32).

### 7.3.3 Part 3 – Structuring of Project Teams

For Part 3 of the postal questionnaire, tabular reports are prepared and present the responses given regarding the structuring of project teams. Table 7.33 depicts, in summary, responses given regarding the definition of the project structure at various project organisational levels and, as mentioned previously, more detailed results and the split between Client and Contractor PMs is shown in respective tables in Appendix D.

Table 7.33 Summary response indicating the level which defines the corresponding project structure

| **Question:** 3q1 Consider the questions below and reply in terms of the norm in your company: | **Result** | | | **Detailed results in Appendix D Table:** |
|---|---|---|---|---|
| | **Reply** | **Highest Freq/cy** | **Highest %** | |
| a) Who defines the overall project structure? | The PM | 44 | 49 | AP.D-7.34 |
| b) Who defines the design team structure? | The PM | 36 | 40 | AP.D-7.35 |
| c) Who defines the site team structure? | The PM | 42 | 48 | AP.D-7.36 |

The lowest organisational level at which the PMs will define the project structure is shown below, in Tables 7.37 and 7.38, below. As explained in the previous chapter the postal questionnaire included a number of interconnecting questions one of which is question 3q7 for which the results are shown in Table 7.38.

Table 7.37 Detailed Response regarding lowest level of definition of project structure

Question: 3q2 Indicate down to what level do you, as the PM, define the structure?

| | Overall Frequency | Overall Valid % | Client Frequency | Client % | Contractor Frequency | Contractor % |
|---|---|---|---|---|---|---|
| Discipline Leader | 9 | 10.2 | 6 | 11.5 | 3 | 8.3 |
| Team Leader | 30 | 34.1 | 25 | 48.1 | 5 | 13.9 |
| Supervisor | 14 | 15.9 | 2 | 3.8 | 12 | 33.3 |
| Team Members | 26 | 29.5 | 13 | 25.0 | 13 | 36.1 |
| None | 9 | 10.2 | 6 | 11.5 | 3 | 8.3 |
| Total | 88 | 100.0 | 52 | | 36 | |

The overall results in table 7.37 do not provide a statistically significant response, however, 34% of the respondents indicated that project team structures are defined down to Team Leader level with the second highest response (30%) indicating that the project structure is defined down to Team Member level. The former is mainly backed up by the Client PMs, whereas the latter by the Contractor PMs.

Table 7.38 Responses regarding the lowest level respondents structured their project

Question: 3q7 For your most recently completed project indicate down to what level was the structure defined?

| | Overall Frequency | Overall Valid % | Client Frequency | Client % | Contractor Frequency | Contractor % |
|---|---|---|---|---|---|---|
| Disc. Leader | 7 | 7.8 | 5 | 9.8 | 2 | 5.1 |
| Team Leader | 10 | 11.1 | 7 | 13.7 | 3 | 7.7 |
| Supervisor | 9 | 10.0 | 6 | 11.8 | 3 | 7.7 |
| Design Team Member | 23 | 25.6 | 15 | 29.4 | 8 | 20.5 |
| Site Team Member | 39 | 43.3 | 17 | 33.3 | 22 | 56.4 |
| Structure Not Defined | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| Total | 90 | 100.0 | 51 | | 39 | |

The results in Table 7.38 also do not provide a response with statistical significance. Interestingly, however, the majority of respondents indicated that for their most recently completed project, they defined the project structure down to Site Team member level.

Respondents were also asked to indicate the type of structure followed at different organisational levels. The responses obtained are shown in Table 7.39.

Table 7.39 Type of structure per organisational level in percent of total response

| | Type of Structure | | | | | |
|---|---|---|---|---|---|---|
| | **Matrix** | **Functional** | **Network** | **Team** | **Mixture** | **Don't Know** |
| Discipline leader | 39 | 26 | 1 | 13 | 7 | 14 |
| Design team | 33 | 27 | 8 | 15 | 7 | 10 |
| Construction team | 23 | 30 | 2 | 27 | 6 | 12 |
| Support team | 18 | 31 | 1 | 14 | 14 | 22 |

The results in Table 7.39 indicate that the matrix and the functional types of structure were most commonly found throughout the project team levels of construction projects, with the exception of the construction team where 27% indicated that the team structure is implemented.

## 7.3.4 Part 4 – Management Style

In Part 4 of the postal questionnaire, the management style followed was examined as one of the main activities of managing teams, and the tables below depict the responses received. Due to the size of the tables generated from the responses, the more detailed output is included in Appendix D. In order to understand the level of formality given to / consciousness of a decision made, regarding the management style to be followed, a relevant question was included in the postal questionnaire and the responses given are shown in Table 7.40.

Table 7.40 Response regarding conscious decision made about the management style to be followed in projects

Question: 4q1 Is a formal decision made regarding the management style to be followed on a project?

| | **Overall Frequency** | **Overall Valid %** | Client Frequency | Client % | Contractor Frequency | Contractor % |
|---|---|---|---|---|---|---|
| Yes | 22 | 24.4 | 12 | 23.1 | 10 | 26.3 |
| No | 65 | 72.2 | 38 | 73.1 | 27 | 71.1 |
| Don't Know | 3 | 3.3 | 2 | 3.8 | 1 | 2.6 |
| Total | 90 | 100.0 | 52 | | 38 | |

Question 4q3 was another integrating question and respondents were requested to consider their most recently completed project and select from an explanatory list the closest description of the overall management style adopted. Responses are presented in Table 7.41 and more detailed breakdown is shown in Tables AP.D-7.41.1 and AP.D-7.41.2 (Appendix D). The overall results in Table 7.41 do not provide a response with statistical significance, however, 18% and 15% of the respondents indicated that the prevailing management styles are the 'situational' and 'egalitarian' respectively. Also from the 36% who indicated that two styles are used, the prevailing ones are again a combination of the egalitarian and situational styles.

Table 7.41 Combined response of the Management Style adopted

| Statistical Analysis of responses to Management Style adopted | | | Statistical Investigation of responses where two codes were selected | | |
|---|---|---|---|---|---|
| **Freq** | **%** | **Description** | **Freq** | **%** | **Description** |
| 14 | 15.4% | A-Egalitarian | 2 | 6.1% | A & G |
| 1 | 1.1% | B-Dictatorial | 2 | 6.1% | D & G |
| 1 | 1.1% | C-Manage Themselves | 8 | 24.2% | A & F |
| 3 | 3.3% | D-Standard Processes | 6 | 18.2% | A & C |
| 0 | 0.0% | E-Technocratic | 1 | 3.0% | D & J |
| 16 | 17.6% | F-Situational | 1 | 3.0% | D & E |
| 0 | 0.0% | G-Control System | 1 | 3.0% | C & F |
| 0 | 0.0% | H-People | 2 | 6.1% | D & F |
| 0 | 0.0% | J-Long term | 3 | 9.1% | F & G |
| 33 | 36.3% | Two codes have been selected | 1 | 3.0% | F & H |
| 13 | 14.3% | Three codes have been selected | 5 | 15.2% | A & D |
| 10 | 11.0% | More than three codes | 1 | 3.0% | B & C |

The summarised response given to the management style adopted at different project structure levels is indicated below in Tables 7.42.1, 7.42.2 and 7.42.3. The results indicate, although still with no statistical significance, that Client and Contractor PM practitioners have varying views regarding the prevailing management style. The majority of Client and Contractor PM practitioners consider that the egalitarian style prevails throughout the project levels. However, in the case of Design and Site Team members, the more strict style of Standard Processes is implemented. Also Contractor PM practitioners consider that at Supervisor level the flexible style of managing themselves is adopted.

Tables 7.42.1, 7.42.2 and 7.42.3 Summary information regarding the adopted management style at the different project levels (including the 1st and 2nd frequencies of response).

| Table 7.42.1 | Discipline Leader | | | Team Leader | | |
|---|---|---|---|---|---|---|
| | **Total %** | **Client %** | **Contractor %** | **Total %** | **Client %** | **Contractor %** |
| A-Egalitarian | 42.5 | 40.0 | 45.9 | 35.6 | 38.0 | 32.4 |
| C-Manage Themselves | | | | | | |
| D-Standard Processes | | | | 11.5 | 18.0 | |
| F-Situational | 14.9 | 16.0 | 13.5 | 18.4 | | 27.0 |
| G-Control System | | | | | | |

| Table 7.42.2 | Supervisors | | | Design Team Members | | |
|---|---|---|---|---|---|---|
| | **Total %** | **Client %** | **Contractor %** | **Total %** | **Client %** | **Contractor %** |
| A-Egalitarian | 19.8 | 28.0 | | 29.4 | 28.0 | 31.4 |
| C-Manage Themselves | 16.3 | | 25.0 | | | |
| D-Standard Processes | | | | 18.8 | 28.0 | |
| F-Situational | | | | | | |
| G-Control System | | | | | | |

| Table 7.42.3 | **Site Team Members** | | |
|---|---|---|---|
| | **Total %** | **Client %** | **Contractor %** |
| A-Egalitarian | 18.6 | 22.0 | 10.0 |
| C-Manage Themselves | | | |
| D-Standard Processes | 19.8 | 26.0 | |
| F-Situational | | | |
| G-Control System | 12.8 | | 12.0 |

The data for the above tables are extracted from the tables shown in Appendix D in Tables AP.D-7.42.4.1 to 5. In order to cross-reference responses regarding the management style followed, respondents were also asked to indicate the prevailing culture for each project organisational level (see question: '*For the corresponding project organisation levels indicate the culture that describes best your most recently completed project*'). A set of tables are produced and these can be seen in Appendix D – Tables AP.D-7.43.1 to AP.D-7.43.5.

### 7.3.5 Part 5 – Project Outcome

In this last part of the postal questionnaires, the respondents were asked to evaluate their most recently completed project, thus closing the set of interconnecting questions. They were also asked to rank the project management processes which contributed to the quality of the project management outcome (Collins and Baccarini, 2004). The responses regarding the contribution of the three sub-processes under investigation to the project outcome are shown in the tables below. The feedback on the remaining sub-processes can be seen in the respective tables in Appendix D.

Table 7.44 presents a summary of the respondents' overall ranking of the project management sub-processes under investigation. From the overall view of the highest three levels of ranking (8 to 10), Table 7.45 presents the overall percentage of all seven project management sub-processes. The detailed results, as well as the ranking by Client and Contractor PM and the ranking of the remaining four processes, are shown in Appendix D Tables AP.D-7.44.1 to AP.D-7.44.7.

Table 7.44. Ranking of Project Management sub-processes: Selection of Team Members and Structuring the Team and the Management Style adopted.

| | Selecting Team Members | | Structuring the Team | | Management Style | |
|---|---|---|---|---|---|---|
| Ranking | Overall Freq/cy | Overall Valid % | Overall Freq/cy | Overall Valid % | Overall Freq/cy | Overall Valid % |
| 1 – Lowest | 3 | 3.3 | 1 | 1.1 | 0 | 0.0 |
| 2 | 2 | 2.2 | 2 | 2.2 | 2 | 2.2 |
| 3 | 0 | 0.0 | 1 | 1.1 | 1 | 1.1 |
| 4 | 3 | 3.3 | 4 | 4.4 | 2 | 2.2 |
| 5 | 3 | 3.3 | 5 | 5.6 | 0 | 0.0 |
| 6 | 6 | 6.7 | 8 | 8.9 | 3 | 3.4 |
| 7 | 13 | 14.4 | 22 | 24.4 | 17 | 19.1 |
| 8 | 25 | 27.8 | 27 | 30.0 | 18 | 20.2 |
| 9 | 15 | 16.7 | 17 | 18.9 | 21 | 23.6 |
| 10 – Highest | 20 | 22.2 | 3 | 3.3 | 25 | 28.1 |
| Total | 90 | 100.0 | 90 | 100.0 | 89 | 100.0 |

Table 7.45 Overall percentage ranking of project management sub-processes that contribute to the quality of the project management outcome.

| | Selecting Team members | Structuring the Team | Management Style | Monitoring and Control | Reporting | Conflict Management | Efficient use of resources |
|---|---|---|---|---|---|---|---|
| Overall Total | 67% | 52% | 72% | 69% | 42% | 58% | 49% |
| Client PMs | 65% | 51% | 74% | 75% | 43% | 55% | 50% |
| Contractor PMs | 69% | 54% | 79% | 62% | 41% | 62% | 47% |

The overall results in Table 7.45 indicate that respondents rank the management style as the prime contributor to the quality of the project management outcome with the two sub-processes under investigation - selection of team members and structuring the team - third and fifth respectively.

For question 5q2, respondents were asked to evaluate the rate of success of their most recently completed project, thus interconnecting all previous answers and enabling, as much as possible, an objective review of the outcome. The detailed results of the ratings provided are shown in Appendix D Tables AP.D-7.46.1 to AP.D- 7.46.7, again for all of the sub-processes. The summary level of the overall frequency and valid percent for the three processes under investigation are shown below in Table 7.46. On Table 7.47 the results for all sub-processes and only for the 'successful' responses are presented.

Table 7.46. Rate of success of topics under investigation for the most recently completed projects within a successful project

| Ranking | **Selecting Team Members** | | **Structuring the Team** | | **Management Style** | |
|---|---|---|---|---|---|---|
| | Overall Freq/cy | Overall Valid % | Overall Freq/cy | Overall Valid % | Overall Freq/cy | Overall Valid % |
| Unsuccessful | 2 | 2 | 2 | 2 | 1 | 1 |
| Acceptable | 50 | 56 | 51 | 57 | 41 | 46 |
| Successful | 38 | 42 | 37 | 41 | 48 | 53 |

Survey results in Table 7.46 indicate clearly that the majority of respondents consider the contribution of the two sub-processes - selecting team members and structuring the team - as contributing only to an acceptable level, whereas the contribution of the management style adopted is considered as successful.

Table 7.47 Overall percentage rate of success of the project management sub-processes, For 'successful' only responses.

| | **Selecting Team Members** | **Structuring the Team** | **Management Style** | **Monitoring and Control** | **Reporting** | **Conflict Management** | **Efficient use of resources** |
|---|---|---|---|---|---|---|---|
| Overall Total | 42% | 41% | 53% | 20% | 24% | 42% | 25% |
| Client PMs | 41% | 41% | 57% | 14% | 24% | 41% | 24% |
| Contractor PMs | 44% | 41% | 49% | 28% | 26% | 42% | 26% |

(Note: Data extracted from tables AP.D-7.46.1 to AP.D-7.46.7)

Results in Table 7.47, as also in Table 7.45, indicate that respondents valued the management style adopted as the highest contributor to the success of their projects with the sub-processes of selecting team members and structuring the team third and fourth. Thus, indicating that there is concern regarding those two areas.

Finally, having been given a detailed description of the term 'successful project' and corresponding descriptions for five-level Likert scale (from Very Little to Excellent), respondents were requested to indicate the contribution of each one of the project management sub-processes towards the project outcome. Table 7.48 provides a summary of the responses given, indicating only the first and second highest levels, in terms of frequency of response. The detailed results can be seen in Appendix D Table AP.D-7.49.

Table 7.48 Response regarding contribution of project management sub-processes to the success of the quality of the project management

| | | Overall | | Clients | | Contractors | |
|---|---|---|---|---|---|---|---|
| **PM Sub-process** | **Level** | **Freq/cy** | **%** | **Freq/cy** | **%** | **Freq/cy** | **%** |
| **Selecting Team Members** | Subst/Excel | 56 | 62 | 30 | 57 | 26 | 67 |
| **Structure of the Team** | Subst/Excel | 43 | 47 | 20 | 39 | 23 | 59 |
| **Management Style** | Subst/Excel | 71 | 78 | 39 | 75 | 32 | 82 |
| **Monitoring & Control** | Subst/Excel | 59 | 65 | 31 | 60 | 28 | 72 |
| **Reporting** | Subst/Excel | 24 | 26 | 13 | 25 | 11 | 28 |
| **Conflict Resolution** | Subst/Excel | 38 | 42 | 15 | 29 | 23 | 59 |
| **Efficient usage of Resources** | Subst/Excel | 45 | 50 | 19 | 37 | 26 | 68 |

As indicated previously in Tables 7.45 and 7.47, PM practitioners rate the contribution of the management style adopted as the highest and that of the selection of team members and structuring of teams as third and forth. Client PM practitioners' response in terms of the contribution gives the same overall rating, however, Contractor PM practitioners differ in that they rate 'Monitoring and Control' as the second highest sub-process with selection of team members and structuring the team third and forth.

## *7.4 Interview results*

This section of the research results presents findings from the 31 extensive interviews. Two sets of results are presented from the questionnaires used during the interviews; the first concerns results from the general complexity questionnaires, and the second those from the complexity characteristics questionnaires. As described in the Research Method Chapter, the purpose of the interviews was twofold, to establish the current thinking in terms of general complexity and, whilst testing Hypothesis 2, to examine the applicability of the 16 complexity characteristics in the three project management sub-processes and the implementation of measures to enable the management of its effects.

### 7.4.1 General Complexity interview results

The detailed feedback from the interviews is presented in Appendix D Table AP.D-7.50. From the information available, a set of figures was created and shown below. Together with the figures in Section 7.4.2, these will be used to prove or refute Hypotheses H2.1, H2.2 and H2.3. The figures depict frequencies of response to the questions set during the interviews. In order to establish the level of understanding and clarity of the issue of complexity, all interviewees were asked a number of generic questions. The response given to the question asking if their organisations define complexity is shown below in Figure 7.4. As shown below, Figures 7.5 and 7.6 depict how organisations identify complexity and what generates complexity.

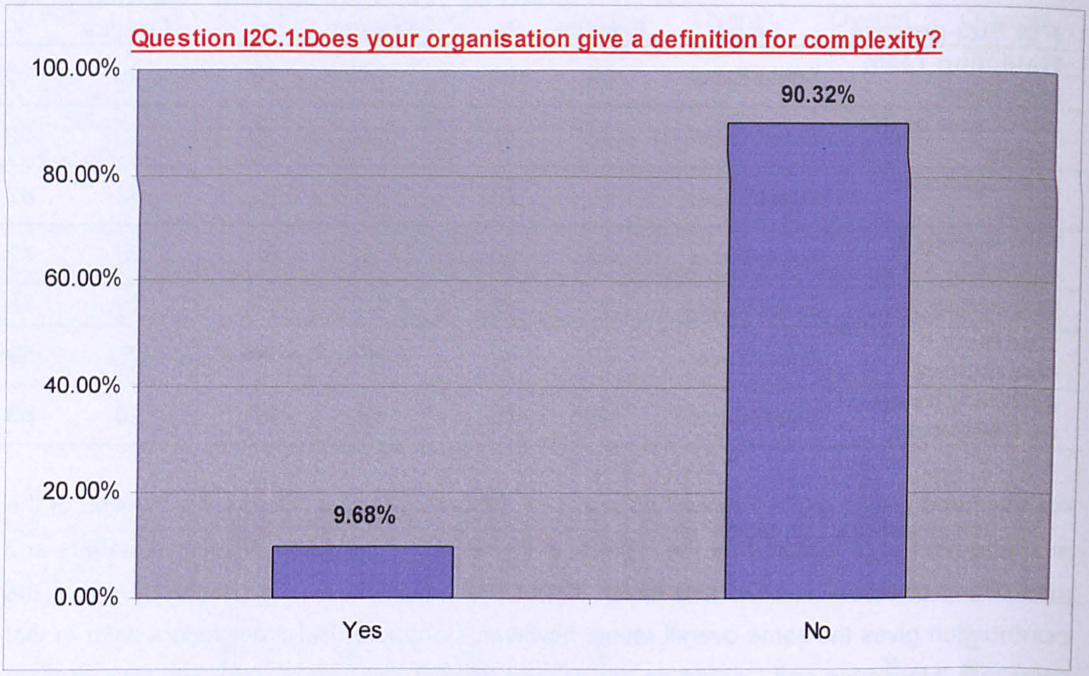



Figure 7.4 Response regarding companies giving a definition for complexity

Figure 7.4 indicates clearly that organisations do not give a definition for complexity. The three respondents who replied 'Yes' (in Figure 7.4) gave the descriptions shown in Table 7.51.

Table 7.51 Descriptions of the definition of complexity given by respondents

| Interviewee | Description |
|---|---|
| 1 | Complexity is defined as the risks and how do we interface with operations; effect on business; procurement route |
| 5 | The management of commercial and project size complexity |
| 7 | Using the commercial strategy to group suppliers and reduce commercial risks |

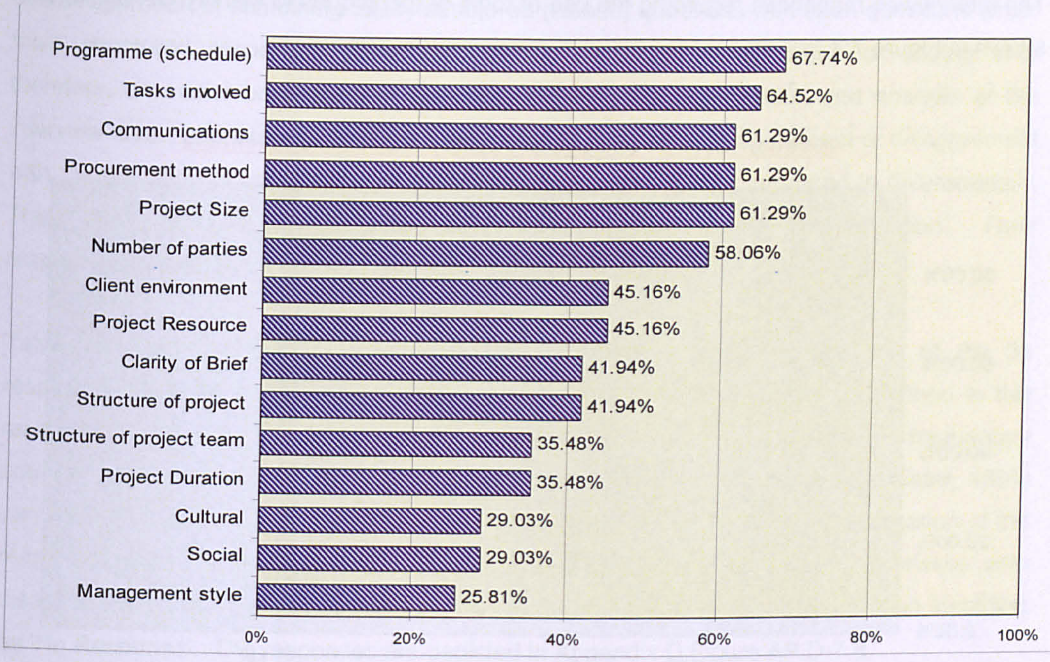



Figure 7.5 Response regarding the identification of complexity in projects

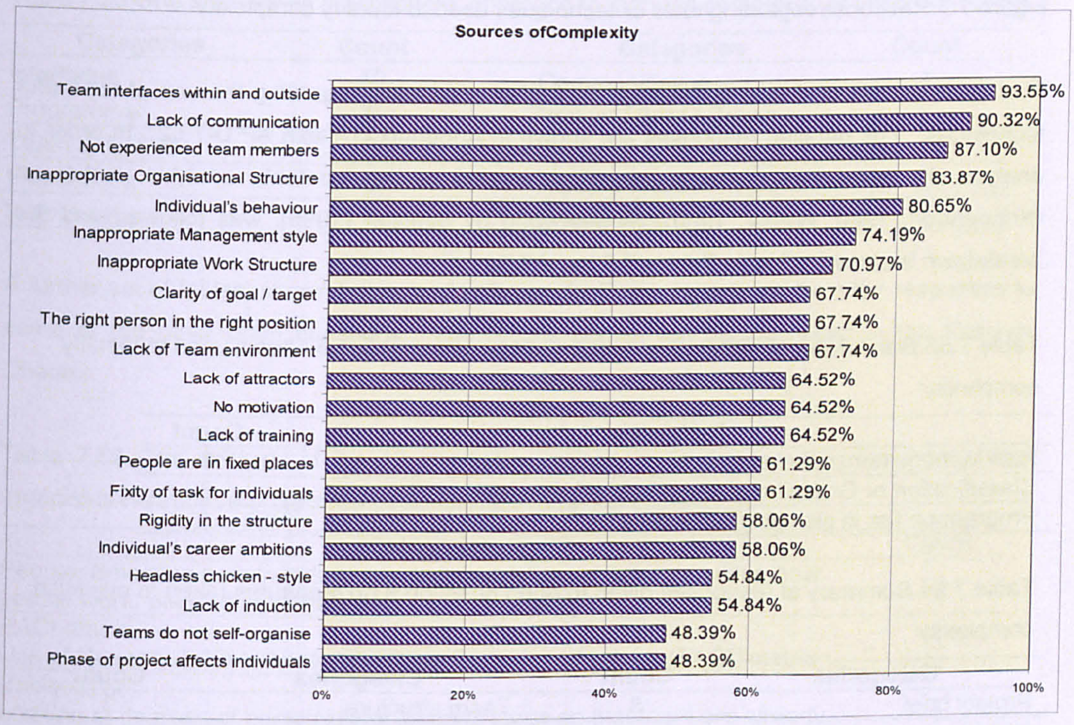



Figure 7.6 Factors identified as source of complexity

Figures 7.5 and 7.6 indicate clearly that, whereas at company level mechanistic means are considered as contributing to complexity, at PM practitioner level more behavioural issues are prevailing. Further analysis of the findings will be conducted in the Analysis Chapter.

The interviewee responses regarding the use of tools or techniques to identify complexity are shown in Figure 7.7.

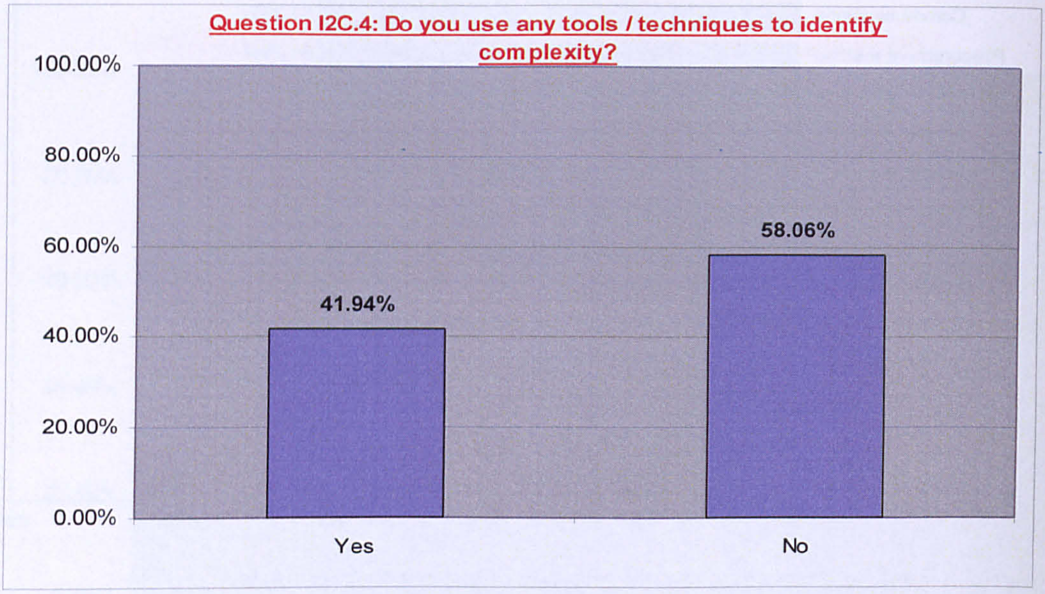



Figure 7.7 Response regarding tools or techniques used to identify complexity

Two open questions, 5 and 6, investigated further responses regarding the use of tools and techniques. The detailed responses are shown in Appendix D Table AP.D-7.52. In order to analyse the responses given, a simplified version of the 'contents analysis' technique (Krippendorf, 1980; Weber, 1990), as described by Simister (1995), was followed and the breakdown is shown below in Tables 7.53 and 7.54.

Table 7.53 Breakdown of affirmative responses to open question 5 - 'tools used to identify complexity'

| Response | Count |
|---|---|
| Risk Management used as a tool | 8 |
| Classification or Grouping of projects used as a tool | 2 |
| Programme (as in planning) used as a tool | 1 |

Table 7.54 Summary of responses given to open question 6 on measures taken to minimise complexity

| Categories | Count | Categories | Count |
|---|---|---|---|
| Project brief | 8 | Team structure | 3 |
| Interfaces | 6 | Risks \ Issues | 3 |
| Programme (as in planning) | 5 | Monitoring \ Control | 2 |
| Communication | 5 | | |

Of the 31 responses to the open question 6 regarding 'measures taken to minimise complexity' recorded in Table AP.D-7.52 Appendix D, Table 7.54 presents the breakdown of the responses, using again a simplified version of the 'contents analysis' technique. The overall approach of combining totally structured (closed) questions with open questions which have structured responses (Bouchard, 1976), supported simplification of coding and, therefore, an easier breakdown of the content during the organisation and analysis of the interview data. Interviewees were also requested to indicate their agreement or disagreement with the definition of complexity, as formulated by Lucas (2000b) and used in this research. The majority of interviewees, 87%, 'agreed/strongly agreed' with the definition. Their response is shown in Figure AP.D-7.8 in Appendix D.

Table 7.55 below presents the worked out composition (contents analysis) of the 31 responses given by the interviewees if they were to manage complexity as defined in this research. The analysis grid (Gillham, 2000: 74) used to categorise and extract a frequency / count of 'object structures' (Beard and Easingwood, 1989, as referenced by Simister, 1995) can be seen in Appendix D (see Table AP.D-7.57) together with a tabular presentation of the responses (see Table AP.D-7.56). It should be noted that four of the interviewees who disagreed with the definition did not respond to the question and these have been identified as 'No Response'. The responses are depicted in Appendix D Figure AP.D-7.8.

Table 7.55 Grid analysis on practitioners' approach to manage complexity of interconnections

| Categories | Count | Categories | Count |
|---|---|---|---|
| Interfaces | 10 | Communication | 4 |
| Programme | 6 | Project / Brief / Scope | 3 |
| Team Structure | 5 | System | 3 |
| Interactions | 5 | Roles & Responsibilities | 2 |
| Individuals | 5 | Unclassified | 5 |

A further set of tables, shown below and in Appendix D, are developed from the responses to some of the other open questions. The results shown will be discussed in the Analysis Chapter.

Table 7.59 Grid analysis of the 12 affirmative responses to the question 'how does your organisation structure project teams specifically to tackle complexity'

| Categories | Count |
|---|---|
| People: Selecting certain individuals, individuals' capabilities, knowing how people work, peoples' experience, | 5 |
| RACI matrix<br>Use of Responsibilities, Accountabilities, Consult and Inform (RACI) matrix | 3 |
| Unclassified:<br>Looking at degrees of complexity at an early stage so that team are already identified | 1 |

The detailed results can be seen in Table AP.D-7.58 in Appendix D.

Table 7.60 Grid analysis of the 5 affirmative responses to the question: 'Does your organisation use specific management techniques that depend on the level of complexity of the project?'

| Categories | Count |
|---|---|
| People: Specific person / the PM | 2 |
| Process | 1 |
| Unclassified: | 2 |

The detailed results can be seen in Table AP.D-7.61 in Appendix D.

### 7.4.2 Complexity characteristics interview results

The results from the second part of the interviews, on the complexity characteristics, were collated by project management sub-process and strata and then entered in MS Excel. In order to generate graphical output, overall and by strata, common tables are formed and these can be seen in Appendix D as Tables AP.D-7.62.1, 2, 3; AP.D-7.63.1, 2, 3; and AP.D-7.64.1, 2, 3. A summary of all the averages can be seen below in Table 7.65. The average of the responses, shown in Table 7.65, together with the more detailed information included in Appendix D and referenced above, are used to create a number of radar graphs. The tabular reports and the graphs display, in percentages, the level of the actions taken by the interviewees to minimise or maximise the effects of the complexity characteristics on their projects and for the sub-processes investigated in this research.

Table 7.65 Level of overall average achieved for managing each complexity characteristic and for each sub-process.

| | | **Overall average achieved management of complexity (in %)** | | |
|---|---|---|---|---|
| | | **Selecting the Team** | **Structuring the Team** | **Management Style** |
| Conditional Characteristics | Autonomous agents | 16 | 58 | 55 |
| | Instability | 60 | 45 | 62 |
| | Non-equilibrium | 50 | 48 | 60 |
| | Non-linear | 53 | 51 | 59 |
| | Attractors | 67 | 50 | 65 |
| Developmental Characteristics | Co-evolution | 39 | 53 | 59 |
| | Self-modification | 41 | 53 | 55 |
| | Self-reproduction | 46 | 56 | 45 |
| | Downward Causation | 49 | 54 | 55 |
| | Mutability | 41 | 37 | 42 |
| | Non-uniform | 52 | 39 | 57 |
| | Emergence | 44 | 56 | 63 |
| | Phase changes | 38 | 49 | 55 |
| Behavioural Characteristics | Unpredictability | 63 | 52 | 47 |
| | Non-standard | 30 | 65 | 69 |
| | Undefined values | 24 | 53 | 60 |

The results in Table 7.65 indicate that none of the complexity characteristics are managed at a level that will enable the minimising or maximising of their characteristics. Detailed analysis and discussion of these results will be conducted in the Analysis and Discussion Chapters respectively.

For all of the above results, a radar graph was created representing the overall average. Detailed overall graphs by complexity characteristic and by strata are shown in Appendix D. These will be discussed in more detail in the Analysis Chapter.

As mentioned above, the response represents the level (as a percentage) by which current PM actions cover the required level of conduct needed to manage the effect of the corresponding complexity characteristic. For example, in Figure 7.9 and for 'autonomous agents', one of the complexity characteristics investigated and reviewed with the interviewees, the overall average of actions taken covers only 16% of the required level of actions / activities which will ensure a 100% management of complexity when selecting team members. It should be noted that proposed actions for all the characteristics were reviewed with the interviewees and any additional actions were included in the listings.

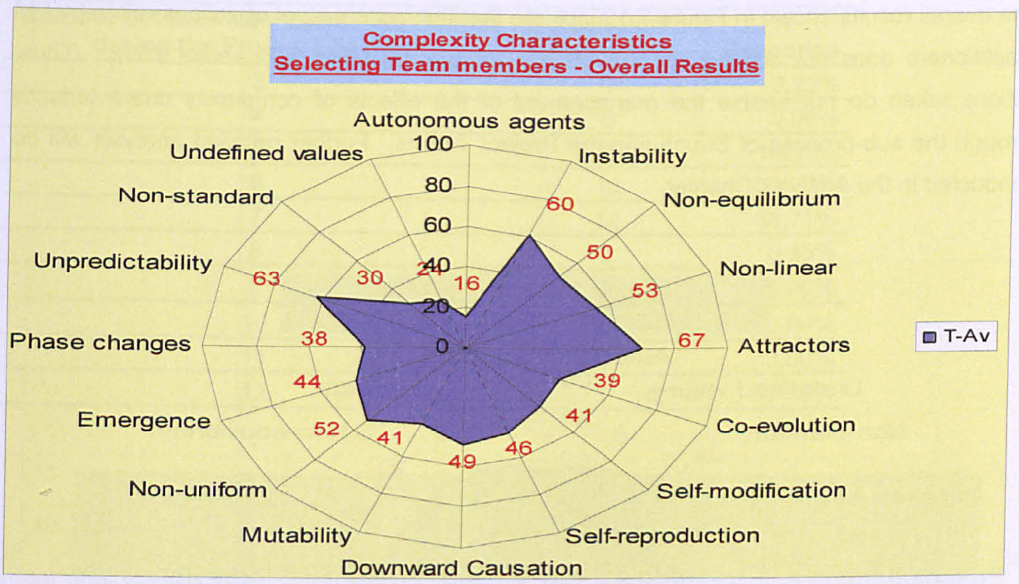



Figure 7.9. Overall results for current level of actions taken for managing the effect of complexity characteristics when Selecting Team members

The overall results shown in Figure 7.9 indicate that the current level of actions taken by PM practitioners does not achieve the acceptance criteria set (over and above 75%). Thus, actions taken do not enable the management of the effects of complexity characteristics through the sub-process of Selecting Team members. Further detailed analysis will be conducted in the Analysis Chapter.

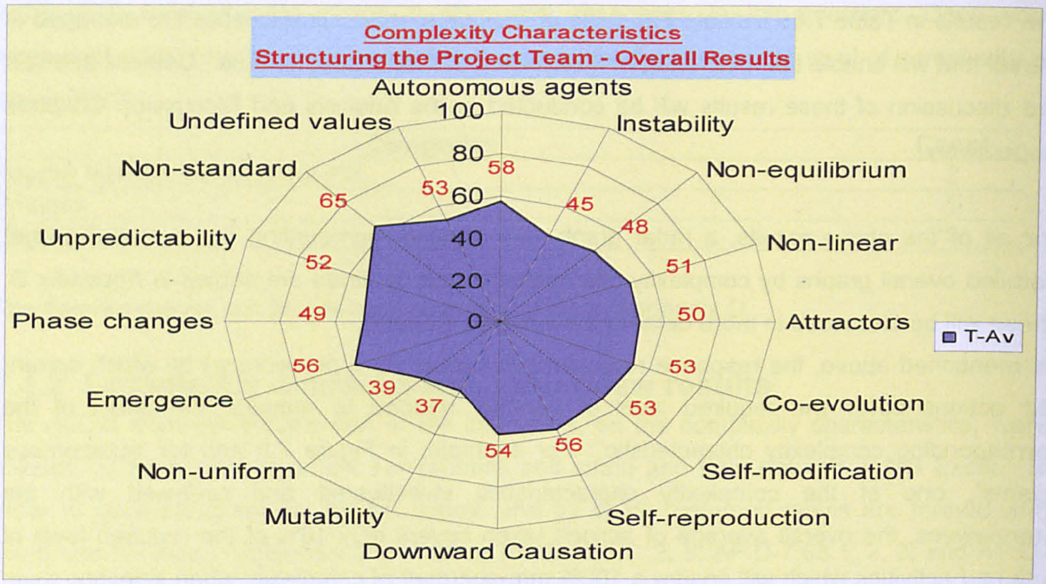



Figure 7.10. Overall results for current level of actions taken for managing the effect of complexity characteristics when Structuring the Project Teams

The overall results shown in Figure 7.10 indicate that the current level of actions taken by PM practitioners does not achieve the acceptance criteria set (over and above 75%). Thus, actions taken do not enable the management of the effects of complexity characteristics through the sub-process of Structuring the Project Teams. Further detailed analysis will be conducted in the Analysis Chapter.

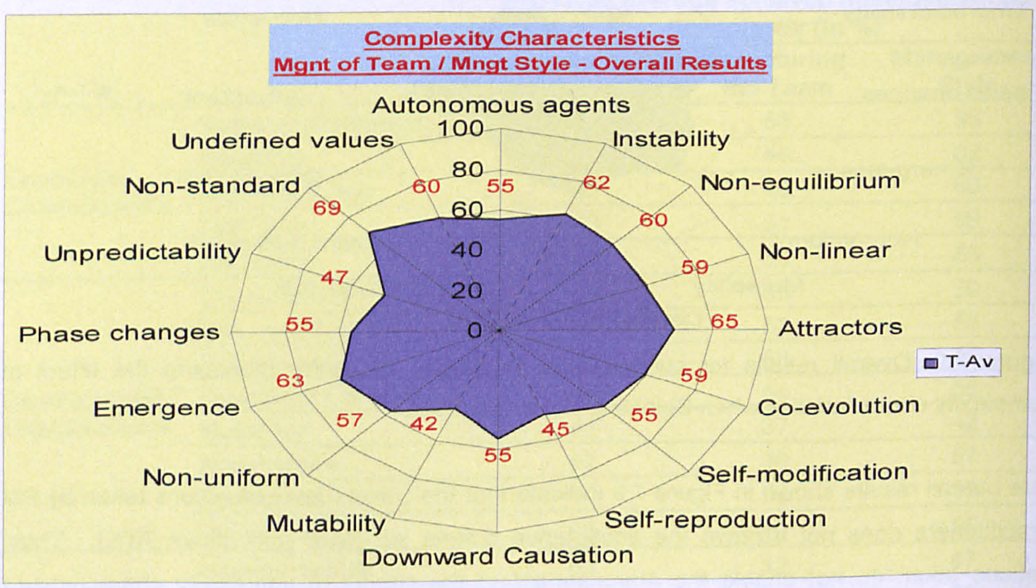



Figure 7.11. Overall results for current level of actions taken for managing the effect of complexity characteristics by the Management Style followed

The overall results shown in Figure 7.11 indicate that the current level of actions taken by PM practitioners does not achieve the acceptance criteria set (over and above 75%). Thus, actions taken do not enable the management of the effects of complexity characteristics through the Management Style adopted. Further detailed analysis will be conducted in the Analysis Chapter.

Detailed results from the interviews regarding complexity characteristics are shown in Tables AP.D-7.61 to AP-7.64 and AP.D-7.66 in Appendix D and will be used in the Analysis Chapter. In addition to the above and the detailed radar graphs (shown in Appendix D), interviewees were asked to indicate the number of times teams form and disband on a project. All the respondents, having considered the three basic stages - design, construction and commissioning - excluding one, provided answers at the discipline level. Together with a graphical representation of the frequency of response these are shown below in Table 7.67 and Figure 7.33.

Table 7.67 Interviewees frequency and percent response on 'number of times new teams form and disband during the project life cycle'

| Number of times New Teams are formed during the Project Life cycle | Response Frequency | % Response |
|---|---|---|
| 3 | 1 | 3.23% |
| 4 | 0 | 0.00% |
| 5 | 5 | 16.13% |
| 6 | 10 | 32.26% |
| 7 | 12 | 38.71% |
| 8 | 2 | 6.45% |
| 9 | 0 | 0.00% |
| 10 | 0 | 0.00% |
| 11 | 0 | 0.00% |
| 12 | 1 | 3.23% |

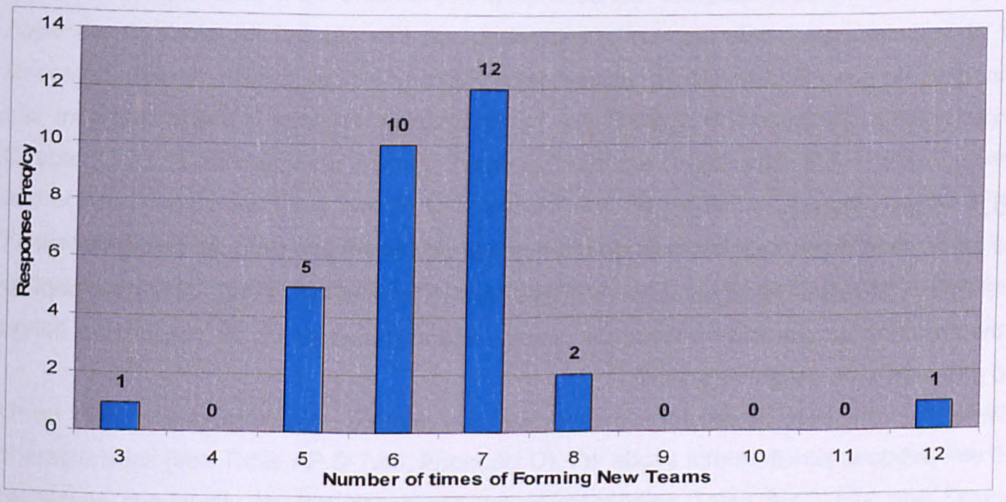



Figure 7.33 Number of times new teams form and disband during the project life cycle.

## 7.5 Case Studies results

The results for the five case studies are presented in the sections below. A separate section will be used for the presentation of the overall / comparative results. Each section - case study - will be structured and include the following information:

- Brief description of the project basic data, including comments from the case study PM (where available);
- Calendar start and completion of the case study, number of activities monitored during the case study;
- Tabular report of weekly frequencies of occurrence of coded reasons for delay, with the corresponding histograms in Appendix D;
- Tabular report of weekly frequencies of complexity characteristic(s) which caused delay, with the corresponding histograms in Appendix D;
- Case study performance data;
- Graphical presentation of simple % drop in performance against time;
- Graphical presentation of the relationship between percent drop in performance and number of complexity characteristics that affect performance;
- Graphical presentation of modelling performance based on Total Duration achieved against Time taken.

In order to link the 'layman's' reasons for delay used for the case studies, shown in Appendix C-3.5, to the complexity characteristics investigated, a cross-correlation table was produced. The tabular report is shown in Appendix C-3.6 and a simplified version in Appendix D Table AP.D-7.68. Also a typical example of a case study programme, received from contributors to the case studies, is shown in table AP.D-7.69 in Appendix D and a sample of a completed spreadsheet template used to calculate case study performance is shown in Appendix C-3.10. For the comparative results (see Section 7.5.6) a number of the above outputs will be combined and compared and, as previously detailed, outputs will be included in Appendix D.

### 7.5.1 Case Study 1 – G1.3

The information presented was provided by the PM and the Team Planner during the initial meeting and the weekly progress reporting was conducted over the phone. Electronic copies of the progress templates were forwarded weekly and explanations on the reasons for delay and progress were sought / discussed.

Table 7.70. Case study G1.3 brief project details

| | |
|---|---|
| **Project Title:** 44409 --- WwTW | |
| **Brief Description:** Wastewater Treatment Works | |
| **Initial Duration:** 59 weeks | ***Estimated Final Duration:*** 63 weeks |
| **Initial Cost Estimate:** £624K | |
| **Current Anticipated Final Cost:** £610K | |
| **Initial Start Date (Baseline):** early August 2007 | |
| **Planned Completion Date (Baseline):** mid September 2008 | |
| **Current Start Date:** early August 2007 | |
| **Expected Completion Date:** mid October 2008 | |
| ***Project Manager Comment on initial conditions:*** Scheme is essentially a package unit wastewater treatment works to existing works that is currently struggling to meet consent. Scope of Works is *as per* the brief (Asset Maintenance). Completion of design is dependent on receipt and approval of supplier drawings. Internal design elements currently being progressed via a subsidiary oversees. Expected delays will be inevitable due to inexperience of design team. | |

Table 7.71. Case study G1.3 details

| |
|---|
| **Case Study Start date:** 21-Dec-07 – no Christmas break |
| **Case Study Completion date:** 22-Feb-08 |
| **Number of activities monitored:** 27, with durations ranging from 5 days to 15 days with the exception of one 60 day activity |
| **Comment:** The project was performed by a partnering organisation and it was at design stage and the PM had more than 20 years experience. Main activities involved preparation of Site layouts, P&IDs, loading and instrument schedule, etc. |

The programme provided was at the appropriate level of detail and, therefore, all activities were monitored during the nine week period of the case study. On completion of the case study period, the data were entered into a spreadsheet template (see typical example in Appendix C Table AP.C-3.10) and the performance was calculated as described in the Research Method. The graphical and tabular presentations shown below are created using this information and a detailed examination of the findings is discussed in the Analysis Chapter. The detailed and summarised breakdowns of the coded reasons for delay, by week and activity, can be seen in Appendix D Tables AP.D-7.72 and AP.D-7.73 and Figures AP.D-7.34 and AP.D-7.35. The information given provides an indication of the combined effect that complexity characteristics have had on the performance of the project during the case study period.

Using the cross-correlation between coded reasons for delay and the complexity characteristics (see Table AP.D-7.68, Appendix D), the above information is decoded into the respective complexity characteristics and the corresponding Table AP.D-7.74 and Figures

AP.D-7.36 and AP.D-7.37 are generated and shown in Appendix D. The figures depict the weekly frequency as well as the frequency of occurrence of the complexity characteristics causing delay. Also as described in the Research Method Chapter, two of the most obvious and simple ways of calculating performance are used (see example in Appendix C-3.7) and thus two sets of performance data, Figures 7.38 and AP.D-7.39 (in Appendix D), are obtained. The performance figures are extracted from the very detailed progress template and can be seen in Table 7.75.

Table 7.75. Case study G1.3 performance data

| | Wk 1 | Wk 2 | Wk 3 | Wk 4 | Wk 5 | Wk 6 | Wk 7 | Wk 8 | Wk 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Simple % Drop in Performance** (in %) (see Figure 7.38) | 0 | 9 | 26 | 29 | 32 | 23 | 24 | 22 | 26 |
| **Time Elapsed % Drop Performance** (in %) (see Figure AP.D-7.39) | 0 | 31 | 67 | 77 | 85 | 64 | 76 | 58 | 84 |

The figures indicate that as time progresses (in weeks), performance drops. For example, in week two, four complexity characteristics (see Figure AP.D-7.36 in Appendix D), which were not dealt with, resulted in a 9% drop in performance. However, as it was very early in the process, and as the team were finding out about the problems in their design office overseas, problems escalated, complexity increased twofold and, as a result, performance dropped by 32%. There off, through actions taken by the PM and the team, the drop in performance 'stabilised' at approximately 24%.

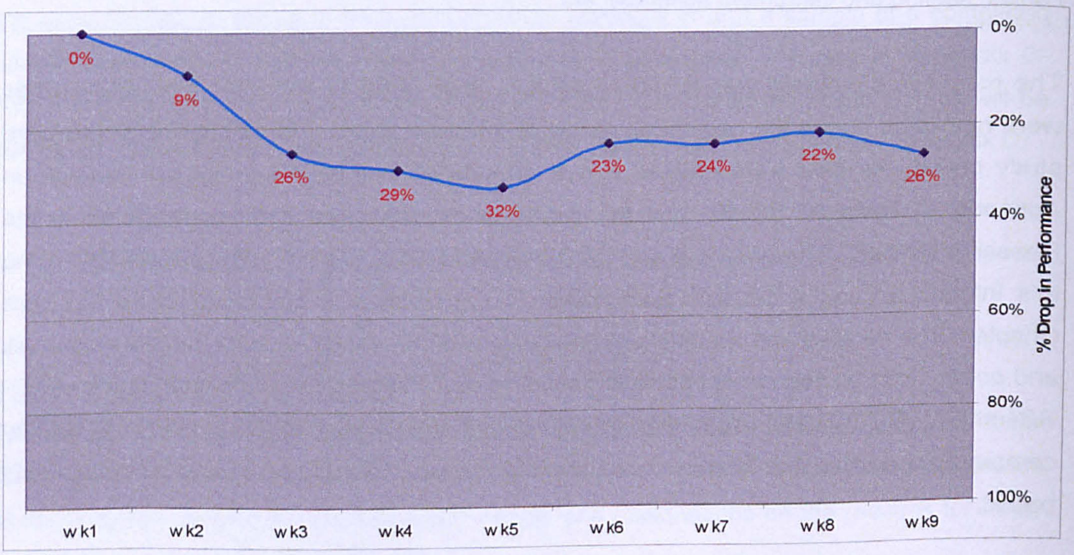



Figure 7.38. Case study G1.3, simple % drop in performance against time

The time elapsed method of evaluating performance amplifies the effect delays have on the activities to be performed and this can be seen in Appendix D Figure AP.D-7.39.

Theoretically, this approach is more accurate since it takes into account how much time has elapsed; however, when discussed with the PM he was confident that this would be recovered. Using the results obtained, Figure 7.40 is generated to indicate the relationship between performance and complexity.

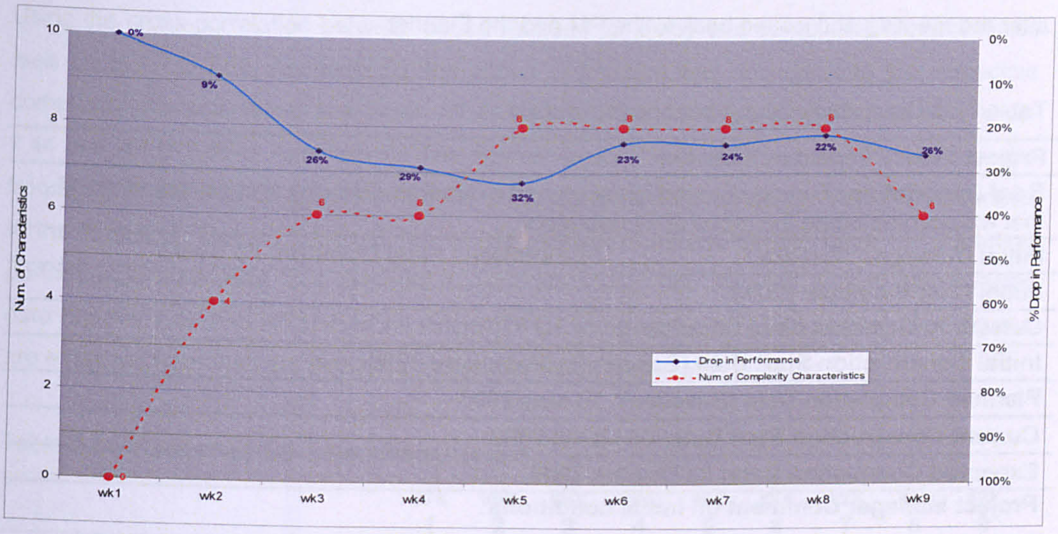



Figure 7.40. Case study G1.3, % drop in performance against number of complexity characteristics that affected performance

The significance of the drop in performance can be seen in Figure 7.41, which displays the 'Cumulative Planned' and the 'Cumulative Achieved' durations for the case study period. As can be seen, only 74% of the planned activity time (or 117 days out of 158) was achieved and the team had to reconsider the design activities performed abroad.

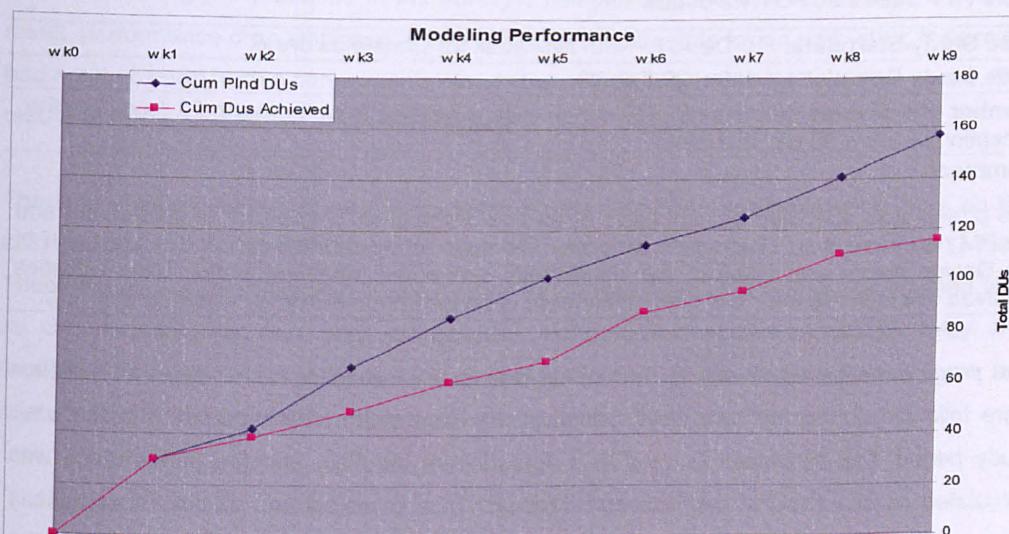



Figure 7.41. Case study G1.3 modelling of performance based on Total Duration achieved against time taken

### 7.5.2 Case Study 2 – G1.1.2

The information presented was provided by the PM and the Team Planner during the initial meeting and the weekly progress reporting was conducted on-site. Progress and explanations of reasons of delays were discussed and hard copies were created during the progress meetings. Electronic copies of the progress templates were produced immediately after the meeting and issued back to the PM and the Planner.

Table 7.76 Case study G1.1.2 brief project details

| | |
|---|---|
| **Project Title:** Forecourt Extension | |
| **Brief Description:** Forecourt reconfiguration and extension. Part of a programme of works that will accommodate the move of 54 operators | |
| **Initial Duration:** 71weeks | **Estimated Final Duration:** 85 weeks |
| **Initial Cost Estimate:** £87M | |
| **Current Anticipated Final Cost:** £54M | |
| **Initial Construction Start Date (Baseline):** 07-January-2008 | |
| **Planned Completion Date (Baseline):** 16-May-2009 | |
| **Current Construction Start Date:** 06 March 2008 | |
| **Expected Completion Date:** 23 October 2009 | |
| **Project Manager Comment on initial conditions:** No contract overlapping with enabling works. | |
| Explanatory note by researcher. The project was at Scheme Design stage and in order to achieve the initial 33 weeks duration enabling works were supposed to overlap with Design. However, due to various issues, it was impossible to complete the Design on time for the client to be able to award the enabling works contract with the minimum amount of risk. In order to achieve the end date, the team decided to proceed with enabling works. Actions taken by the team were not enough to alleviate problems later on and, in particular from the surveys, more issues were uncovered. This resulted to a threefold increase in duration and reduction of the works to be performed. | |

Table 7.77 Case study G1.1.2 details

| |
|---|
| **Case Study Start date:** 10-Dec-07 – with two week for Christmas break |
| **Case Study Completion date:** 22-Feb-08 |
| **Number of activities monitored:** 63, with durations ranging from 5 days to 25 days with the *exception of a few 30 day activities* |
| **Comment:** The project was executed by contractor A, as one of the client framework of contractors and the PM had more than 15 years experience. The case study commenced at the latter part of the Design period and followed the significantly overlapped enabling works. Main activities involved works in the main car park, movement of underground services, street lighting, etc. |

The programme provided was at the appropriate level of detail and, therefore, all activities were followed during the nine week period of the case study. On completion of the case study period, the data were entered in a spreadsheet template and the performance was calculated as described in the Research Method. The graphical and tabular presentations shown below have been created using this information and a detailed examination of the findings is discussed in the Analysis Chapter. The detailed, as well as summarised, breakdown of the coded reasons for delay, by week and activity, can be seen in Appendix D, Tables AP.D-7.78 and AP.D-7.79 and Figures AP.D-7.42 and AP.D-7.43. The detail given provides an indication of the combined effect complexity characteristics have had on the performance of the project during the case study period.

Using the cross-correlation between coded reasons for delay and complexity characteristics (see Table AP.D-7.68, Appendix D), the above information was decoded into the respective complexity characteristics, see Table AP.D-7.80 and the corresponding Figures see AP.D-7.44 and AP.D-7.45 in Appendix D. The figures depict the weekly frequency as well as the frequency of occurrence of the complexity characteristics causing delay. Also, as described in the Research Method Chapter, two of the most obvious and simple ways of calculating performance were used (see example in Appendix C-3.7) and thus two sets of performance data Figures 7.46 and AP.D-7.47 (in Appendix D) were produced. The performance figures are extracted from the very detailed progress template and shown in Table 7.81.

Table 7.81. Case study G1.1.2 performance data

| | Wk 1 | Wk 2 | Wk 3 | Wk 4 | Wk 5 | Wk 6 | Wk 7 | Wk 8 | Wk 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Simple % Drop in Performance** (in %) (see Figure 7.46) | 55 | 50 | 52 | 49 | 50 | 56 | 58 | 55 | 43 |
| **Time Elapsed % Drop Performance** (in %) (see Figure AP.D- 7.47) | 55 | 59 | 76 | 70 | 80 | 91 | 89 | 80 | 56 |

The figures indicate that as time progresses (in weeks), performance drops. For example, in week one, six complexity characteristics (see Figure AP.D-7.44, Appendix D), which were not dealt with, have resulted in a 55% drop in performance. As work progressed and as the team were uncovering the problems in the surveys, complexity continued to increase and, as a result, performance drop stabilised at 52%. Despite the attempts for an early start, the project had not recovered, with a consequent delay to the completion and reduction in the scope. The results are analysed further in the next chapter.

The time elapsed method of evaluating performance amplifies the effect delays have on the activities to be performed and this can be seen in Appendix D Figure AP.D-7.47. Theoretically, it is more accurate since it takes into account how much time has elapsed and, as can be seen, recovery was not possible, with the subsequent results of delay and reduction in scope. Using the results obtained, Figure 7.48 is generated to indicate the relationship between performance and complexity.

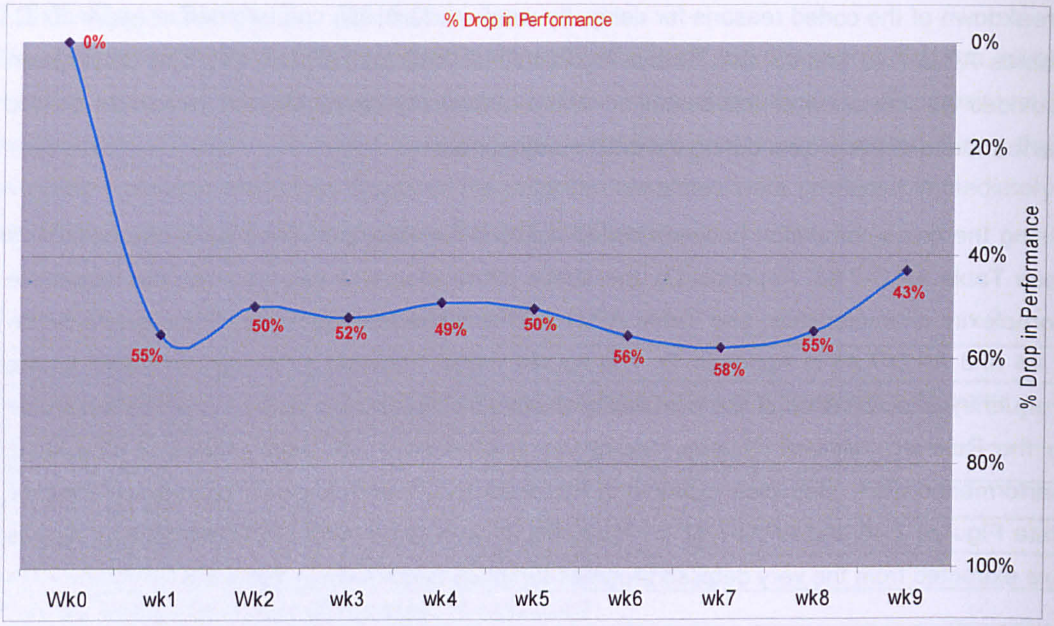



Figure 7.46. Case study G1.1.2, simple % drop in performance against time

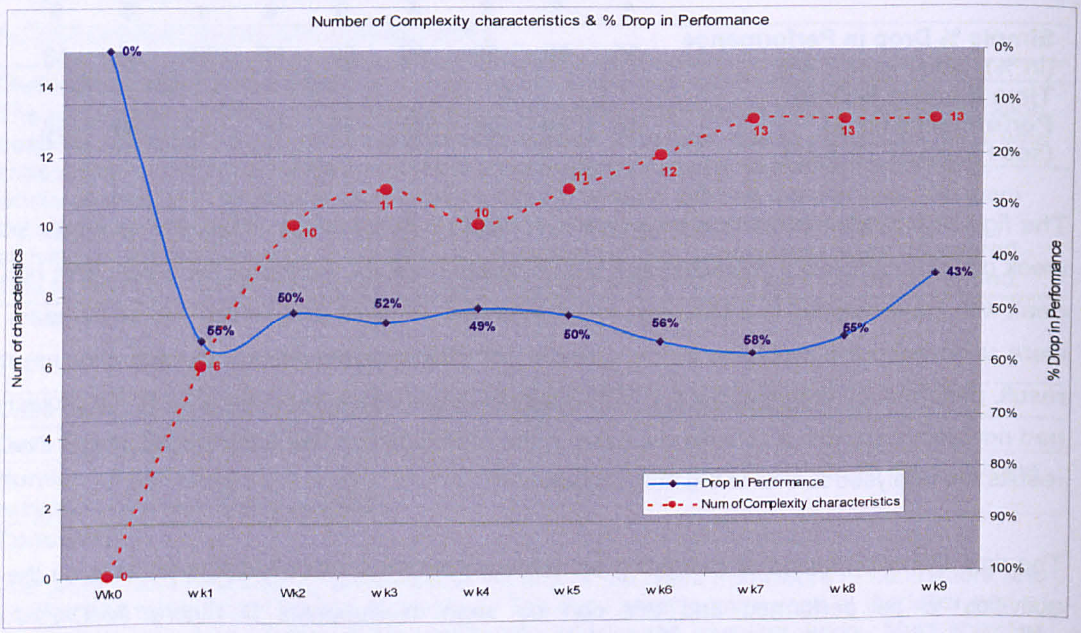



Figure 7.48. Case study G1.1.2, % drop in performance against number of Complexity characteristics that affected performance

The significance of the drop in performance can also be seen in Figure 7.49, which displays 'Cumulative Planned' and the 'Cumulative Achieved' durations for the case study period. As can be seen, only 57% of the planned activity time (or 373 days of the 654) was achieved which resulted in delaying the delivery of the project by eight months and a reduction in the scope of works.

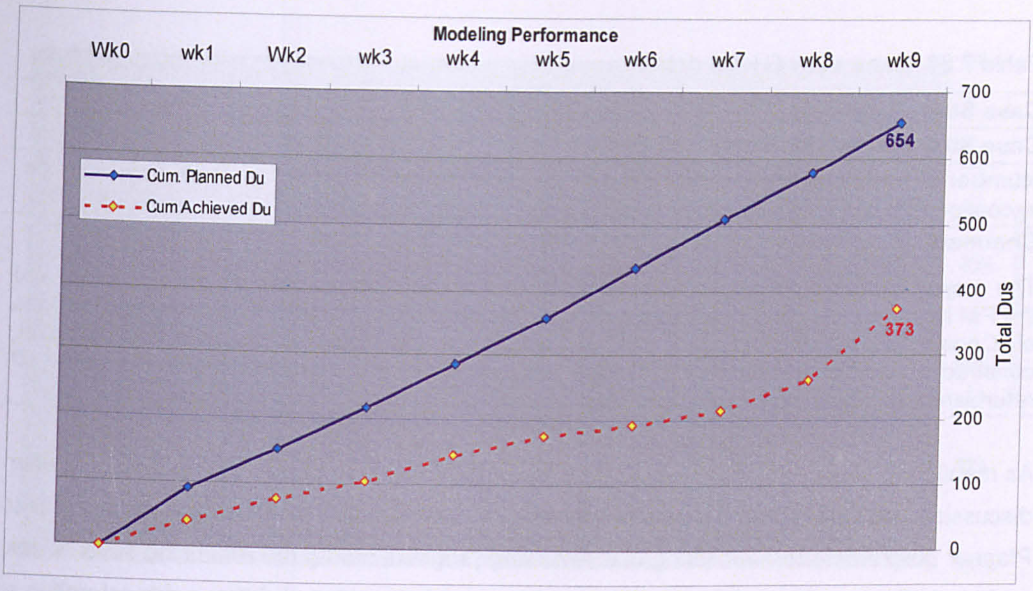



Figure 7.49. Case study G1.1.2, modelling of performance based on Total Duration achieved against Time taken

## 7.5.3 Case Study 3 – G1.1.4

The information presented was provided by the PM and the Site Manager during the initial meeting and the weekly progress reporting was conducted on-site. Progress and explanations for reasons for delays were discussed and hard copies were created during the progress meetings. Electronic copies of the progress templates were produced immediately after the meeting and issued back to the PM and the Site Manager.

Table 7.82. Case study G1.1.4 brief project details

| | |
|---|---|
| **Project Title**: Extensive redevelopment and New Lounge | |
| **Brief Description:** Reconfiguration of lounge and the retail units to accommodate the movement of operators as well as the increase in customer movements due to closure of other areas. | |
| **Initial Duration:** 21 months | **Estimated Final Duration:** 22 months |
| **Initial Cost Estimate:** £30M | |
| **Current Anticipated Final Cost:** £32M | |
| **Initial Start Date (Baseline):** June 2007 | |
| **Planned Completion Date (Baseline):** March 2009 | |
| **Current Start Date:** June 2008 | |
| **Expected Completion Date:** April 2009 | |
| **Project Manager Comment on initial conditions:** The Project is to modify and refurbish an existing structure and its systems. During its operational life certain areas of the building had been modified and altered, these areas present some 'discovery' issues which require design resolution and scope amendments. There is extensive work over restricted access areas. | |
| Explanatory note by researcher. The project programme was not in the appropriate format – inadequate detail, for the initial two weeks (apart from the fact that it was the Christmas period) and a more detailed version was issued on the 7th January 2008. | |

Table 7.83. Case study G1.1.4 details

| |
|---|
| **Case Study Start date:** 17-Dec-07 – no Christmas break |
| **Case Study Completion date:** 15-Feb-08 |
| **Number of activities monitored:** 83, with durations ranging from 5 days to 20 days with the exception of a few activities which had a duration longer than 40 days |
| **Comment:** The project was executed by contractor B, as one of the client framework of contractors and the PM had in excess of 10 years experience. The case study commenced at the early stages of Construction. Main activities involved works in the main zone, asbestos removal, construction and installation of a bridge link, removal and installation of AHU units, lift refurbishment, plant-room operations, etc. |

As mentioned above, the initial programme was not at the appropriate level of detail but after discussion with the PM and the Site Manager it was possible to utilise the project's Last Planner programme for monitoring and reviewing progress during the remaining seven-week period of the case study. On completion of the case study period, the data were entered in a spreadsheet template and the performance was calculated as described in the Research Method. The graphical and tabular presentations shown below have been created using this information and a detailed examination of the findings is discussed in the Analysis chapter. The detailed and summarised breakdowns of the coded reasons for delay, by week and activity, can be seen in Appendix D Tables AP.D-7.84 and AP.D-7.85 and Figures AP.D-7.50 and AP.D-7.51. The detail given provides an indication of the combined effect that complexity characteristics have had on the performance of the project during the case study period.

Using the cross-correlation between coded reasons for delay and complexity characteristics (see Table AP.D-7.68, Appendix D), the above information was decoded into the respective complexity characteristics, see Table AP.D-7.86, and the corresponding Figures AP.D-7.52 and AP.D-7.53 in Appendix D. The figures depict the weekly frequency as well as the frequency of occurrence of the complexity characteristics causing delay. Also as described in the Research Method Chapter, two of the most obvious and simple ways of calculating performance were used (see example in Appendix C-3.7) and thus two sets of performance data Figures 7.54 and AP.D-7.55 (in Appendix D) were produced. The performance figures are extracted from the very detailed progress template and shown in Table 7.87.

Table 7.87. Case study G1.1.4 performance data

| | **Wk 1** | **Wk 2** | **Wk 3** | **Wk 4** | **Wk 5** | **Wk 6** | **Wk 7** | **Wk 8** | **Wk 9** |
|---|---|---|---|---|---|---|---|---|---|
| **Simple % Drop in Performance** (in %) (see Figure 7.54) | 20 | 23 | 29 | 34 | 35 | 36 | 41 | 42 | 41 |
| **Time Elapsed % Drop Performance** (in %) (see Figure AP.D-7.55) | 20 | 33 | 48 | 56 | 42 | 43 | 76 | 69 | 67 |

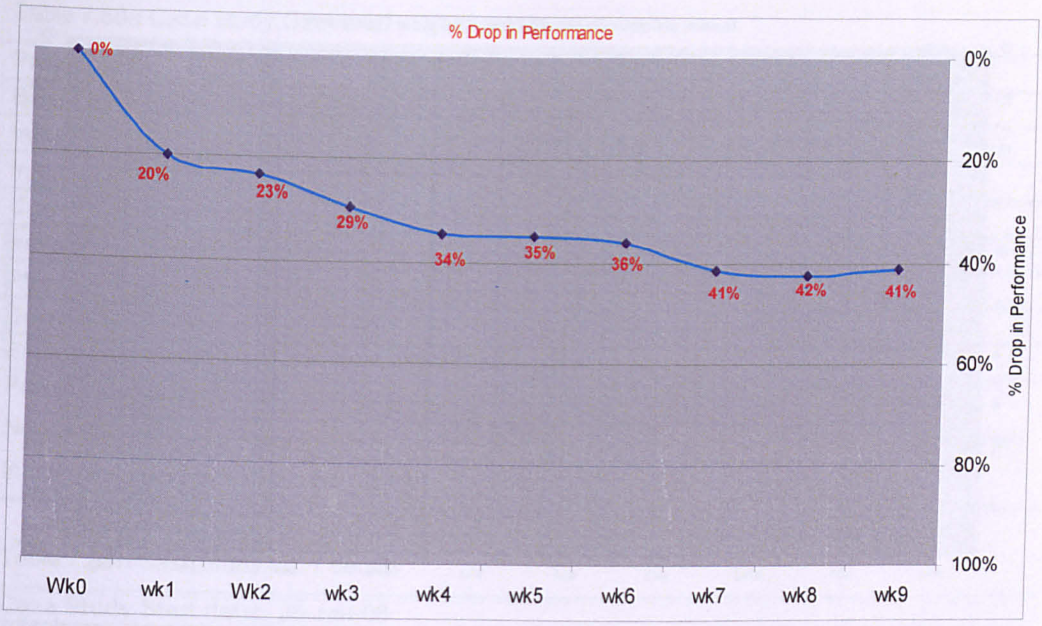



Figure 7.54 Case study G1.1.4, simple % drop in performance against time

The figures indicate that as time progresses (in weeks), performance drops. Despite the fact that the programme used for monitoring had to be altered to a more detailed one after Week 2, it is clear that, even with the higher level programme, performance dropped. Reviewing Figure AP.D-7.52 in Appendix D and for example in week four, eleven complexity characteristics, which were not dealt with, resulted in a 34% drop in performance. As work progressed the effects of complexity continued and, as a result, the performance drop stabilised at an average of 38%. The results are analysed further in the next chapter.

The time elapsed method of evaluating performance amplifies the effect delays have on the activities to be performed and this can be seen in Appendix D Figure AP.D-7.55. Theoretically, it is more accurate since it takes into account how much time has elapsed, and as can be seen, recovery was not possible, with the subsequent results of delay. Using results obtained, Figure 7.56 is generated to indicate the relationship between performance and complexity.

The significance of the drop in performance can also be seen in Figure 7.57, below, which displays 'Cumulative Planned' and the 'Cumulative Achieved' durations for the case study period. As can be seen, only 59% of the planned activity time (or 401 days of the 679) was achieved which resulted in delaying the delivery of the project by eight months and a reduction in the scope of works.

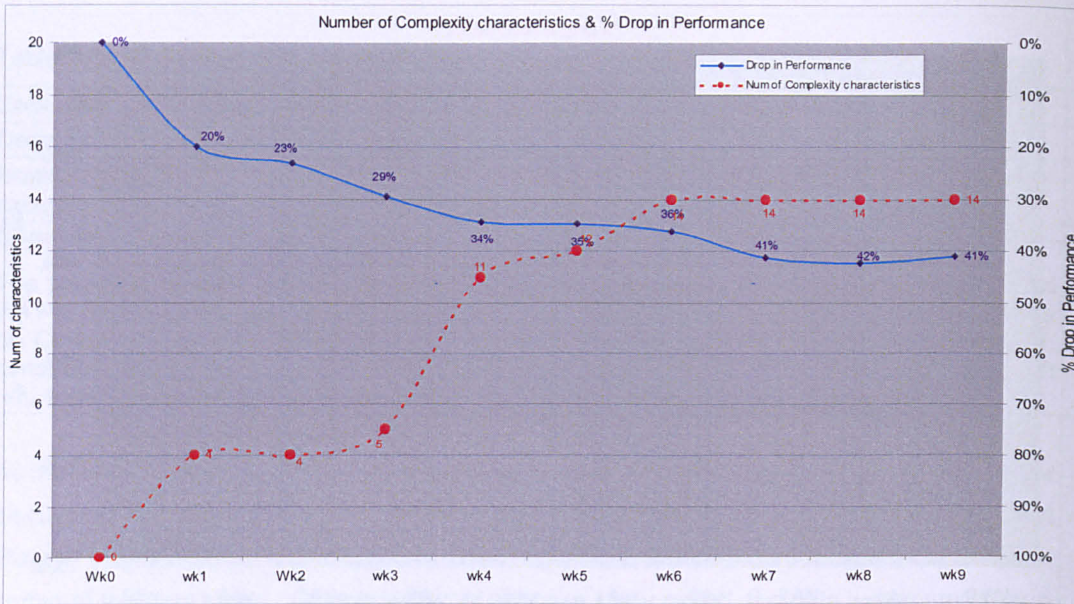



Figure 7.56. Case study G1.1.4, % drop in performance against number of complexity characteristics that affected performance

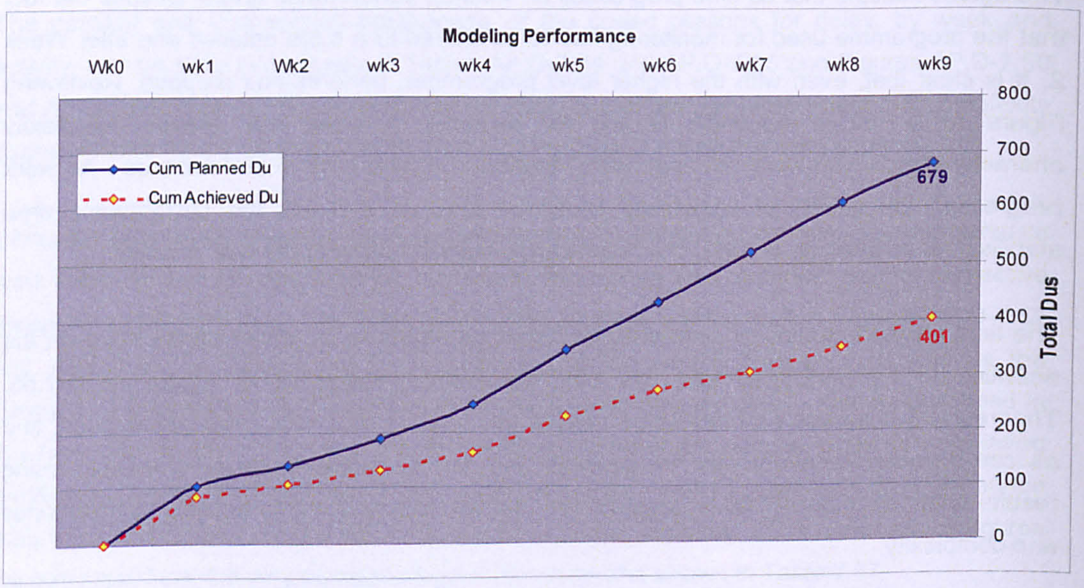



Figure 7.57 Case study G1.1.4, modelling of performance based on Total Duration achieved against time taken.

### 7.5.4 Case Study 4 – G2.1

The information presented was provided by the PM and the Senior Planner during the site visits and the weekly progress reporting was conducted by telephone. Electronic copies of the progress templates were forwarded weekly and explanations of the reasons for delay and progress were sought as necessary.

Table 7.88a Case study G2.1 brief project details

| | |
|---|---|
| **Project Title:** Building | |
| **Brief Description:** Construction of 28 fully fitted luxury flats | |
| **Initial Duration:** 95 wks from tender | **Estimated Final Duration:** 113 weeks |
| **Initial Cost Estimate:** £19.2 M | |
| **Current Anticipated Final Cost:** £23.5 M | |
| **Initial Start Date (Baseline):** end April 2006 | |
| **Planned Completion Date (Baseline):** end Feb 2008 | |
| **Current Start Date:** end April 2006 | |
| **Expected Completion Date:** end June 2008 | |
| **Project Manager Comment on initial conditions:** Negotiated tender, not in competition, on basis that rates from existing contracts in progress in the same location with the employer would form the basis for the project. | |

Table 7.88b Case study G2.1 details

| |
|---|
| **Case Study Start date:** 28-Jan-08 |
| **Case Study Completion date:** 28-Mar-08 |
| **Number of activities monitored:** 81, with durations ranging from 2 days to 15 days |
| **Comment:** The PM had more than 20 years experience and the activities followed during the case study were a mixture of construction and fit-out activities in flats – 1.1, 2.1, 3.1, 4.1, 5.3, 8.2, 9.1 |

The programme provided initially was detailed and extensive. Each one of the 28 flats had on average 40 activities, therefore the PM was requested to select a number of 'flats' which would be monitored over the case study period. In total, 81 activities were monitored and performance was recorded during the case study. On completion of the case study period, the data were entered in a spreadsheet template (see typical sample in Appendix C Table AP.C-3.10) and the performance was calculated as described in the Research Method. The graphical and tabular presentations shown below have been created using this information and a detailed examination of the findings is discussed in the Analysis chapter. The detailed, as well as summarised, breakdown of the coded reasons for delay, by week and activity, can be seen in Appendix D Tables AP.D-7.89 and AP.D-7.90 and Figures AP.D-7.58 and AP.D-7.59. The detail given provides an indication of the combined effect complexity characteristics have had on the performance of the project during the case study period.

Using the cross-correlation between coded reasons for delay and complexity characteristics (see Table AP.D-7.68, Appendix D), the above information was decoded into the respective complexity characteristics, see Table AP.D-7.91, and the corresponding Figures AP.D-7.60 and AP.D-7.61 in Appendix D. The figures depict the weekly frequency as well as the frequency of occurrence of the complexity characteristics causing delay. Also as described in the Research Method, two of the most obvious and simple ways of calculating performance were used (see example in Appendix C-3.7) and thus two sets of performance data, see

Figures 7.62 and AP.D-7.63 (in Appendix D), were prepared. The performance figures are extracted from the very detailed progress template and shown in Table 7.92.

Table 7.92. Case study G2.1 performance data

| | Wk 0 | Wk 1 | Wk 2 | Wk 3 | Wk 4 | Wk 5 | Wk 6 | Wk 7 | Wk 8 | Wk 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Simple % Drop in Performance** (in %) (see Figure 7.62) | 0 | 72 | 62 | 67 | 61 | 65 | 59 | 58 | 58 | 57 |
| **Time Elapsed % Drop Performance** (in %) (see Figure AP.D-7.63) | 0 | 72 | 64 | 87 | 79 | 93 | 78 | 92 | 99 | 99 |

The figures indicate that as time progresses (in weeks), performance drops. For example, in week one, nine complexity characteristics (see Figure AP.D-7.60 in Appendix D), which were not dealt with, have resulted in a 72% drop in performance. From that point onwards and through actions taken by the PM and the team, the drop in performance 'stabilised' at approximately 60%. The results are analysed further in the next chapter.

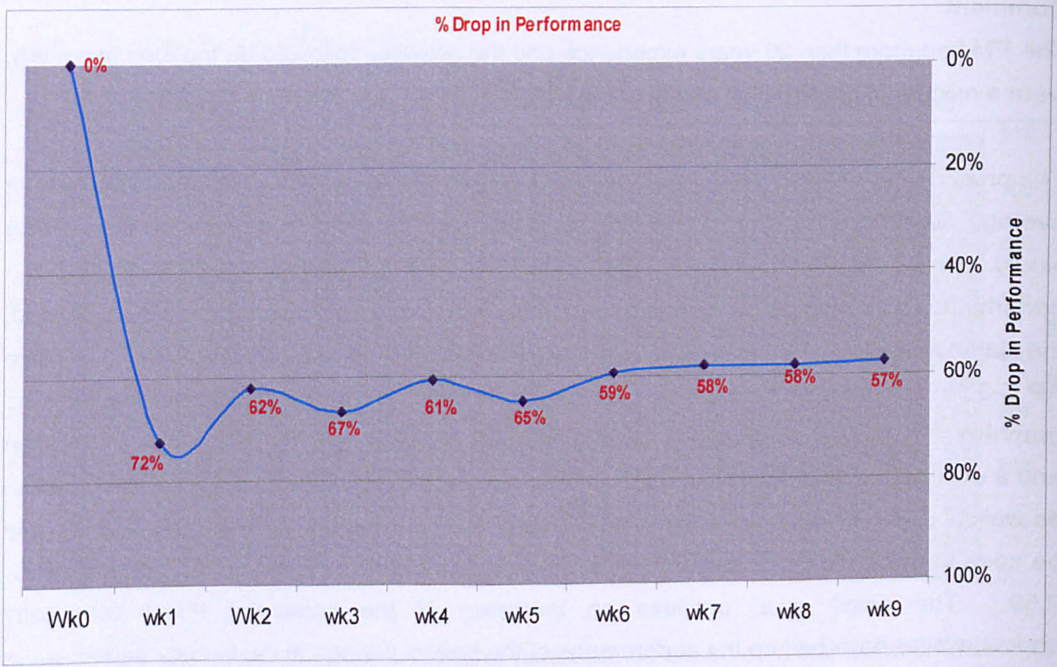



Figure 7.62. Case study G2.1, simple % drop in performance against time

The time elapsed method of evaluating performance amplifies the effect delays have on the activities to be performed and this can be seen in Appendix D Figure AP.D-7.63. Using the results obtained, Figure 7.64 is generated to indicate the relationship between performance and complexity.

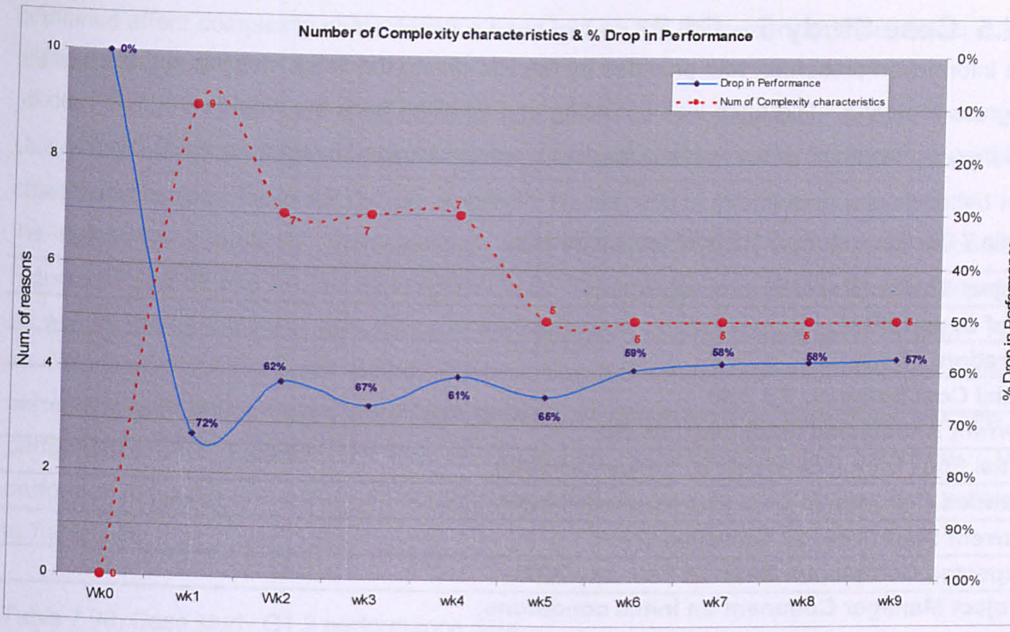



Figure 7.64. Case study G2.1, % drop in performance against number of complexity characteristics that affected performance.

The significance of the drop in performance can be seen in Figure 7.65, which displays 'Cumulative Planned' and the 'Cumulative Achieved' durations for the case study period. As can be seen only 43% of the planned activity time (or 252 days of the 590) was achieved and the PM had to move a number of fit-out tasks to a later stage.

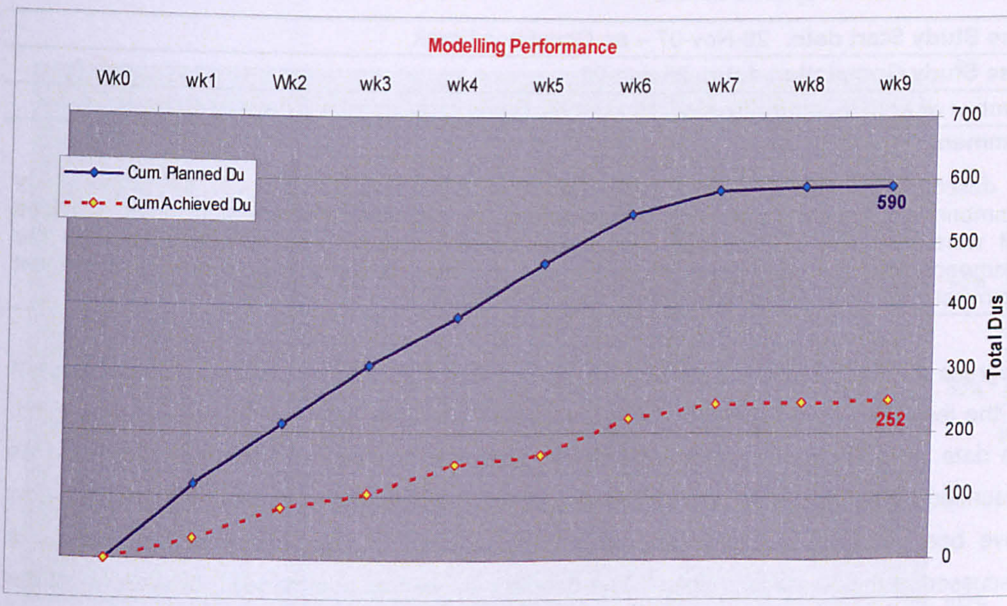



Figure 7.65. Case study G2.1, modelling of performance based on Total Duration achieved against time taken

### 7.5.5 Case Study 5 – G1.2

The information presented was provided by the PM during the initial meeting and the weekly progress reporting. The team was recording and emailing back the weekly progress reports and then explanations of the reasons for delays were discussed by telephone with the PM.

Table 7.93. Case study G1.2 brief project details

| |
|---|
| **Project Title**: Chemical removal plant |
| **Brief Description:** |
| **Duration:** 76 weeks |
| **Initial Cost Estimate:** £5.26M |
| **Current Anticipated Final Cost:** £5.2M |
| **Initial Start Date (Baseline):** 20 September 2006 |
| **Planned Completion Date (Baseline):** 06 March 2008 |
| **Current Start Date:** 20 September 2006 |
| **Expected Completion Date:** 28 February 2008 |
| **Project Manager Comment on initial conditions:**<br>The project scope is to provide a new process stream (nitrate removal) into the existing water treatment plant (max output 23Mld). At the start of this case study (Dec 2008), construction is nearing completion and the project is moving into the commissioning stage. The 'key players' over the next 3 to 4, months in addition to the Client's PM and PMR, will be the Contractor's PM, the main subcontractor's commissioning team and the Client's Commissioning Manager.<br>Commission meetings are held on-site weekly and progress is monitored relative to the overall project programme and the detailed commissioning programme. |

Table 7.94. Case study G1.2 details

| |
|---|
| **Case Study Start date:** 26-Nov-07 – no Christmas break |
| **Case Study Completion date:** 25-Jan-08 |
| **Number of activities monitored:** 10, with durations ranging from 5 days to 45 days. |
| **Comment:**<br>As described by the PM, who had more than 25 years experience, the case study commenced at the early stages of commissioning. In particular, three commissioning activities that were followed by the team had commenced between 3 to 5 weeks prior to the commencement of the case study. Main activities involved pipework testing, wet commissioning, water quality sampling, transfer of flows, etc. |

Progress and identification of reasons for delay were conducted by the PM and the site team on the templates given during the initial meetings. On completion of the case study period, the data were entered in a spreadsheet template and the performance was calculated as described in the Research Method. The graphical and tabular presentations shown below have been created using this information and a detailed examination of the findings is discussed in the Analysis chapter. The detailed, as well as summarised, breakdown of the coded reasons for delay, by week and activity, can be seen in Appendix D Tables AP.D-7.95 and AP.D-7.96 and Figures AP.D-7.66 and AP.D-7.67. Despite the fact that during commissioning there is much less action, the detail given provides an indication of the combined effect complexity characteristics have had on the performance of the project during the case study period.

Using the cross-correlation between the coded reasons for delay and the complexity characteristics (see Table AP.D-7.68, Appendix D), the above information was decoded into the respective complexity characteristics, see Table AP.D-7.97, and the corresponding Figures AP.D-7.68 and AP.D-7.69 in Appendix D. These Figures depict the weekly frequency as well as the frequency of occurrence of the complexity characteristics causing delay. Also as described in the Research Method Chapter, two of the most obvious and simple ways of calculating performance were used (see example in Appendix C-3.7) and thus two sets of performance data, Figures 7.70 and AP.D-7.71 (in Appendix D), were produced. The performance figures are extracted from the very detailed progress template and shown below in Table 7.98.

Table 7.98. Case study G1.2 performance data

| | Wk 1 | Wk 2 | Wk 3 | Wk 4 | Wk 5 | Wk 6 | Wk 7 | Wk 8 | Wk 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Simple % Drop in Performance** (in %) (see Figure 7.70) | 53 | 40 | 27 | 21 | 19 | 19 | 18 | 17 | 17 |
| **Time Elapsed % Drop Performance** (in %) (see Figure AP.D-7.71, Appendix D) | 74 | 37 | 31 | 24 | 40 | 60 | 50 | 50 | 50 |

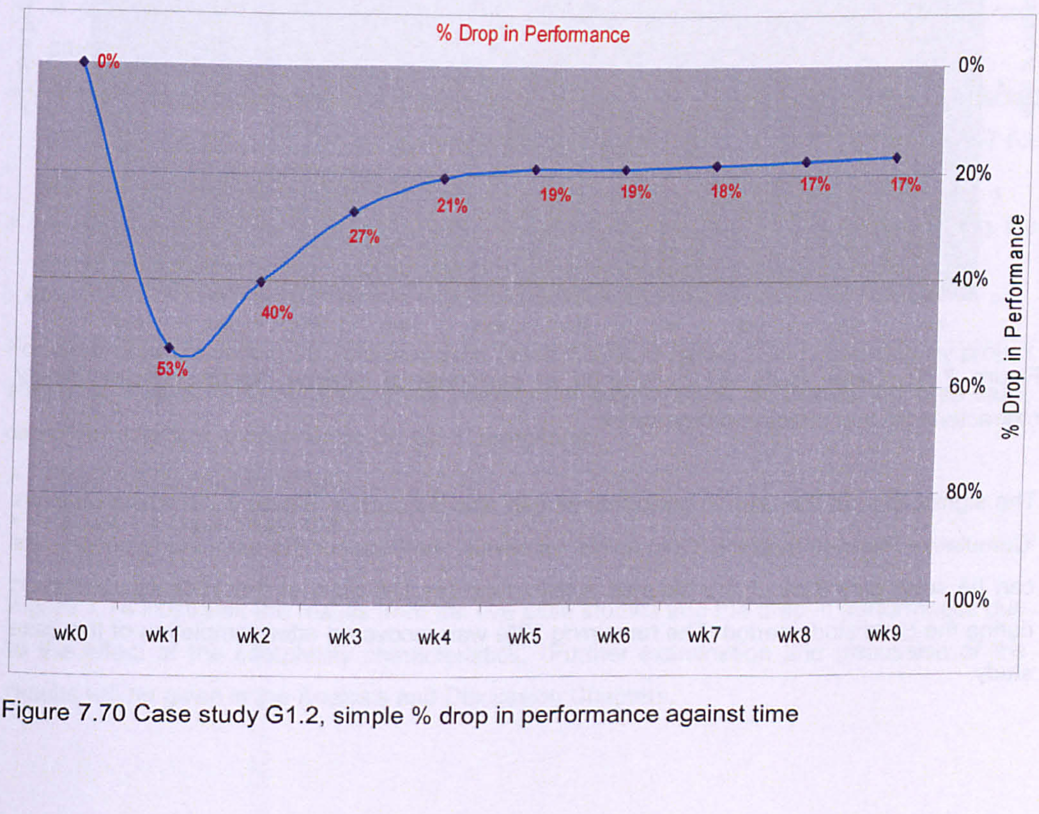



Figure 7.70 Case study G1.2, simple % drop in performance against time

The figures indicate that as time progresses (in weeks), performance drops. In particular it can be seen that the initial stages of commissioning are affected excessively by the effects of complexity. Reviewing Figure AP.D-7.68 (in Appendix D) and for example between weeks one and four, seven complexity characteristics, which were not dealt with, resulted in a 53% to 21% drop in performance. Thereafter and as work progressed, the effects of complexity were reduced and as a result the performance drop stabilised at 18%. The results are analysed further in the next chapter.

The time elapsed method of evaluating performance amplifies the effect delays have on the activities to be performed and this can be seen in Appendix D Figure AP.D-7.71. Theoretically, it is more accurate since it takes into account how much time has elapsed and, as can be seen recovery was not possible, resulting in the subsequent delays. Using the results obtained, Figure 7.72 is generated to indicate the relationship between performance and complexity.

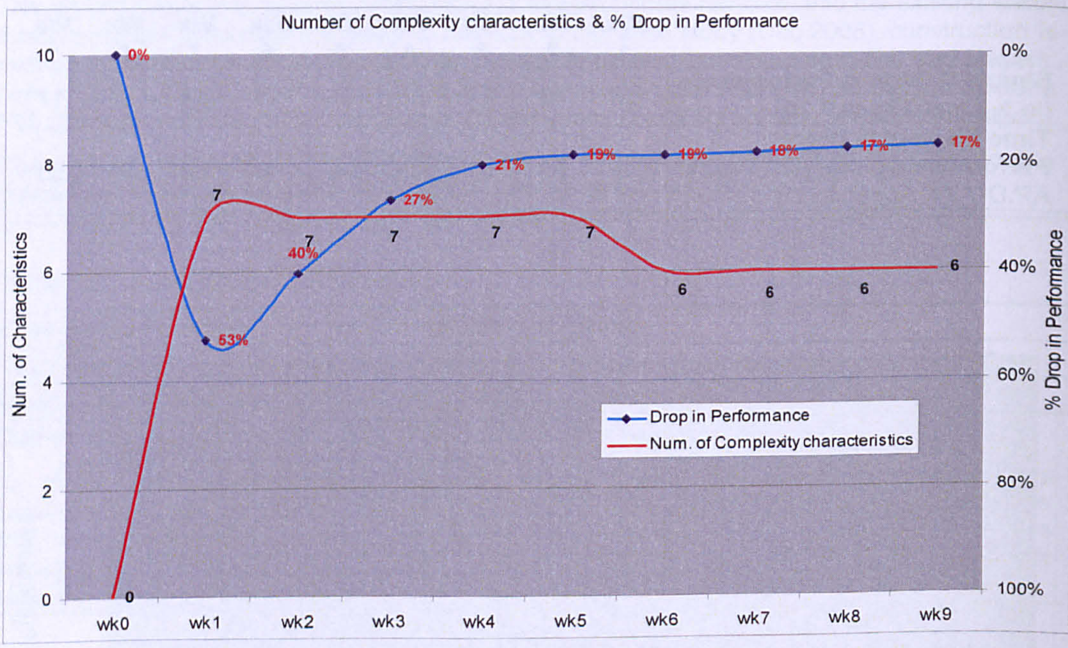



Figure 7.72. Case study G1.2, % drop in performance against number of complexity characteristics that affected performance

The significance of the drop in performance can also be seen in Figure 7.73, which displays 'Cumulative Planned' and the 'Cumulative Achieved' durations for the case study period. As can be seen only 83% of the planned activity time (or 128 days of the 154) was achieved during the case study period. The remaining 17% was recovered after completion of the case study.

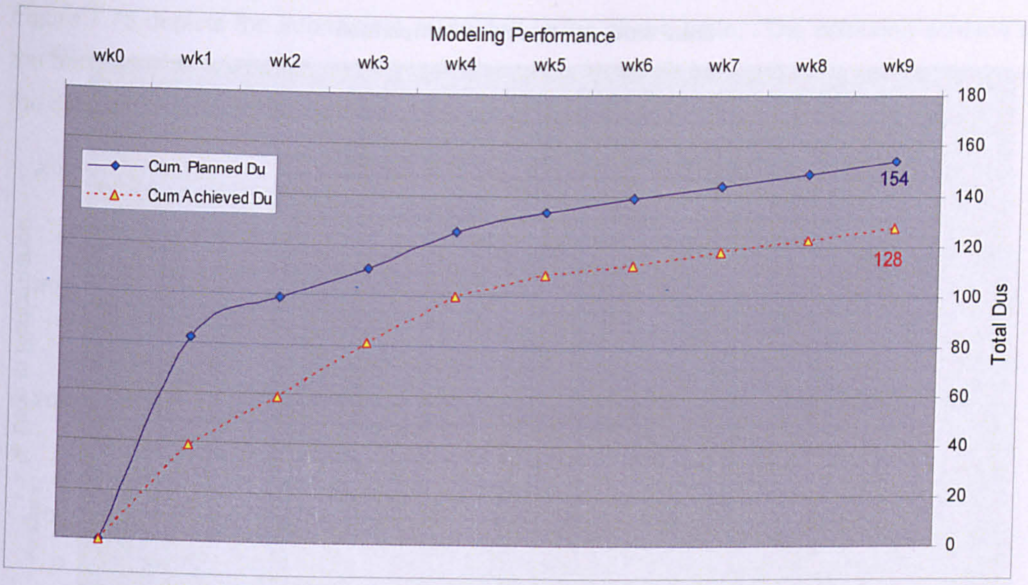



Figure 7.73 Case study G1.2, modelling of performance based on Total Duration achieved against time taken

### 7.5.6 Case Studies – Overall results

With regard to overall results and since the purpose of the case studies is to identify replication (Yin, 2003:32) and to prove or refute Hypothesis H2.4, the results shown previously are brought together and then summarised in the following:

- A graphical representation (Figure 7.74) of the performance curves from the five case studies (using figures, 7.38, 7.46, 7.54, 7.62 and 7.70);
- A table of results (Table 7.99) with all the complexity characteristics which affected performance, from the five case studies (using figures AP.D-7.37, AP.D-7.45, AP.D-7.53, AP.D-7.60 and AP.D-7.69 in Appendix D); and
- A histogram (Figure 7.75) drawn from the information in Table 7.99 and depicting the frequency of the complexity characteristics which affected performance.

For ease of presentation, the information in Table 7.99 and Figure 7.75 is depicted by project stage. In Figure 7.74, the data labels indicate the project stage as well as the case study code. For example, label - 'Cnstr CS G2.1' represents:

- Cnstr = Construction stage;
- CS G2.1 = Case Study G2.1

Figure 7.74 illustrates the results from the five case studies and the drop in performance due to the effect of the complexity characteristics. Further examination and discussion of the results will be given in the Analysis and Discussion Chapters.

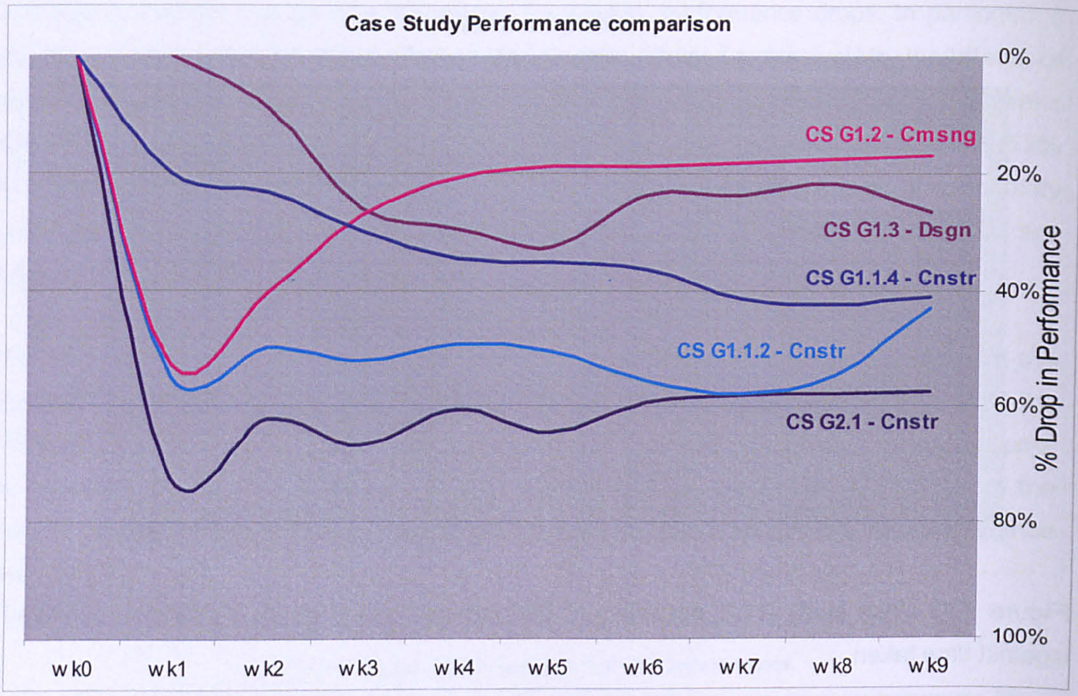



Figure 7.74. Case studies summary; drop in performance due to the effects of complexity

Table 7.99. Frequency of occurrence of complexity characteristics which affected performance per case study and project stage

| | | Construction | | | Design | Commissioning |
|---|---|---|---|---|---|---|
| | | Case Study 1.1.2 | Case Study 1.1.4 | Case Study 2.1 | Case Study 1.3 | Case Study 1.2 |
| Unpredictability | B1 | 9 | 9 | 9 | | |
| Non-standard | B2 | | | | | |
| Undefined values | B3 | | | | 8 | |
| Autonomous agents | C1 | 9 | 6 | 4 | | 9 |
| Instability | C2 | 5 | 9 | 3 | 8 | |
| Non-equilibrium | C3 | 9 | 13 | 9 | 7 | 9 |
| Non-linear | C4 | 8 | 6 | | 8 | |
| Attractors | C5 | | | | | 9 |
| Co-evolution | D1 | 16 | 12 | 5 | 12 | 14 |
| Self-modification | D2 | | 6 | | | 18 |
| Self-reproduction | D3 | | | | | |
| Downward causation | D4 | 17 | 6 | 6 | 4 | |
| Mutability | D5 | 17 | 16 | 18 | | |
| Non-uniform | D6 | | | | | |
| Emergence | D7 | | 4 | | 7 | |
| Phase changes | D8 | 9 | 5 | 1 | | |

Figure 7.75 depicts the information presented in the above table. The colouring scheme of the bars also follows the project stage of the case study with blue indicating construction and the different shades of purple the other two.

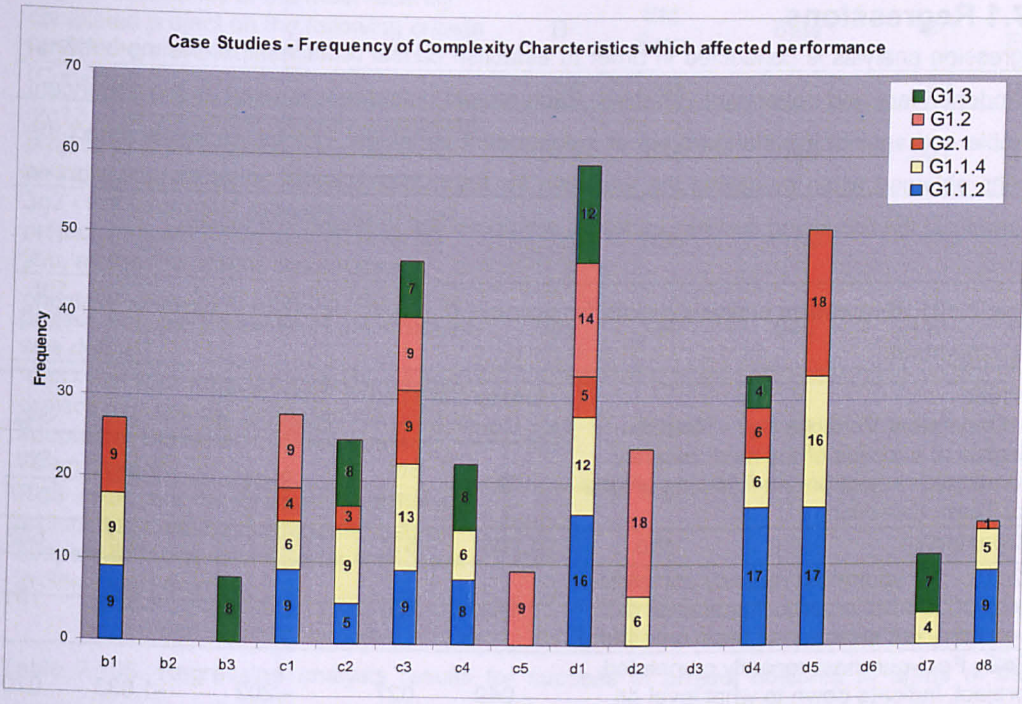



Figure 7.75. Frequency of Complexity characteristics which affected project performance

## 7.6 Effect of Moderating Variables

As discussed in the Research Method Chapter, in testing Hypothesis 1 through the postal questionnaires, a number of moderating variables are considered in order to understand if these influence the three sub-processes under investigation.

Each of the main parts in the postal questionnaire requested respondents to consider the effect these variables might have against the corresponding sub-process. A five-level Likert scale was used, from 'Very Little' to 'Critical', with the appropriate description of the scale. The results in terms of frequency of responses overall, as well as by strata, are shown in Table AP.D-7.100 in Appendix D.

Using the results from Table AP.D-7.100 (in Appendix D), a set of graphs has been created by sub-process and these are also shown in Appendix D (see Figures AP.D-7.76, AP.D-7.77 and AP.D-7.78). Also, more detailed graphs, which include the breakdown by strata, are presented in Appendix D (see Figures AP.D-7.79.1 to AP.D-7.79.15). The graphs indicate clearly that the moderating variables are not considered to be critical or very important to any of the sub-processes investigated. The few exceptions are discussed in detail in the analysis of results chapter, together with comments / comparisons between the responses given by the Client and Contractor strata.

## 7.7 *Other statistical results*

Using SPSS a set of statistical analysis results are generated and presented below and in Appendix D.

### 7.7.1 Regressions

Regression analysis is conducted in order to establish causal relationships existing between the independent and dependent variables. Each project outcome was used as the dependent variable and against it a standard set of independent variables. The tables below depict the results obtained when modelling the variables for the sub-processes under investigation. In Appendix D the remaining success variables are presented in respective tables.

Table 7.101. Regression analysis results for success of project outcome in terms of selecting team members.

| Model<br>a Dependent Variable: 5q2 - Rate the degree of success of the most recently completed project on the following criteria for Team Selection. | Unstandardized Coefficients | | Stand/ized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | B | Std. Error |
| (Constant) | .205 | .371 | | .553 | .582 |
| 2q13 - For your most recently completed project, to what organisational level did you carry out selection of team members? | .114 | .087 | .147 | 1.320 | .191 |
| 3q2 - For your most recently completed project, indicate down to what level do you, as the PM, define the structure. | -.049 | .027 | -.202 | -1.833 | .070 |
| 3q7 - For your most recently completed project, indicate lowest level the structure was defined. | .015 | .151 | .011 | .097 | .923 |
| 4q5 - For your most recently completed project, indicate the management style adopted at the levels of Discipline and Team Leader. | .005 | .029 | .022 | .179 | .858 |
| 4q5 - For your most recently completed project, indicate the management style adopted at the levels of Supervisor down to Site Team member. | .037 | .036 | .128 | 1.032 | .305 |

Table 7.102. Regression analysis results for success of project outcome in terms of structuring the project team.

| Model<br>a Dependent Variable: 5q2 - Rate the degree of success of the most recently completed project on the following criteria for Structure of the Team. | Unstandardized Coefficients | | Stand/ized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | B | Std. Error |
| (Constant) | .150 | .368 | | .409 | .684 |
| 2q13 - For your most recently completed project, to what organisational level did you carry out selection of team members? | .043 | .086 | .056 | .501 | .617 |
| 3q2 - For your most recently completed project, indicate down to what level do you, as the PM, define the structure. | -.039 | .026 | -.162 | -1.476 | .144 |
| 3q7 - For your most recently completed project, indicate lowest level the structure was defined. | .061 | .150 | .046 | .410 | .683 |
| 4q5 - For your most recently completed project, indicate the management style adopted at the levels of Discipline and Team Leader. | .042 | .029 | .182 | 1.481 | .143 |
| 4q5 - For your most recently completed project, indicate the management style adopted at the levels of Supervisor down to Site Team member. | .021 | .036 | .072 | .580 | .564 |

Table 7.103. Regression analysis results for success of project outcome in terms of the management style followed.

| Model<br>a Dependent Variable: 5q2 - Rate the degree of success of the most recently completed project on the following criteria for Management style. | Unstandardized Coefficients | | Stand/ized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | B | Std. Error |
| (Constant) | .239 | .361 | | .661 | .510 |
| 2q13 - For your most recently completed project, to what organisational level did you carry out selection of team members? | .124 | .084 | .164 | 1.469 | .146 |
| 3q2 – For your most recently completed project, indicate down to what level do you, as the PM, define the structure. | -.038 | .026 | -.161 | -1.461 | .148 |
| 3q7 - For your most recently completed project, indicate lowest level the structure was defined. | .128 | .147 | .097 | .868 | .388 |
| 4q5 - For your most recently completed project, indicate the management style adopted at the levels of Discipline and Team Leader. | -.001 | .028 | -.004 | -.034 | .973 |
| 4q5 - For your most recently completed project, indicate the management style adopted at the levels of Supervisor down to Site Team member. | -.026 | .035 | -.092 | -.745 | .459 |

Tables AP.D-7.104 to 107 are shown in Appendix D and depict the regression analysis results for the remaining four project outcome dependent variables

## 7.7.2 Factor Analysis

Factor analysis is conducted between the questions used to test the correlation between the project management sub-processes of selecting team members and structuring the project team as well as the management style adopted and the level of the project outcome (i.e. successful and acceptable levels). The results are shown below in Tables 7.108.1, 7.108.2 and 7.108.3.

Tables 7.108.1. Factor Analysis of Coefficients of Successful and Acceptable Project Management Outcome in Selecting team members against the sub-process under investigation.

| Table 7.108.1 **Selecting team members** | Cases for which Selecting team members has **Successful** Project Outcome | | | | Cases for which Selecting team members has **Acceptable** Project Outcome | | |
|---|---|---|---|---|---|---|---|
| | Rotated Component | | | | Rotated Component | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| 2q5 - Personal profiling considered as part of the selection process when appointing Project Managers. | .049 | -.021 | .968 | -.023 | .195 | -.689 | .039 |
| 2q4 - Personal profiling has been carried out for project team members. | .060 | .078 | .000 | .921 | .075 | -.066 | .977 |
| 2q13 - For your most recently completed project, to what organisational level did you carry out selection of team members? | -.164 | -.866 | .014 | .084 | .174 | .748 | .043 |
| 3q7 - For your most recently completed project, indicate lowest level the structure was defined. | -.107 | .811 | -.011 | .155 | .336 | .583 | -.093 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Discipline Leader level. | .756 | -.005 | -.482 | -.263 | .744 | .191 | .218 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Team Leader level. | .838 | .216 | -.103 | .048 | .863 | .080 | -.075 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Supervisor level. | .828 | -.105 | .210 | .351 | .918 | -.071 | -.096 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Design Team Member level. | .811 | .087 | .101 | -.266 | .866 | .176 | .091 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Site Team Member level. | .880 | -.116 | .023 | .199 | .857 | .038 | .112 |

Table 7.108.1 indicates that for a successful and for an acceptable level of project management outcome for the sub-process of selecting team members there is high correlation (see highlighted cells) at the first component with the management style adopted at all project team levels. There is also a high correlation for the second and third components for conducting personal profiling at PM level, as well as project team members and also structuring project teams to the lowest levels.

Tables 7.108.2. Factor Analysis of Coefficients of Successful and Acceptable Project Management Outcome in Structuring of project teams against the sub-process under investigation.

| Table 7.108.2 **Structure of Team** | Cases for which Structure of Team has **Successful** Project Outcome | | | Cases for which Structure of Team has **Acceptable** Project Outcome | |
|---|---|---|---|---|---|
| | Rotated Component | | | Rotated Component | |
| | 1 | 2 | 3 | 1 | 2 |
| 2q5 - Personal profiling considered as part of the selection process when appointing Project Managers. | -.004 | -.095 | -.622 | .143 | .808 |
| 2q4 - Personal profiling has been carried out for project team members. | .244 | -.240 | .684 | .098 | .629 |
| 2q13 - For your most recently completed project, to what organisational level did you carry out selection of team members? | -.089 | -.781 | -.045 | .341 | -.464 |
| 3q7 - For your most recently completed project, indicate lowest level the structure was defined. | -.138 | .465 | .563 | .329 | -.249 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Discipline Leader level. | .599 | .520 | .160 | .781 | -.285 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Team Leader level. | .793 | .373 | .025 | .834 | -.017 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Supervisor level. | .910 | -.097 | .063 | .897 | .188 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Design Team Member level. | .608 | .608 | -.215 | .886 | .046 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Site Team Member level. | .904 | .036 | .084 | .870 | .152 |

Table 7.108.2 indicates that for a successful and for an acceptable level of project management outcome of the sub-process of structuring team members there is high

correlation (see highlighted cells) at the first component with the management style adopted at all project team levels. However there is mediocre correlation at the second and third components for conducting personal profiling at PM level, as well as project team members and also structuring project teams to the lowest levels.

Tables 7.108.3. Factor Analysis of Coefficients of Successful and Acceptable Project Management Outcome from the Management style adopted against the sub-process under investigation.

| Table 7.108.3 **Management of Team – Style adopted** | Cases for which Management style enables **Successful** Project Outcome | | | Cases for which Management style enables **Acceptable** Project Outcome | | |
|---|---|---|---|---|---|---|
| | Rotated Component | | | Rotated Component | | |
| | 1 | 2 | 3 | 1 | 2 | 3 |
| 2q5 - Personal profiling considered as part of the selection process when appointing Project Managers. | -.088 | .007 | .940 | .287 | -.666 | .334 |
| 2q4 - Personal profiling has been carried out for project team members. | .256 | -.117 | .231 | -.064 | -.049 | .882 |
| 2q13 - For your most recently completed project, to what organisational level did you carry out selection of team members? | -.193 | -.855 | -.006 | .242 | .793 | .086 |
| 3q7 - For your most recently completed project, indicate lowest level the structure was defined. | -.105 | .833 | -.078 | .277 | .543 | .443 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Discipline Leader level. | .772 | .255 | -.184 | .714 | .513 | -.163 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Team Leader level. | .809 | .214 | .025 | .855 | .203 | .051 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Supervisor level. | .816 | -.088 | .306 | .931 | -.010 | .065 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Design Team Member level. | .841 | .000 | -.107 | .848 | .007 | -.048 |
| 4q4 - For your most recently completed project, indicate the management style adopted at the Site Team Member level. | .835 | -.119 | .062 | .895 | .087 | .152 |

Table 7.108.3 indicates that for a successful and for an acceptable level of project management outcome for the management style adopted, there is high correlation (see highlighted cells) at the first component with the management style adopted at all project

team levels. There is also high correlation at the second and third components for conducting personal profiling at PM level, as well as project team members and also structuring project teams to the lowest levels.

Further analysis and discussion of the above results will be conducted at the respective chapters. Also correlations between the other project management sub-process and the success of the project outcome can be seen in Appendix D Tables AP.D-7.108.4 to AP.D-7.108.7.

## 7.8 Summary

In this chapter, results were presented from the implementation of the research multi-methodology, which lasted over a period of 10 months and encompassed 91 postal questionnaires, 31 interviews and five case studies covering all three stages of the project life-cycle.

For the postal questionnaires, the responses obtained, through stratified sampling, covered respectively 32% and 8% of the client and contractor PM practitioner population of the two strata. Due to lack of data regarding PM population in UK and making conservative estimations, with confidence level of 95% and confidence interval of 10%, it was proved that the sample (91 responses) reflects a general population size between 7,500 to 150,000 construction PMs. Therefore the sample taken is considered to be representative of the general construction PM practitioner population.

For a construction environment that remains complex and dynamic but is becoming friendlier, results indicate that techniques for selecting team members and structuring the project teams are not followed and no consideration is given to the management style to be adopted. However, there was some indication that structuring of project teams is performed to the lowest level – team members. In terms of the project management outcome, and with the current level of implementation of processes, the majority of PM practitioners indicated that the outcome achieved is only at an acceptable rather than successful level. Indeed, in the case of structuring the project organisation and with the current level of implementation, the process is considered as contributing very little to the project management outcome.

Interviewees indicated clearly that the effects of complexity are not considered when selecting project team members, structuring the team or when deciding on the management style to be followed. In particular with regard to the complexity characteristics, actions taken do not achieve the required level to manage the effects on the three sub-processes under investigation. The actions required to enable the management of the effects of complexity of interconnections characteristics onto the three sub-processes investigated were discussed and agreed by the practitioners interviewed. Thus, a realistic set of activities, acceptable to practitioners, was established.

The effect of the complexity of interconnections on the project performance was investigated by the five case studies. The results indicate that the effects on performance considerably influence the outcome with an average drop of 40%. The drop occurs at all three stages of the project lifecycle albeit with different levels, those in construction incurring a higher decline.

Detailed analysis of the results obtained will be presented in the following chapter.

# Chapter 8 – Analysis and Validation of results

## 8.1 Introduction

The results obtained and described in the previous chapter are analysed in response to the research objectives. As in the previous chapter, the approach in the analysis of results reflects the multi-methodology research design.

Firstly, the analysis of results from the 91 postal questionnaires is conducted, which examined the current status of the sub-processes investigated. However, the analysis of the quantitative data is preceded by the generalisation of the research findings and a review of the demographics of the sample.

Next, the results from the interviews are analysed and this section is divided into two parts: the analysis of the responses to questions on general complexity and those relevant to this research and the complexity of interconnections and its characteristics. Following on, analysis of the results from the case studies and the causes of delay that produce a drop in performance are elaborated upon.

Results obtained from the three stage multi-methodology are analysed and used to present the testing of the research hypotheses and the effect of moderating variables. Next statistical correlation results are evaluated for their contribution to this research. The chapter will close with the first stage of the validation process and the analysis of the results obtained.

## 8.2 Analysis of Postal Questionnaire results

The purpose of the postal questionnaires was to establish the current approach and depth, in terms of organisational level, of implementing techniques for selecting team members, structuring the team and defining the management style to be followed. The level of contribution of the three sub-processes to the successful project management outcome was also to be investigated.

Questionnaire data, recorded in SPSS v.15, were analysed using descriptive as well as inferential statistical methods (Naoum, 1998). The former is conducted through frequency distribution and the latter through statistical significance tests, mainly the chi square test which will also test the difference between the Client and Contractor strata. Regression and factor analysis are also conducted for some results.

Prior to the analysis of the postal questionnaire data, the case of the sample size and the generalisation of findings are examined from the results presented in Section 7.2 (Chapter 7). Logical inferences are made whenever the nature of the responses allows. The theoretical implications of the results are considered further in the Discussion Chapter.

### 8.2.1 Generalisation of Results

In order to establish a wider generalisation of the findings, a number of tables were generated and presented in Section 7.2.2 (Chapter 7). The analysis of these results will ascertain that the statistical inferences made from the postal questionnaire can be considered as a general view of the practising PMs in GB.

In terms of the response from the stratified sample, the high percentage achieved (50.5%) demonstrates how successful this sampling method can be. However, the success was also attributed to the *continuous monitoring* and *weekly reporting* of the responses back to the Senior Managers / 'champions' from each organisation. Also from the individual feedback received by a number of respondents, the paradigm of running the survey as 'charity project' was considered beneficial to the whole process. Of the 91 valid responses received, 57% were from the Client stratum and 43% from the Contractor stratum, providing a well balanced view.

The sizeable total output of the London and South East regions at 30% (see Table AP.D-7.3 in Appendix D) provides the reassurance that the regions considered reflect a considerable part of the construction industry in GB. Coupled with the fact that the strata sampled are easily within the top five of their sector, this further strengthens the validity of the outcome. In terms of employment figures (see Table AP.D-7.4, Appendix D), those for the two regions, at an overall figure of 12%, are the highest in GB.

In order to compare the contractor sample size, the figures from the Construction Statistics Annual Report 2007 were used as a basis for generating the estimated population of PMs in GB. Considering the information generated in Tables 7.9 and 7.13 (in Chapter 7) for PMs and for 'Total employment for firms with over 300 staff in GB' and 'Contractors' staff less operatives in sampled areas', the contractors' response was between 0.3% and 0.5% respectively. The overall size of the sample / response (see Table 7.13 in Chapter 7) for the same categories was 0.69% and 1.21% respectively.

All the above figures provide considerable confidence for generalising the results from the postal questionnaires. This was confirmed by carrying out general statistical calculations which indicated that a sample size of 91, with confidence level 95% and confidence interval 10%, can represent a population size of 7,500 to 150,000, which exceeds the estimated population of PMs in GB.

### 8.2.2 Part 1 – Demographics

The analysis of the postal questionnaire demographics emphasises the significance of the results obtained. The majority of respondents (84%) were at the level of PM and Senior PM, with six respondents being Project Directors (PDs). It should be noted that the PDs were not the Senior Company Directors to whom progress was reported weekly. In addition 61% of the respondents have over 15 years experience and 66 respondents or (72%) have more than 10 years experience, thus again confirming that the responses will be reflecting practices built through many years in the industry. Finally, it is interesting to note that the vast majority of the respondents (86%) have no professional qualifications in project management, however, 53% have 'chartered' status indicating that project management is still considered an occupation (Gorog, 2006; Turner, 2005).

### 8.2.3 Part 2 – Selection of Project Team Members

The three, largely soft, issues under investigation are influenced by a number of factors most of which have been incorporated as moderating factors. Regarding the selection sub-process all factors concerning the individuals were included under the overarching factor of 'personal development plan'. These represent the individuals' level of education, skills, attitude and behaviour (Crawford, 2003, 2005). However, one of the most influential factors is the project environment (Hughes, 1989; Newcombe et al., 1990; Lansley, 1994; Shirazi, et al., 1996). For this reason, the order of the questions was considered carefully and question 6 – description of the project environment - was intentionally placed in that particular part of the questionnaire (Hague, 1993) and requested respondents to consider their most recently completed project and indicate the prevailing conditions. The responses provided an interesting feedback that actually represents the prevailing conditions and drive in construction for the last decade and perhaps even since the Latham report (Latham, 1994; Egan, 1998). That is, an environment which is becoming more 'friendly', but which has neither lost its dynamism nor its complexity. Table 8.1, below and Figure 7.3 (in Chapter 7) depict these conditions and 49% of the respondents confirmed that the prevailing conditions are 'more to mostly' friendly, whereas 50% and 64% indicated that the conditions are 'more to mostly' complex and dynamic, respectively. Thus, the modern procurement methods enable a friendlier environment, despite projects remaining complex and dynamic.

Table 8.1. Respondents' characterisation of Project Environment in percentage.

| | Static to Dynamic Valid % | Simple to Complex Valid % | Friendly to Hostile Valid % |
|---|---|---|---|
| Mostly Static, Simple & Friendly | 4 | 0 | 7 |
| More Static, Simple, Friendly | 17 | 17 | **42** |
| Half way | 14 | 33 | 34 |
| More Dynamic, Complex, Hostile | **50** | **36** | 14 |
| Mostly Dynamic, Complex & Hostile | **14** | **14** | 2 |

The significance of these responses, in terms of the consequences to the selection of team members, the structuring of the team and the management style (as part of the management activities) will be discussed in detail in the following chapter.

For a number of questions in this part, respondents were requested to indicate, in an 'escalating' approach, if they were given guidance on team selection techniques and whether they were aware that personal profiling, as one of the techniques, was used for any level of project team members. The results from questions '2q1', '2q2' and '2q4' (see Tables 7.17 in Chapter 7 and AP.D-7.18 to AP.D-7.20 in Appendix D) indicate that, whereas 68% are given guidance and 71% are aware of the technique, 73% confirmed that profiling is not performed for any level of project team members. In particular, in one of the participating Client organisations the internal project management processes – Organisation & Resources – indicates that Belbin or Myers Briggs should be used when selecting the project team. Overall, and for both contractor and client strata, there was a significant difference between the positive and negative responses, however, in the case of client organisations and for carrying out personal profiling, the variance was in excess of 67% (see Table AP.D-7.20, Appendix D).

In terms of using personal profiling as a selection technique (Belbin, 2000), with Belbin and Myers Briggs being the most renowned (see Table 8.2 below), the overall response clearly indicates (see Tables 7.21, in Chapter 7 and AP.D-7.22 to AP.D-7.24 in Appendix D) that it is not used for selecting PMs or any other team members.

Table 8.2. Responses regarding Personal profiling techniques.

| 2Q3: Please complete the table below, regarding personal profiling techniques | a) Tick those techniques you have heard of | b) Are any of these being used in your company? | c) Which one(s) have you used? |
|---|---|---|---|
| Belbin only | 9.9% | 8.8% | 10.0% |
| Myers Briggs only | 2.2% | 3.3% | 4.4% |
| Belbin & Myers Briggs | **47.3%** | 15.4% | 26.7% |
| Margerison & 16PF | 13.2% | 4.4% | 2.2% |
| None / No | 27.5% | **68.1%** | **56.7%** |

In particular, 71% of respondents (see Table 7.21 – Chapter 7) indicated that no techniques are considered at the lowest project organisational levels. It is interesting to note, from the detailed tables in Appendix D, the high percentage of 'Don't Know', especially when considering that for question 2q4 - Table AP.D-7.20 (Appendix D) - 40% of the Contractor PMs responded positively to personal profiling being performed at the various project levels. When comparing responses in Tables 7.17 (in Chapter 7) and AP.D-7.22 in Appendix D, the negative responses are consistent. As far as the particular techniques used to select team members, 78% of respondents indicated that no techniques are used (see Table AP.D-7.24 in Appendix D).

As shown in Tables 7.27 (in Chapter 7), AP.D-7.28 and AP.D-7.29 (in Appendix D), 52% of respondents indicated that, for their most recently completed project, they selected project team members down to the level of Discipline and Team Leader level. However, 76% indicated that no personal profiling was performed in their 'most recently completed project'.

Similar responses were also given with regard to sub-contractors and their selection techniques (see Tables AP.D-7.30, AP.D-7.31 and AP.D-7.32 in Appendix D).

Regarding selection criteria used for PMs, Tables AP.D-7.25 and AP.D-7.26 in Appendix D indicate, in a descending order of percentage, that Capability, Management skills, Leadership skills, and Availability were considered 'very important', whereas Personal Development and Personal Profiling were ignored. For all the other project team members, respondents indicated that the 'very important' criteria for selection were, in a descending order of percentage, Capability and Technical skills, and again Personal Development and Personal Profiling are ignored. Thus, despite the acceptance that the project environment is more complex and dynamic, no formal techniques are used to support the selection of PMs and team members. Practitioners are aware and are given guidance in selection techniques; however, subjective selection criteria are used and even these only down to the Team Leader level.

### 8.2.4 Part 3 – Structuring of Project Teams

In order to establish the degree of consideration given to the structuring of project teams, and the depth in terms of organisational level, a set of nine questions, the majority attitudinal (Hague, 1993), were formulated from general to more specific issues. The overall valid percent, shown in Table 7.33 (in Chapter 7), indicates that the PM is generally the person that defines the project structure. In terms of defining the overall structure (see Tables AP.D-7.34 to AP.D-7.36 in Appendix D), the Client respondents indicated, by 65%, that this is performed by the PM, as would be expected, whereas the Contractor respondents indicated, by 64%, that this is performed by the Project Director. This is to be anticipated, as the Client Project Directors have a more overall role and are responsible for a number of projects. For the lower levels, i.e. Design and Site Teams, responses from both strata concur that this is performed by the PM. It is worth noting that the overall level of 'Don't Knows' is between 14% and 16%, which for the level of the sample, in terms of experience and seniority, is unexpected.

Results from questions 2 and 7, shown in Tables 7.37 and 7.38 (in Chapter 7), also concur with what has been described above. The Client PMs define the structure down to Team Leaders (48%) and the Contractor PMs down to Site Team members (36%). It should be noted that 43% of the respondents indicated that the lowest level they structured their most recently completed project down to was Site Team member level and 26% down to Design Team member level.

Respondents were also asked to identify the type of organisational structure followed at different levels, see Table 7.39 in Chapter 7. The results indicate two prevailing types, that of the matrix and the functional approach. In particular Discipline leaders and Design teams tend to operate within a matrix structure, whereas Construction and Support teams operate within a functional structure. It is also interesting to note that for some of the respondents, construction teams operate within team structures.

As noted earlier, in excess of 10% of the respondents (see Table 7.37 and 7.39 in Chapter 7) indicated that they do not structure their project teams or do not know the type of structure implemented. Considering that the environment is viewed as more complex and dynamic, this percentage should be construed as unacceptable.

### 8.2.5 Part 4 – Management Style

In part 4, the respondents were requested to indicate the Management Style followed, this being one of main activities in the management of teams in projects overall and at the various levels. The management style metaphors used were those identified by Lansley (1994) and Turner (1999) and brief descriptions were given with the questions.

Question 1 aimed to establish the level of conscious decision made in terms of defining a management style to be followed. The results in Table 7.40 in Chapter 7 indicate, with a response in excess of 70% from both Client and Contractor PMs that no formal decision is made about the management style to be followed. Thus, despite the fact that the environment is acknowledged as being more dynamic and complex, no effort is put into deciding on the style needed for the management of the project.

In terms of the management style, see Tables 7.41 in Chapter 7 and AP.D-7.41.1, 7.41.2 in Appendix D, responses, although not statistically significant, indicated that in their most recently completed projects the style followed was situational (18%) and egalitarian (15%), for Client and Contractor PMs respectively. A significant proportion of respondents, 36%, indicated that they used two management styles. For the Client PMs, the majority indicated a combination of egalitarian and situational styles, whereas the Contractor PMs indicated a combination of situational and 'manage themselves' styles of management. The responses that included more than two styles, 24%, are not included in this analysis.

Analysing the more detailed responses for the management style at different project organisation levels, see Tables 7.42.1, 7.42.2, 7.42. 3 in Chapter 7 and AP.D-7.42.4.1 to 5 in Appendix D, the egalitarian style is followed almost throughout, again though with no statistical significance. Two exceptions occurred at the levels of Supervisor and Site Team members. For the former, Contractor PMs indicated that Supervisors 'manage themselves'. For the latter, Client PMs indicated that the prevailing style is that of 'standard processes' whereas Contractor PMs indicated that the style is that of 'control' system.

In addition to the management style followed, in order to compare and discuss, it was important to identify what the prevailing culture at each project organisation level is. The two strata concur (see Tables AP.D-7.43.1 to 5 in Appendix D) that the prevailing culture throughout the organisational levels is that of people being in structured places. Therefore, from this part of the questionnaire, responses indicate that the complex and dynamic conditions are faced by fitting people in structured places but following, in a non-statistically significant majority, an egalitarian or situational management style.

### 8.2.6 Part 5 – Project Management Outcome

The last part of the postal questionnaire examined the contribution of the three project management sub-processes to the project management outcome. This was conducted by bringing together the interconnecting questions, as well as requesting respondents firstly to rank the sub-processes and then to indicate the contribution of each one towards the project outcome.

In analysing the results shown in Tables 7.44, 7.45 in Chapter 7 and AP.D-7.44.1.to AP.D-7.44.7 in Appendix D, respondents, using a 10-level Likert scale, indicated that in terms of the sub-processes under investigation, overall the 'management style' was ranked top with 'selection of team members' third and 'structuring of project team' fifth, lagging behind 'monitoring and control' (2$^{nd}$) and 'conflict management' (4$^{th}$). The overall results indicate that PM practitioners demonstrate a clear appreciation of the contribution of soft issues ('management style' and 'selection of team members') without, however, losing track of 'monitoring and control'. The low ranking of 'structuring the project team' and its contribution towards the project outcome indicates that PM practitioners do not believe that setting up the project organisation structure contributes toward project success.

In terms of response per strata, results indicate that Client PM practitioners ranked 'monitoring and control' first with 'management style' and 'selection of team members' second and third respectively and 'Structuring the team' was 5$^{th}$, falling behind 'conflict resolution'. The Contractor PM practitioners ranked 'management style' and 'selection of team members' 1$^{st}$ and 2$^{nd}$, with 'structuring the project team' 4$^{th}$. The results by strata indicate clearly that Contractor PMs are more considerate of the project soft issues and their contribution towards the outcome. Perhaps surprisingly, Client PMs were found to give more emphasis to monitoring and control, suggesting a different dimension to the point made above regarding the friendlier environment with less confrontational procurement methods. Therefore it can be said that some dispensation is made for the softer management style followed by giving more emphasis on monitoring and control. Contractor PMs also ranked 'monitoring and control' third. Thus, both strata indicated that the machine metaphor and the control paradigm are still adhered to.

'Conflict resolution' was also ranked highly by both strata and that is despite the fact that new, less confrontational, procurement methods are generally implemented in a friendlier environment.

The intention of question 2 in part 5 was to bring together all the interconnecting questions, from each of the other questionnaire parts and to review the success of the corresponding project management sub-process, see Tables 7.46 in Chapter 7 and AP.D-7.46.1, 7.46.2 and 7.46.3 in Appendix D. For the 'Selection of Team Members' sub-process, the majority of respondents indicated, interestingly, that an acceptable result (56%) is achieved despite having revealed in earlier questions that no selection techniques are used. Furthermore, 42% of respondents indicated that a successful outcome is achieved although no selection techniques are used. Similarly, 57% and 41%, for acceptable and successful results respectively, indicated that project teams are structured to the lowest level, that of Site Team members.

In terms of the style adopted, within the management of team sub-process, 53% of respondents indicated that a successful result was achieved when the egalitarian style was used. The summary results for all sub-processes, shown in Table 7.47 in Chapter 7, indicate that the rate of success with the current processes and level of use is mediocre, with the small exception of management style, which shows a higher percentage of success.

Analysis of responses given to question 3, see Tables 7.48 in Chapter 7 and AP.D-7.49 in Appendix D, indicate for both strata by 62% and 78% respectively, that the contribution of the selection of team members and the management style sub-processes is substantial / excellent. However, for the structuring of the team sub-process, Client PMs indicated, only by 39%, that the contribution of the sub-process is substantial/excellent, whereas the Contractor PMs indicated, only by 59%, that the sub-process contribution was substantial/excellent.

From the remaining four sub-processes, it is important to note that 65% of respondents ranked 'monitoring and control' as having a substantial / excellent contribution to the project management outcome, indeed both strata concurred. 'Reporting' however is providing a very low contribution to the quality of the project management outcome.

## *8.3 Interview results analysis*

The purpose of the interviews was to establish the current thinking of practitioners in terms of general complexity and examine the applicability of the 16 complexity characteristics (Lucas, 2000b) as a tool for managing the effects of the complexity of interconnections in the three project management sub-processes investigated. Additionally the purpose of the interviews, through the feedback obtained, was to identify the required tasks that will facilitate the management of these effects.

The analysis of the two parts will be done in Sections 8.3.1 and 8.3.2 and the overall discussion of the findings in the following chapter.

## 8.3.1 General complexity interview questionnaire

In order to set up a baseline, respondents were asked a number of exploratory questions, firstly in terms of their company and then about their responses. Responses to the closed questions 1, 3 and 7 (see Appendix C-3.2) provide a clear view of how complexity is not yet fully understood and companies and individuals use the term to describe something that is intricate and with a certain level of difficulty. Figure 7.4 in Chapter 7 depicts the lack of a specific definition given by companies with an overwhelming confirmation by the majority of interviewees. Those that gave a positive answer, as shown in Table 7.51, were considering other project management sub-processes.

From the breakdown provided in Figure 7.5 (see Chapter 7), it is clear that mechanistic sub-processes e.g. programme (68%), tasks involved (technicalities) (65%) and project size and procurement method (61%), are considered as the main identifiers of / for complexity. With the exception of two factors, soft issues, such as the project resource (people); the structure of the team; the culture; social factors and the management style, are rated very low in the reasons for causing complexity. The two non-mechanistic reasons with high responses, those of communications (61%) and number of parties (58%), indicate that there is a slow shift towards complexity being identified by the number of interfaces and communication.

When asked about factors of complexity which originate from the project organisation, see Figure 7.6 (see Chapter 7), respondents' emphasis shifts from the mechanistic to the behavioural causes of complexity. Apart from communication, team interfaces (94%), inappropriate structure (84%) and individuals' behaviour (81%) stand out in terms of frequency of response. It is noticeable that, whereas companies do not identify complexity arising from the management style followed or the structure of the team, respondents do identify both reasons as causing complexity, with 74% of responses pointing to management style and 84% to an inappropriate organisational structure. This can actually be explained by how respondents identify differently to issues as individuals, rather than as / on behalf of organisations. Other factors that have been identified by a significant number of respondents include, lack of team environment (68%), people being in the right positions (68%) and even people being in fixed places (61%). Interviewees also identified, by 65%, lack of motivation and lack of 'attractors' (Lucas, 2005) as having a significant impact and causing complexity.

Interviewees concurred by 87% (see figure AP.D-7.8 in Appendix D), that complexity is caused by the interaction structures rather than the objects that are interacting (Lucas, 2000a). This provided strong support to this research in terms of the application of the definition in project management and the next step which included the investigation into the 16 characteristics.

As described in the Research Method, interviewees were asked a number of open questions in order to investigate current practices in terms of tools / techniques used to minimise complexity, including specific management techniques or structuring of the project teams. The contents analysis of each of the questions will be examined below and further points will be discussed in the following chapter.

One of the open questions was concerned with the use of any tools/techniques to identify complexity. The majority of interviewees (58%, see Figure 7.7 in Chapter 7) responded negatively. Contents analysis was performed on the affirmative responses (see Table 7.53, Chapter 7) and the results confirmed a misunderstanding that exists when using risk management techniques to identify complexity. A similar response was given to the question regarding the existence of a definition of complexity.

Two more open questions considered the measures taken to minimise complexity in general and then complexity as defined in this research. The results from the contents analysis are shown in Tables 7.54 and 7.55 (Chapter 7), with more details in Appendix D. With regard to the former, interviewees indicated that measures taken to minimise complexity are, in descending order of frequency of response; an improved project brief, management of the interfaces, careful planning (programme) and management / clarity of communication. Essentially, with the exception of management of interfaces, complexity is considered as a by-product of another process and therefore measures are mainly focused on the main processes. When focusing on complexity caused by the interaction structures, interviewees identified two of the three areas of investigation in this research; namely the management of interfaces and interactions as well as the structure of the team and the individuals themselves.

In order to test Hypotheses H2.2 and H2.3, interviewees were asked if organisations consider setting up the project teams and the management style specifically to tackle complexity. The responses shown in Tables AP.D-7.58 and AP.D-7.61 in Appendix D indicate clearly, by 62% and 84% respectively, that organisations do not have any such considerations. Contents analysis performed on the affirmative responses and shown in Tables 7.59 and 7.60 (in Chapter 7) points out that, in the case of setting up the teams, 16% of interviewees indicated that some consideration is given when selecting certain individuals and taking into account their capabilities. In terms of the management style adopted, only 6% (2) of the interviewees indicated that a specific person (the PM) is selected and appointed to the project in order to manage complexity.

### 8.3.2 Complexity Characteristics interview questionnaire

As described previously, for each complexity characteristic a set of simple actions, drawn from the everyday project management practices and which are linked to theory described in the literature review, were proposed in order to manage its effects. The actions, shown in

Appendices C-3.3 and C-3.4, were discussed and agreed with the interviewees and their responses were evaluated against these in order to derive a level achieved in managing complexity. The actions proposed for each sub-process were accepted by the interviewees. The graphical output, created from the interviewee responses - see Section 7.4.2 and Appendix D – shows clearly the current level of actions taken to manage the effects of complexity on the sub-processes investigated. As can be seen from the overall Figures 7.9, 7.10 and 7.11 in Chapter 7, only in very few instances did actions taken achieve more than 65% in managing the effect(s) of each complexity characteristic. This overall result concurs with the findings from the general complexity questionnaire, Section 8.3.1, where interviewees indicated, by a substantial majority, that no consideration is given to managing complexity when setting up (selecting and structuring) the project team nor to the management style to be followed.

Simple observation of the three graphs divulges a gradual increase in percentage achieved for managing the effects of complexity from the lowest level - selecting team members - to the highest level – the management style adopted. Detailed analysis of results for a number of complexity characteristics and for each sub-process is shown below in Tables 8.3, 8.4 and 8.5. The information is extracted from data in Table 7.65 and Figures 7.9, 7.10 & 7.11 in Chapter 7, together with all the detailed information in tables and graphs in Appendix D which are listed in Tables AP.D-7.61 and AP.D-7.66. Comparisons are also made of the responses by the different strata.

For ease of reference, the tables below include a brief description of the characteristics, which is also shown in Table 5.1 in Chapter 5, and the overall average, as well as the Client and Contractor average percentages achieved for managing the corresponding complexity characteristic.

Table 8.3. Analysis of interviewee responses for managing complexity characteristics when Selecting Team members.

| | Description of Characteristics Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments for the levels achieved for managing complexity when selecting team members |
|---|---|---|---|---|---|
| Conditional | **Autonomous agents**<br>Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | **16** | **5** | **24** | The low percentage achieved indicates that with the current level of activities the contribution of individuals to the project is not adequately considered if it is to minimise complexity.<br>The variance between Client and Contractor PMs highlights the distance of the former from the process and, more importantly, how little the characteristic of autonomous agents is considered. |
| | **Non-equilibrium**<br>The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | **50** | **39** | **59** | A moderate level of achievement indicates that, in particular for Contractor PMs, non-equilibrium is anticipated and when selecting team members, steps are taken to anticipate the influence of 'attractors'. However, especially for the Client PMs, further actions need to be taken to improve the management of complexity introduced through non-equilibrium. |
| Developmental | **Co-evolution**<br>The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment, which is self-evident in the Project Management world | **39** | **39** | **39** | A below moderate level of achievement scored since individuals are not considered as co-evolving when brought together in the wider system of the project.<br>Perhaps, interestingly, here both strata have achieved the same level, whereas Contractor PMs should have achieved considerably more. |
| | **Self-modification**<br>Individuals and teams form and change their | **41** | **37** | **44** | As per the characteristic of co-evolution, self-modification is only considered at below |

| | Description of Characteristics Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments for the levels achieved for managing complexity when selecting team members |
|---|---|---|---|---|---|
| | associations as they are evolving and learning during the project life-cycle | | | | moderate level. PMs do not take an appropriate level of actions to minimise complexity caused by the continuous evolution of individuals and teams. |
| Developmental | **Self-reproduction** The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different individuals and teams may require different organisational structures. Similarly the Management style is copied/imposed throughout. | 46 | 52 | 41 | The effects of cloning the structure and placing individuals into a fixed structure, irrespective of their characteristics and attributes, is not considered adequately by Contractor PMs; whereas Client PMs have a more realistic approach, as can be seen by the level of actions taken to minimise increase in complexity rising due to self-reproduction |
| | **Downward Causation** The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. | 49 | 50 | 48 | The moderate level of achievement indicates that some consideration is given by PMs to minimise the downward systemic features in projects. However, a higher level of management actions is required |
| | **Mutability** It is typical for random mutations to occur in Projects. Project Management has to identify and manage them | 41 | 46 | 38 | Implementing measures that will manage mutability whilst selecting team members, was another characteristic which was not managed to a level that would reduce or maximise the effect of this complexity characteristic. Contractor PMs' responses lagged behind that of the Client PMs despite the fact that they should be more familiar and able to address issues of mutability when selecting team members |

| | Description of Characteristics Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments for the levels achieved for managing complexity when selecting team members |
|---|---|---|---|---|---|
| Developmental | **Emergence**<br>Again this is the power of the whole to deliver a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project | **44** | **48** | **41** | The characteristic of emergence was one of the 16 discussed which most interviewees were familiar with, as similar concepts were part of their employers' processes. However, when considering actions required which would maximise the effect, the results achieved were not as high as expected. |
| | **Phase changes**<br>Feedback processes lead to phase changes, sudden jumps in system properties.<br>As far as the individual is concerned, this characteristic highlights the importance of feedback processes, e.g. for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence on the individuals' characteristics / attributes.<br>These changes could range from the standard phase changes that are based on feedback to higher management levels, to those within the standard PM processes which could lead to the sudden jumps described by this characteristic. | **38** | **23** | **51** | Establishing feedback mechanisms within the projects differs between Client and Contractor PMs, as can be seen from the results. Phase changes which could lead to sudden jumps are not considered to the appropriate level. Interviewees clearly indicated the lack of mechanisms, at individual as well as inter-team levels, which would enable issues to be fed back to higher management levels and thus minimise the impact of the complexity characteristic. |
| Behavioural | **Non-standard**<br>Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | **30** | **32** | **28** | Considering individuals as well as teams as 'systems' and enabling them to self-organise was one of the complexity characteristics that is not managed at the required level. Neither Client nor Contractor PMs select team members who will ameliorate the non-standard effects. |

| | Description of Characteristics Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments for the levels achieved for managing complexity when selecting team members |
|---|---|---|---|---|---|
| Behavioural | **Undefined values** Identifying the system's/project's interfaces, with the environment as the external stakeholders. This characteristic recognizes the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project | **24** | **16** | **31** | This is the second lowest percent achieved by both strata, indicating weakness when considering the effect of undefined values on the project and how, by selecting team members, they can minimise complexity. In particular the identification of attractors becomes crucial as at the initial stages of the project the system's interfaces evolve and the selection of team members affects the set up. |

Table 8.4. Analysis of interviewee responses for managing complexity characteristics when Structuring the Project Team.

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Conditional | **Instability** Stepped evolution(s) or catastrophes do occur in projects. Attractors appear (currently unintentionally) and become system parameters which will attract and avoid chaotic behaviour of the project system | **45** | **34** | **53** | Structuring the team to be able to accommodate instability was not considered adequately by PMs. Identifying the roles within the structure that will create bifurcations and avoid chaotic behaviour was very low, especially for the Client PMs |
| | **Non-equilibrium** The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors | **48** | **42** | **53** | As per selecting team members, the moderate level of percentage achieved indicates that structuring teams to minimise the effects of non-equilibrium is not considered. Also responses to question Q_SLC3Str_b indicate |

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Conditional | which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | | | | that the attractors identified within the project structure remain at a very high level. |
| | **Non-linear** Complex system outputs are not proportional to their inputs. Individuals are seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment that encourages team work, understanding and noticing individuals' contribution. Establishing team work rather than group work or individualistic behaviour. | 51 | 44 | 56 | A moderate percentage was achieved when considering the complexity characteristic, which, in the case of structuring the project team, implies establishing the means to encourage teamwork throughout the structure and also to promote encouragement, recognition and appreciation. In particular implementation of any measures to maximise the effect of non-linearity remained at a high organisational level. |
| | **Attractors** Simple systems (individuals) come together and often self-organise to form more complex systems, which are pulled by the presence of the dynamic attractors of the moment. So we have individuals, not necessarily the line managers, who because of their capabilities, abilities and behavioural attributes are assigned to be 'attractors' should a certain situation arise. | 50 | 43 | 56 | Again, a moderate level of achievement for a complexity characteristic which could be considered as similar to the 'liaison devices' proposed by Galbraith (1973). Interviewees did not establish the means, within the project structure, to allow for self-organisation. Nor did they manage this characteristic by establishing attractors who would be able to generate bifurcations that would avoid chaotic behaviours. |

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Developmental | **Co-evolution** The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment, which is self-evident in the Project Management world | 53 | 63 | 44 | A considerable variance occurred in the management of this characteristic. Client PMs allowed for / instilled more flexibility in the project structure to allow for co-evolution of the parties, whereas the Contractor PMs took a more reserved approach. |
| | **Self-modification** Individuals and teams form and change their associations as they evolve and learn during the project life-cycle | 53 | 47 | 58 | A moderate level of managing this complexity characteristic was achieved as Contractor PMs indicated that they could more easily accommodate self-modification and enable the project structures to form and change during the project life cycle. However, activities to manage this complexity characteristic need to increase substantially |
| | **Mutability** It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | 37 | 37 | 37 | The lowest level achieved for managing this complexity characteristic indicates that project structures are not set up to accommodate random changes. Responses by both strata PMs highlighted very low tolerance and preparedness; rigidity of structure proved once again to be the obstacle. |
| | **Non-uniform** The individual parties evolve separately and bring diversity in projects. This again has to be identified and managed rather than controlled and stopped. | 39 | 48 | 32 | As per mutability, Client PM responses indicated that they are more prepared to accept diversity within projects. |

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Developmental | **Phase changes**<br>Feedback processes lead to phase changes, sudden jumps in system properties.<br>These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence on the individuals' characteristics / attributes.<br>These changes could range from the standard phase changes that are based on feedback to higher management levels, to those within the standard PM processes which could lead to the sudden jumps described by this characteristic. | 49 | 56 | 44 | Again, a level of moderate achievement from both strata. Client PMs made allowances for phase changes to the structure due to feedback mechanisms in place. Contractor PMs indicated a lower level of tolerance, adopting a fixed approach to managing this complexity characteristic. |
| Behavioural | **Unpredictability**<br>This represents the importance of the initial project conditions which, if not managed appropriately, could lead to chaotic conditions occurring later on the projects (see also *pathogens and incubation period* (Busby and Hughes, 2004)). | 52 | 46 | 56 | Results suggest that Contractor PMs are more responsive to changes to initial conditions and allow for appropriate flexibility in the structure, although not to a level that is able to manage unpredictability. This indicates that more actions will need to be taken. Client PMs lagged behind in the level achieved, perhaps because setting up these initial project conditions is their responsibility. |
| | **Non-standard**<br>Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | 65 | 56 | 71 | The highest Contractor PM level achieved, within the structuring of the team sub-process, indicating preparedness to accept a dynamic self-organisation of the structure. This however, contradicts their view to allow for mutability and non-uniformity. The level achieved by the Client PMs is also higher than those reached for mutability and non-uniformity. |

Table 8.5. Analysis of interviewee responses for managing complexity characteristics for the Management Style followed.

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Conditional | **Autonomous agents**<br>Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | 55 | 52 | 57 | Adopting a management style that would accommodate the existence and encouragement of autonomous agents achieved a moderate level for managing this characteristic of complexity. Both strata of PMs interviewed were not implementing the apposite approach. |
| | **Non-linear**<br>Complex system outputs are not proportional to their inputs.<br>Individuals are seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment that encourages team work, understanding and noticing individuals' contribution. Establishing team work rather than group work or individualistic behaviour. | 59 | 50 | 66 | A moderate level of achievement indicates that, for Contractor PMs in particular, non-linearity is anticipated and the management style followed partly accommodates for its effects. However, for the Client PMs, further actions need to be taken to implement management style(s) which will maximise team work between the various parties and thus manage complexity introduced through non-linearity. |
| Developmental | **Self-reproduction**<br>The management style is set up to be the same throughout the project - cloned/imposed, despite the fact that different teams may require a different approach. | 45 | 50 | 42 | The second lowest level of achievement indicates that both strata of PMs consider it appropriate to follow / clone the management style throughout the project structure, thus not considering the effects of self-reproduction adequately. Contractor PMs recorded the lowest level of achievement in the whole section of management style, demonstrating rigidity in the approach taken, thus increasing the likelihood of complexity occurring due to self-reproduction in the management style. |

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Developmental | **Mutability**<br>It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | 42 | 39 | 44 | This complexity characteristic recorded the lowest level of achievement. Neither strata demonstrated taking any measures in order for their management style to accommodate the effect of random changes. |
| | **Non-uniform**<br>The individual parties evolve separately and give diversity in projects. This again has to be identified and managed, rather than controlled and stopped. | 57 | 58 | 56 | Despite the fact that PMs do not accommodate for the effects of mutability, responses regarding non-uniformity indicated a moderate level of actions taken to manage its effects. |
| | **Phase changes**<br>Feedback processes lead to phase changes, sudden jumps in system properties.<br>These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence on the individuals' characteristics / attributes.<br>These changes could range from the standard phase changes that are based on feedback to higher management levels, to those within the standard PM processes which could lead to the sudden jumps described by this characteristic. | 55 | 61 | 50 | A moderate level of achievement was again recorded for accommodating phase changes in the PMs' adopted management style. Client PMs pointed out a greater readiness in allowing for feedback mechanisms within their management style, perhaps because the direct relationship with the parties to 'their' projects is at a similar organisational level. Contractor PMs, however, did not achieve a high percentage because the project organisation is more vertical and depending on the project phase and the number of teams, the organisational level varies. |

| | Characteristics' Description Relevant to Construction | Overall Average Achieved Mngt of Complexity (in %) | Client Average Achieved Mngt of Complexity (in %) | Contractor Average Achieved Mngt of Complexity (in %) | Comments |
|---|---|---|---|---|---|
| Behavioural | **Unpredictability**<br>This represents the importance of the initial project conditions which, if not managed appropriately, could lead to chaotic conditions occurring later on the projects (see also *pathogens and incubation period* (Busby and Hughes, 2004)). | 47 | 48 | 46 | The below moderate level result recorded was due to the fact that neither side considered the required changes to the management style in order to accommodate the passing of projects through the different phases. The initial project conditions are always critical and pathogens (Busby and Hughes, 2004) are introduced and incubate in the project system until suitable conditions prevail for these to cause their damage. Therefore the means to minimise this complexity characteristic by implementing the apposite management style are required. |
| | **Non-standard**<br>Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | 69 | 64 | 74 | For this complexity characteristic, interviewees attained the highest percentage. All have indicated that the appropriate management style is followed, which will therefore allow for each party to the project to change from its initial homogeneous status to a more dynamically self-organised one. |

Finally, as described in Chapter 7, all interviewees were requested to indicate the number / frequency of times teams form and disband during the three main project life cycles. The vast majority, 71% (see Figure 7.33 in Chapter 7), indicated that during the project life cycle six to seven major teams are formed and disband. These, at a very high level, were:

- For the Design phase: Civil and Services.
- For the Construction phase: Building works, Fit-out, Mechanical and Electrical Services.
- For the Commissioning phase: One team of the various professions.

The importance of this result will be discussed in the following Chapters since any proposals to manage the effect of the complexity characteristics for the three sub-processes should be implemented as new teams are set up and managed.

## 8.4 Case Studies results analysis

The purpose of the case studies was to establish how complexity of interconnections affects project performance. In order to extract inclusive and integrated inferences as well as establish replication, the analysis of the case study results is conducted holistically rather than each one in isolation (Yin, 2003). It consists of two parts; firstly, the performance curves are analysed and then the reasons for delay caused by the complexity characteristics are examined using the graphical and tabular reports generated in Chapter 7 and its appendix.

Reviewing the performance results from the five case studies in conjunction and using the Figures, 7.40, 7.48, 7.56, 7.64, 7.72 and 7.74 in Chapter 7, it can be deduced that project complexity is inversely correlated to project performance.

As the effect of the complexity characteristics on each activity monitored increase, performance drops and, as remedial actions are implemented, the effects are managed and keep the project performance at a plateau. All case study curves, irrespective of the project phase, support this finding. Thus the results confirm replication. Results from case study G1.2 - commissioning phase - provide further evidence of the point made above. In actual fact the case study, with the continuous increase in performance, also presents the stage after the plateau. As the project reaches completion and complexity is dealt with (see Figures 7.72, in Chapter 7, and AP.D-7.66 and AP.D-7.68 in Appendix D), the number of complexity characteristics causing delay are gradually reduced in number and performance increases.

For all the performance graphs generated and points raised in this Chapter, and those that follow, analysis is conducted by referring to the 'simple % drop in performance' as this is much less complicated and a repeatable measurement method (Walker, 1997). However, Figures AP.D-7.39, AP.D-7.47, AP.D-7.55, AP.D-7.63 and AP.D-7.71 in Appendix D present a more theoretically accurate view of the percentage drop in performance. This point, as well as others, will be discussed further in the following chapter. As time elapses and activities are not completed, various measures are taken to overcome the performance problems. For example, additional resources might be 'pulled in', or other activities deferred, as is the case with G2.1 where the PM had to delay groups of fit-out activities to a later stage. Therefore, expected performance and, in particular, project reporting techniques such as earned value, the Cost Performance Indicator (CPI) and Schedule Performance Indicator (SPI) could present the true picture. These, however, are beyond the scope of this research.

At the early stages of formulating the hypotheses of the research, the expected graphical output of Hypothesis 2.4 was presumed to resemble that of an exponentially decaying curve (e.g. $e^{-x}$) or a curve similar to an overdamped system such as that presented in pink in Figure 8.1 below. Figure 8.1, below, which depicts the theoretical harmonic oscillations of systems as these come under the influence of various damping devices.

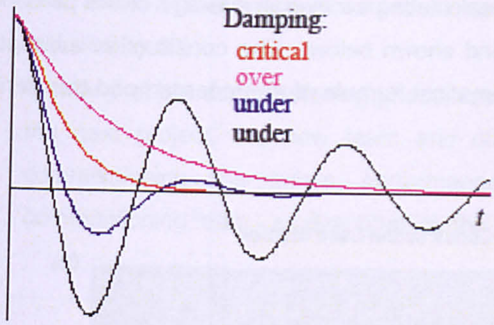



Figure 8.1 Harmonic oscillator with damping. Various cases are depicted, from underdamped to overdamped. As presented in http://www.scar.utoronto.ca/~pat/fun/NEWT1D/PDF/OSCDAMP.PDF

However, as data from the case studies were analysed, it became apparent that, due to the corrective actions taken by the project teams, most of the graphs resembled that of an underdamped transient motion (as per the blue curve in Figure 8.1), which is a combination of an exponentially decaying curve together with a circular frequency curve (Beards, 1981). In attempting to analyse the results from the case study performance curves, it is necessary to review the established formulae / functions in the field of systems and control (dynamics).

The overall concept of motion represented in Figure 8.1 can be described by the equation:

$$\frac{d^2x(t)}{d^2t} + 2\zeta\omega_n\frac{dx(t)}{dt} + \omega^2{}_n x(t) = 0 \qquad (1)$$

Using the equation of motion (1) the graphs depicted above (Figure 8.1) are a combination of two motions (Beards, 1981) which are expressed by the general mathematical function:

$$x = [Ae^{(-\zeta\omega t)}][\sin(\omega(\sqrt{(1-\zeta^2 t)}) + a)] \quad (2)$$

where:

- $\omega$ = undamped natural frequency
- $\zeta$ = damping ratio

The first part of equation 2, $[Ae^{(-\zeta\omega t)}]$, expresses the exponential decay element and the second part, $[\sin(\omega(\sqrt{(1-\zeta^2 t)}) + a)]$, expresses the circular frequency element (Beards, 1981).

The performance curves of two case studies, G1.1.4 in construction and G1.3 in design, can be depicted by the exponential decay curve, whereas those of case studies, G1.1.2 in early construction, and G2.1 in construction, can be depicted by the function of the underdamped transient motion, which combines both elements of equation 2. Thus, not only has replication been established but also consistency, with an already proven and established theory. The only case study that does not accurately conform to these curves is G1.2 which was at the commissioning phase. However this can be explained by the fact that the project was essentially complete just after week 4 of the case study period. Nevertheless, considering the initial deep drop and the gradual recovery, it can still be regarded and represented by an equation of 'underdamped' transient motion but in a slower cyclic mode. Selecting only the case studies that are in 'pure' construction and calculating an overall average of the percent drop in performance, Figure 8.2 is generated and shown below. The construction average curve (red dotted curve) fits precisely the mathematical formula of an underdamped transient motion.

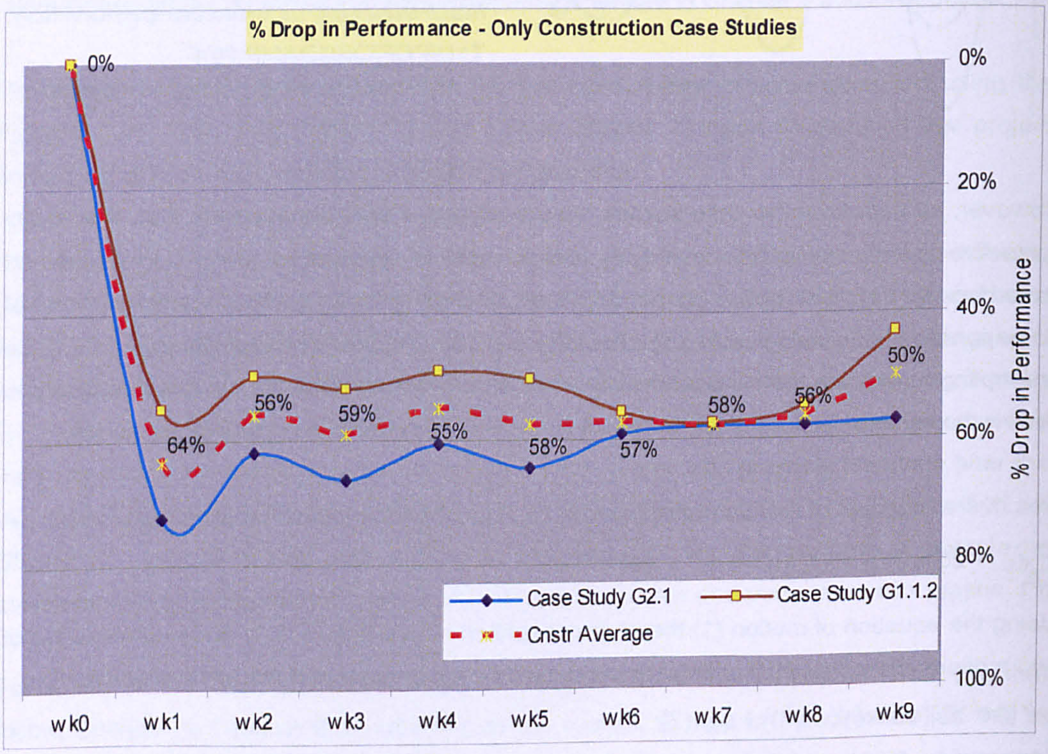



Figure 8.2. Construction only performance drop curves, including average

Considering the whole project life cycle as one overall process and calculating from the results of all five case studies an overall average percent drop in performance, the graph shown below Figure 8.3, is generated.

Comparing Figures 8.2 and 8.3 it is evident that:

- The shapes of the curves follow that of the underdamped transient motion curve as described above.
- The results from the earlier and latter stages of the project lifecycle of case studies G1.2 and G1.3 do not overrule / distort the overall outcome. In actual fact, the exponential decay shape of the design case study and the slightly underdamped shape of the commissioning case study underpin the findings.
- As described by Moore (2002:66 and 90) - in the team effectiveness curve - at the early phase of the project, performance is higher as the team comes together (see Figures 7.38 and 7.40). This can be observed in case study G1.3 where the percentage drop is reduced by 9%.
- Similarly at the commissioning phase, team members become anxious about the future, the next project, the new team and other soft issues (Moore, 2002) and thus, as commissioning approaches, performance drops. Eventually, the 'key players' (the commissioning team - as described by the G1.2 PM) deliver the project.

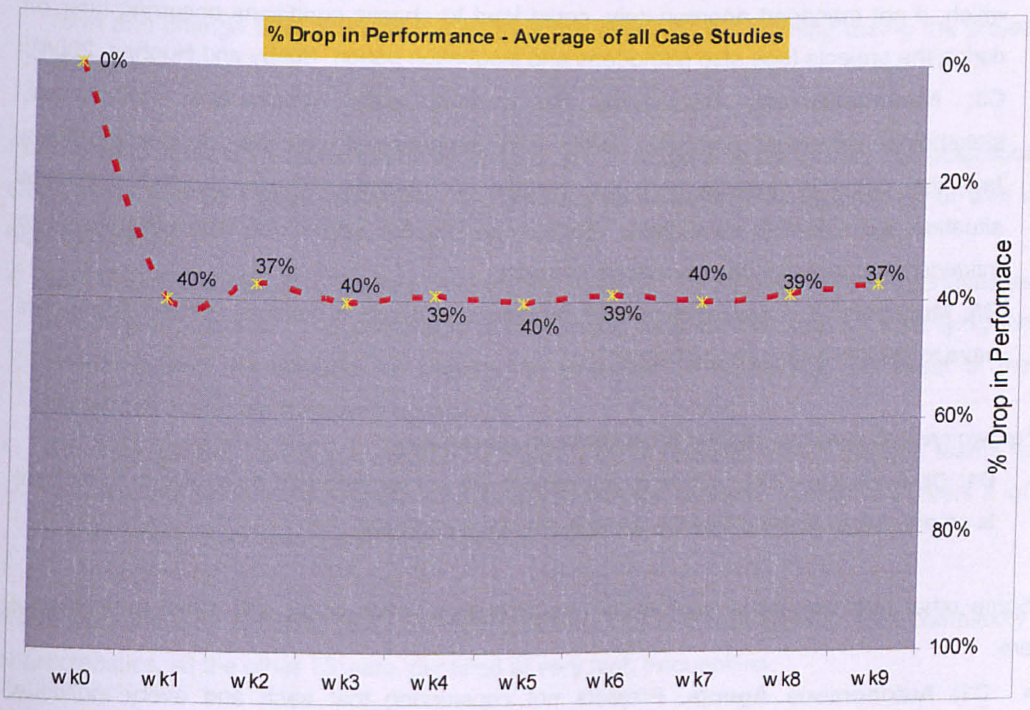



Figure 8.3. Average % performance drop for all case studies

An analysis of the reasons for delay, which is based on Tables AP.D-7.72, 78, 84, 89 in Appendix D, indicates that in all the cases studies, groups of reasons affect the performance of each activity. These reasons remain the same for the duration of each activity, however, in a number of instances, a compounding effect is noticed with further reasons being added to the initial ones, or new ones occurring as a further consequence. For example:

- in G1.1.4 (Table AP.D-7.84, Appendix D) activities 25, 48, 60, 74, 83, etc.
- in G2.1 (Table AP.D-7.89, Appendix D) activities 26, 95, 97, 167, 656, etc..

  In this particular case study a reason for delay, coded by the team as M-D, was introduced to reflect management decision to defer the activity due to the particular reason for delay occurring.

For each case study the increase on the number of reasons for delay can be seen in Figures AP.D-7.34, 42, 50, 58 and 66 in Appendix D.

The simplified reasons for delay, see Appendix C-3.5, are decoded by using Table AP.D-7.68 (in Appendix D) and a number of graphs are produced reflecting the frequency of complexity characteristics which caused delay (see Figures AP.D-7.36, 44, 52, 60 and 68 in Appendix D). This information was used to generate Table 7.99 and Figure 7.75 in Chapter 7. Using this information and for those case studies in construction, the complexity characteristics with the highest frequency of occurrence are detailed below together with the relevant explanation:

- **B1: Unpredictability.** This represents the importance of the initial project conditions which, if not managed appropriately, could lead to chaotic conditions occurring later on during the projects (see also pathogens and incubation period, Busby and Hughes, 2004);
- **C3: Non-equilibrium.** Represents the various 'pulls' (contractual, behavioural, stakeholder influences, company politics and management pressures, to mention but a few) that occur in projects from the multiple contributors. These, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment;
- **D5: Mutability.** It is typical of random mutations to occur in projects. Project Managers have to identify and manage them.

For two case studies the second most common reason was:

- **D1: Co-evolution.** The parties to the project are not regarded as co-evolving, thus there is no attempt to fit them into the wider system environment.

Some other high frequency complexity characteristics which occur and affect performance are:

- **C1: Autonomous Agents.** Projects not considering that each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system.

- **C2: Instability.** PMs do not consider that stepped evolution(s) or catastrophes occur in projects. Attractors are not introduced, thus there is no reduction or avoidance of chaotic behaviour of the project system.
- **C4: Non-linear.** Complex system outputs are not proportional to their inputs and PMs do not establish a team work environment. Instead, there is instead a group work approach or individualistic behaviour.
- **D4: Downward causation.** PMs do not consider how project systemic features affect individuals and teams.
- **D8: Phase changes.** Feedback processes and their effect on individuals are not considered. Therefore as these lead to phase changes or sudden jumps in system properties, they have a detrimental influence on the individuals' characteristics / attributes.

For the case study G1.3 (design phase), and in addition to complexity characteristics C1, C3 and D1 mentioned above, two more complexity characteristics are occurring in high frequency:

- **C5: Attractors.** There is no identification of simple systems (individuals) who enable self-organisation and pull together individuals / teams to overcome difficulties. These individuals, not limited to the line managers, because of their capabilities, abilities and behavioural attributes, are assigned to be 'attractors' should a certain situation arise.
- **D2: Self-modification.** There is distinct lack of flexibility by both individuals and teams to form and change their associations as they are evolving and learning during the project life-cycle.

For the case study G1.2 (commissioning phase), and in addition to complexity characteristics C2, C3, C4 and D1 mentioned above, two different complexity characteristics occur with a high frequency:

- **B3: Undefined Values.** Failure to identify the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project.
- **D7: Emergence.** During commissioning, there is still a need for individuals and teams to combine and perform as a holistic system, given that the power of the whole delivers a lot more to the project than the sum of individual part.

Aside from the Non-standard (B2), Self-reproduction (D3) and Non-uniform (D6) complexity characteristics, all the other 13 were identified at very high frequencies.

Using the results presented in Chapter 7 and Figure 7.75, analysis is conducted to determine the complexity characteristics causing delay through the sub-processes investigated in this research. These results are shown below in Table 8.6.

Table 8.6. Analysis of complexity characteristics causing delay by sub-process

| Phase | Case study | Selecting Team members | Structuring the Team | Management Style |
|---|---|---|---|---|
| Construction | G1.1.2 | Unpredictability (B1) | Instability (C2) | Downward Causation (D4) |
| | | Autonomous Agents (C1) | Non-equilibrium (C3) | Mutability (D5) |
| | | Non-equilibrium (C3) | Co-evolution (D1) | Phase Changes (D8) |
| | | Non-linear (C4) | Downward Causation (D4) | |
| | | Co-evolution (D1) | Mutability (D5) | |
| | | Phase Changes (D8) | Phase Changes (D8) | |
| | G1.1.4 | Unpredictability (B1) | Instability (C2) | Mutability (D5) |
| | | Autonomous Agents (C1) | Non-equilibrium (C3) | Phase Changes (D8) |
| | | Non-equilibrium (C3) | Co-evolution (D1) | |
| | | Non-linear (C4) | Downward Causation (D4) | |
| | | Attractors (C5) | Mutability (D5) | |
| | | Co-evolution (D1) | Phase Changes (D8) | |
| | | Self-modification (D2) | | |
| | | Emergence (D7) | | |
| | G2.1 | Unpredictability (B1) | Instability (C2) | Mutability (D5) |
| | | Autonomous Agents (C1) | Non-equilibrium (C3) | Phase Changes (D8) |
| | | Instability (C2) | Co-evolution (D1) | |
| | | Co-evolution (D1) | Mutability (D5) | |
| | | Downward Causation (D4) | Phase Changes (D8) | |
| | | Mutability (D5) | | |
| Design | G1.3 | Undefined Values (B3) | Instability (C2) | |
| | | Autonomous Agents (C1) | Non-equilibrium (C3) | |
| | | Instability (C2) | Co-evolution (D1) | |
| | | Non-linear (C4) | | |
| | | Co-evolution (D1) | | |
| | | Downward Causation (D4) | | |
| | | Emergence (D7) | | |
| Commissioning | G1.2 | Autonomous Agents (C1) | Non-equilibrium (C3) | |
| | | Non-equilibrium (C3) | Attractors (C5) | |
| | | Co-evolution (D1) | Co-evolution (D1) | |
| | | Self-modification (D2) | | |

An immediate observation is of the lack of complexity characteristics affecting the sub-process of management style for the case studies in design and commissioning. Also of interest, is the commonality of two complexity characteristics, mutability and phase changes, which affected all three case studies in construction. A comment that could be made from the above observation is the relevance of the findings to the Traveller's Dilemma, as people choose for their own benefit or exposure, as opposed to the benefit of the company / organisation for which they work (Basu, 2007).

In terms of selecting team members, the most frequent complexity characteristics which caused delays and a drop in performance were:

- For all five case studies:
  - C1: Autonomous agents.

- D1: Co-evolution.
- For three of the case studies:
  - C3: Non-equilibrium.
  - C4: Non-linear.

For structuring the team sub-process the most frequent complexity characteristics were:

- For all five case studies:
  - C3: Non-equilibrium.
  - D1: Co-evolution.
- For four of case studies:
  - C2: Instability.
- For three of case studies:
  - D5: Mutability.
  - D8: Phase changes.

It is important to note from Table 8.6, above, that, for selecting the team members and structuring the team sub-processes, there were negligible differences in the complexity characteristics which caused delays and drop in performance, despite the fact that these were conducted for different project phases.

## *8.5 Hypotheses testing analysis*

In this section, the results obtained for the three different research methods will be used to prove or refute the hypotheses formulated and presented in the Research Method Chapter.

The results obtained from the statistical analysis of the postal questionnaires, using SPSS (version 15), for testing the Hypothesis 1 and the sub-hypotheses will be presented in Section 8.5.1. In addition to the parametric technique of the chi-squared test ($\chi^2$) and in the case where a relationship is sought between one dependent variable and more than two variables, the technique to be used is multiple regression and these results can be seen in Section 8.7.1. On a very few occasions, where it is considered appropriate, Factor Analysis is performed and the results are included in the appropriate sections.

From the 34 questions in the postal questionnaire, only those that have been designed to extract the relevant response to the respective hypothesis are statistically analysed, with the remainder forming part of the analysis of results, discussion and consideration for the proposal. The results obtained from the interviews for the testing of Hypothesis 2 and its sub-hypotheses H2.1, H2.2 and H2.3, will be presented in section 8.5.2. In order to maintain consistency, brief comments on the acceptance or rejection of sub-hypothesis H2.4, for which the five case studies were used, will also be presented in this section.

## 8.5.1 Hypothesis 1

As described in the Research Methodology, Hypothesis 1 is broken up into two sub-hypotheses, H1.1 and H1.2.

**Hypothesis 1.1**

To simplify the setting up of the questionnaire and the quantitative evaluation of the results, hypothesis H1.1 has been broken down to the following three sub-hypotheses. The results obtained for the testing of the following three sub-hypotheses are shown below:

$H_1^{1.1.1}$ Project team members are selected using personal profiling.

$H_1^{1.1.2}$ The Project Team structure is defined to the lowest level.

$H_1^{1.1.3}$ The Project Management style is defined down to the lowest level.

<u>Hypothesis H1.1.1</u>

Sub-hypothesis $H_1^{1.1.1}$ is tested at two levels, that of selecting the PM and that of the organisational levels below the PM, using questions 2q5, 2q10 and 2q13. To test Hypothesis $H_1^{1.1.1}$, the frequency of responses to the question 2q5 is presented in Figure 8.4.

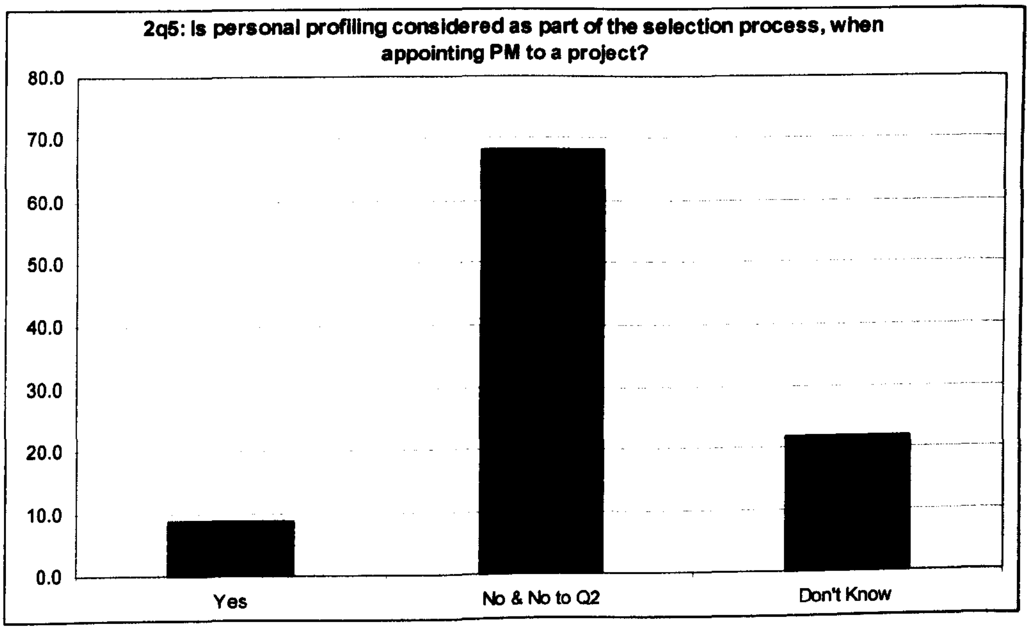



Figure 8.4 Frequency of response as to whether personal profiling is considered for the appointment of the PM on the project.

With a frequency of response in excess of 65%, the result indicates that personal profiling is not considered when selecting the PM, therefore Hypothesis $H_1^{1.1.1}$ is refuted.

In terms of the supervisors using particular selection techniques to set up their project teams, the chi square test results are shown in Tables 8.7 and 8.7.1.

Table 8.7. Crosstabs – Testing for Hypothesis H.1.1.1

| | | | Type of company | | Total |
|---|---|---|---|---|---|
| | | | Client | Contractor | |
| Do site supervisors use any selection process techniques? | Yes | Count | 4 | 9 | 13 |
| | | Expected Count | 7.4 | 5.6 | 13.0 |
| | | % of Total | 4.4% | 9.9% | 14.3% |
| | No & No to Q9 | Count | 37 | 26 | 63 |
| | | Expected Count | 36.0 | 27.0 | 63.0 |
| | | % of Total | 40.7% | 28.6% | 69.2% |
| | Don't Know | Count | 11 | 4 | 15 |
| | | Expected Count | 8.6 | 6.4 | 15.0 |
| | | % of Total | 12.1% | 4.4% | 16.5% |
| Total | | Count | 52 | 39 | 91 |
| | | Expected Count | 52.0 | 39.0 | 91.0 |
| | | % of Total | 57.1% | 42.9% | 100.0 % |

Table 8.7.1. Chi-Square Tests Hypothesis H.1.1.1

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 5.363(a) | 2 | .068 |

The results extracted indicate that p>0.05, therefore $H_0^{1.1.1}$ is accepted proving that the Supervisors do not use any selection techniques to select their team members. Therefore Hypothesis $H_1^{1.1.1}$ is again refuted.

In terms of the subcontractors using particular team selection techniques below the level of Discipline Leader, the chi square test results are shown in Tables 8.8 and 8.8.1.

Table 8.8. Crosstabs – Testing for Hypothesis H.1.1.1

| | | | In your most recently completed project, did your subcontractors follow a team selection process? | | | Total |
|---|---|---|---|---|---|---|
| | | | Discipline & Team Leaders | Supervisors & Team Members | None | |
| Type of company | Client | Count | 25 | 20 | 7 | 52 |
| | | Exp. Count | 26.9 | 19.4 | 5.7 | 52.0 |
| | | % of Total | 27.5% | 22.0% | 7.7% | 57.1% |
| | Contractor | Count | 22 | 14 | 3 | 39 |
| | | Exp. Count | 20.1 | 14.6 | 4.3 | 39.0 |
| | | % of Total | 24.2% | 15.4% | 3.3% | 42.9% |
| Total | | Count | 47 | 34 | 10 | 91 |
| | | Exp. Count | 47.0 | 34.0 | 10.0 | 91.0 |
| | | % of Total | 51.6% | 37.4% | 11.0% | 100.0% |

Table 8.8.1. Chi-Square Tests Hypothesis H.1.1.1

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.014(a) | 2 | .602 |

The results extracted indicate that p>0.05, therefore $H_0^{1.1.1}$ is accepted. Thus there is no evidence that team selection by subcontractors is occurring at the levels below Discipline Leader. Therefore Hypothesis $H_1^{1.1.1}$ is refuted.

Ultimately the results from the three tests indicate that there is no evidence that either Client or Contractor PMs, or any other parties to the project, are selected using Personal Profiling. Nor is there any other indication that 'objective' selection techniques are used for selecting project team members and thus H1.1.1 is refuted.

Hypothesis H1.1.2

For the testing of sub-hypothesis $H_1^{1.1.2}$, question 3q7 was analysed against question 1q1 and the results are shown below in Tables 8.9 and 8.9.1.

Table 8.9. Crosstabs – Testing Hypothesis H.1.1.2

| | | | Type of company | | Total |
|---|---|---|---|---|---|
| | | | Client | Contractor | |
| For the most recently completed project, indicate down to what level the structure was defined | Discipline & Team Leader | Count | 12 | 5 | 17 |
| | | Expected Count | 9.6 | 7.4 | 17.0 |
| | | % of Total | 13.3% | 5.6% | 18.9% |
| | Supervisor, Design & Site Team | Count | 39 | 34 | 73 |
| | | Expected Count | 41.4 | 31.6 | 73.0 |
| | | % of Total | 43.3% | 37.8% | 81.1% |
| Total | | Count | 51 | 39 | 90 |
| | | Expected Count | 51.0 | 39.0 | 90.0 |
| | | % of Total | 56.7% | 43.3% | 100.0% |

Table 8.9.1. Chi-Square Tests Hypothesis H.1.1.2

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.654(b) | 1 | .198 |

The results extracted indicate that p>0.05, therefore $H_0^{1.1.2}$ is proven and thus there is no evidence that the project team structure is defined to the lowest level. Therefore Hypothesis H1.1.2 is refuted.

Looking at the outcome in greater detail, there is no evidence that either the Client or the Contractor PMs consistently define the structure of their project teams to a specific level. There is some minor indication that the Client PMs structure their teams at the level of Supervisor / Site Team members, however, this is not statistically significant.

Cross checking the results from the above analysis by running a crosstab between the 'project level at which the structure was defined' and grouping by seniority i.e. Project Directors and Senior PMs vs PMs to Site Managers, we obtain the results shown below in Tables 8.10 and 8.10.1.

Table 8.10. Crosstabs – Testing Hypothesis H.1.1.2

| | | | For the most recently completed project, indicate down to what level structure was defined | | Total |
|---|---|---|---|---|---|
| | | | Discipline & Team Leader | Supervisor, Design & Site Team | |
| Job roles | P Dirs & SPM | Count | 7 | 33 | 40 |
| | | Expected Count | 7.6 | 32.4 | 40.0 |
| | | % of Total | 7.8% | 36.7% | 44.4% |
| | PMs to Site Managers | Count | 10 | 40 | 50 |
| | | Expected Count | 9.4 | 40.6 | 50.0 |
| | | % of Total | 11.1% | 44.4% | 55.6% |
| Total | | Count | 17 | 73 | 90 |
| | | Expected Count | 17.0 | 73.0 | 90.0 |
| | | % of Total | 18.9% | 81.1% | 100.0% |

Table 8.10.1. Chi-Square Tests Hypothesis H.1.1.2

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | .091(b) | 1 | .763 |

The results extracted indicate that $p>0.05$, therefore $H_0^{1.1.2}$ is proven, indicating that there is no evidence that the project team structure is defined to the lowest level. Therefore Hypothesis H1.1.2 is again refuted.

In order to test if there is any significant difference between Client and Contractor PMs, a T-Test was performed on question 3q2 and 1q1. The results are shown below in Table 8.11.

Table 8.11. T-Test for Hypothesis H1.1.2 – between Client & Contractor PMs

| Independent Samples Test | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Down to what level, as a PM, you define the project structure | | F | Sig. | t | df | Sig. (2-tailed) | Mean Diff. | Std. Error Diff. | 95% Confidence Interval of the Difference | |
| | | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower |
| | Eq. var's assumed | 1.655 | .202 | -.368 | 87 | **.714** | -.194 | .528 | -1.244 | .856 |
| | Eq.var's not assumed | | | -.379 | 84.454 | .706 | -.194 | .513 | -1.215 | .826 |

Hypothesis $H_1^{1.1.2}$ says: 'The project team structure is defined to the lowest level'. Given that p = .714 and because p > 0.05, therefore there is no significant difference in the level the Client and Contractor PMs define the structure of their project teams. Therefore the rejection of Hypothesis H1.1.2 stands for both groups of PMs.

Hypothesis H1.1.3

For the testing of sub-hypothesis $H_1^{1.1.3}$, two sets of chi square tests are conducted between questions 4q1 and 4q4 against 1q1.

Tables 8.12 and 8.12.1, below, depict the results of this analysis.

Table 8.12. Crosstabs Testing for Hypothesis H1.1.3

| | | | Is a formal decision taken regarding management style? | | | Total |
|---|---|---|---|---|---|---|
| | | | Yes | No | Don't Know | Yes |
| Type of company | Client | Count | 12 | 38 | 2 | 52 |
| | | Exp. Count | 12.7 | 37.6 | 1.7 | 52.0 |
| | | % of Total | 13.3% | 42.2% | 2.2% | 57.8% |
| | Contractor | Count | 10 | 27 | 1 | 38 |
| | | Exp. Count | 9.3 | 27.4 | 1.3 | 38.0 |
| | | % of Total | 11.1% | 30.0% | 1.1% | 42.2% |
| Total | | Count | 22 | 65 | 3 | 90 |
| | | Exp. Count | 22.0 | 65.0 | 3.0 | 90.0 |
| | | % of Total | 24.4% | 72.2% | 3.3% | 100.0% |

Table 8.12.1. Chi-Square Tests Hypothesis H.1.1.3

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | .204(a) | 2 | .903 |

The results extracted indicate that p>0.05, therefore $H_0^{1.1.3}$ is proven and thus there is no evidence that a decision is made regarding the project management style to be followed. Therefore Hypothesis H1.1.3 is refuted.

From testing for sub-hypothesis H1.1.3, and using responses to question 4q4, it is possible to test for any prevailing management style. The following results are generated and shown in Tables 8.13 and 8.13.1. In order to enable reasonable statistical testing, the descriptions of the management style adopted are grouped as follows:

- Group A: Egalitarian and People style (A & H).
- Group B: Dictatorial, Standard processes, Technocratic, Control system, Long-term objectives (B, D, E, G & J).
- Group C: Manage themselves (C).
- Group D: Situational (F).

**Table 8.13.** Crosstabs Testing for Hypothesis H.1.1.3

| | | | Type of management style | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | | Group A | Group B | Group C | Group D | Don't Know | |
| Type of company | Client | Count | 19 | 15 | 5 | 6 | 5 | 50 |
| | | Exp Count | 14.0 | 17.4 | 8.1 | 5.8 | 4.7 | 50.0 |
| | | % of Total | 22.1% | 17.4% | 5.8% | 7.0% | 5.8% | 58.1% |
| | Contractor | Count | 5 | 15 | 9 | 4 | 3 | 36 |
| | | Exp Count | 10.0 | 12.6 | 5.9 | 4.2 | 3.3 | 36.0 |
| | | % of Total | 5.8% | 17.4% | 10.5% | 4.7% | 3.5% | 41.9% |
| Total | | Count | 24 | 30 | 14 | 10 | 8 | 86 |
| | | Exp Count | 24.0 | 30.0 | 14.0 | 10.0 | 8.0 | 86.0 |
| | | % of Total | 27.9% | 34.9% | 16.3% | 11.6% | 9.3% | 100.0% |

**Table 8.13.1.** Chi-Square Tests Hypothesis H1.1.3

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 8.146(a) | 4 | .086 |

The results extracted indicate that $p>0.05$, therefore $H_0^{1.1.3}$ is proven and thus there is no evidence that any particular management style is followed. Therefore, it can be seen that there is a prevailing response towards Group A Management style by the Client PMs and Group B by the Contractor PMs, however, this is not statistically significant. Further details of the responses given can be seen in Appendix D Tables AP.D-7.41.1 and AP.D-7.41.2, as well as AP.D-7.42.4.1 to AP.D-7.42.4.5.

From the above results, it can be ascertained that all three sub-hypotheses of Hypothesis H1.1 are refuted, therefore the hypothesis itself is refuted. Thus, available techniques for setting up (selecting and structuring) project teams and the management style in construction projects are not implemented down to the lowest project organisation level.

**Hypothesis H1.2**

Hypothesis 1.2 states that, 'The implementation of team setting up (selection and structuring) processes down to the lowest project organisation level and the management style are positively correlated with improved project management outcome'.

In order to test for Hypothesis $H_1^{1.2}$, a number of chi square tests are run between questions 2q4, 2q5, 2q13, 3q7 and 4q4 (see Appendix C-3.1) against question 5q2 and only for the three sub-processes under investigation. Table 8.14 depicts the Pearson Chi-square value against each test.

Table 8.14. Summary table of chi square test results for Hypothesis $H_1^{1.2}$.

| Test | Pearson Chi-square – Asymp. Sig. (2-sided) |
|---|---|
| Personal profile considered when selecting PM * Success of team selection | .193 |
| Personal profile considered when selecting PM * Success of structuring of the team | .080 |
| Personal profile considered when selecting PM * Success of management of the team | .935 |
| Project team member for which personal profile has been carried out * Success of team selection | .732 |
| Project team member for which personal profile has been carried out * Success of structuring of the team | .823 |
| Project team member for which personal profile has been carried out * Success of management of the team | .572 |
| Personal profiling carried out for any team member * Success of team selection | .677 |
| Personal profiling carried out for any team member * Success of structuring of the team | .265 |
| Personal profiling carried out for any team member * Success of management of the team | .176 |
| Lowest level project structure was defined * Success of team selection | .638 |
| Lowest level project structure was defined * Success of structuring of the team | .663 |
| Lowest level project structure was defined * Success of management of the team | .775 |
| Mngt style adopted at Discipline Leader * Success of team selection | .000 |
| Mngt style adopted at Discipline Leader * Success of structuring of the team | .000 |
| Mngt style adopted at Discipline Leader * Success of management of the team | .698 |
| Mngt style adopted at Team Leader * Success of team selection | .321 |
| Mngt style adopted at Team Leader * Success of structuring of the team | .125 |
| Mngt style adopted at Team Leader * Success of management of the team | .956 |
| Mngt style adopted at Supervisor * Success of team selection | .191 |
| Mngt style adopted at Supervisor * Success of structuring of the team | .120 |
| Mngt style adopted at Supervisor * Success of management of the team | .371 |
| Mngt style adopted at Design Team Member * Success of team selection | .775 |
| Mngt style adopted at Design Team Member * Success of structuring of the team | .850 |
| Mngt style adopted at Design Team Member * Success of management of the team | .007 |
| Mngt style adopted at Site Team Member * Success of team selection | .839 |
| Mngt style adopted at Site Team Member * Success of structuring of the team | .888 |
| Mngt style adopted at Site Team Member * Success of management of the team | .143 |

From the above results, it can be seen that $p>0.05$ for the sub-processes of selecting team members and structuring the project team and, therefore, in the majority, $H_0^{1.2}$ is proven. Thus, there is no evidence that the two processes are positively correlated to the project management outcome with the current processes.

Of the questions regarding the management style, the style adopted at Discipline Leader level is positively correlated to the project management outcome relevant to selecting the team members and structuring the team. However, there is no evidence that a correlation exists between the management style at Discipline Leader level and the project management outcome. Similarly with the exception of the management style at Design Team member level being positively correlated to the project management outcome relevant to the management of the team. Again there is no evidence that the management style at any other level is positively correlated to the project management outcome, relevant to the selection of team members, structuring of the team or the management of the team. Therefore, it can be deduced that overall, and with the current approach taken by PM practitioners towards the three sub-processes investigated, Hypothesis 1.2 is refuted.

## 8.5.2 Hypothesis 2

Testing of Hypothesis 2, as described in the Research Method, is based on the results from the 31 interviews for Hypotheses H2.1, H2.2 and H2.3 and the results from the five case studies for Hypothesis H2.4. As with the testing of Hypothesis 1, some of the questions asked during the interviews are used to prove or refute the relevant hypotheses.

**Hypotheses H2.1, H2.2 & H2.3**

A set of graphs are drawn using the data extracted from the 31 interviews. The data are presented in the Table AP.D-7.50 in Appendix D and will be used for the discussion on Hypotheses H2.1, H2.2 and H2.3. The composition of the interviewees – Client and Contractor PMs - is shown in Table 7.0 in Chapter Seven. The graphs below depict the frequency of responses given to questions, shown on the graph header, during the interviews.

<u>Hypothesis 2.1</u>

Hypothesis $H_1^{2.1}$ states that: 'Complexity characteristics are considered when selecting project team members'.

Figure 8.5 depicts the *frequency of response given by interviewees to the corresponding question*. The majority of respondents (58%) indicated that complexity is not used as a criterion for selecting project team members. Additionally results, obtained from Figure 7.9 (in Chapter 7) and Table 8.3 above, concur that actions are not taken, achieving a level noticeably below the acceptance level of 75%, and therefore Hypothesis 2.1 is refuted.

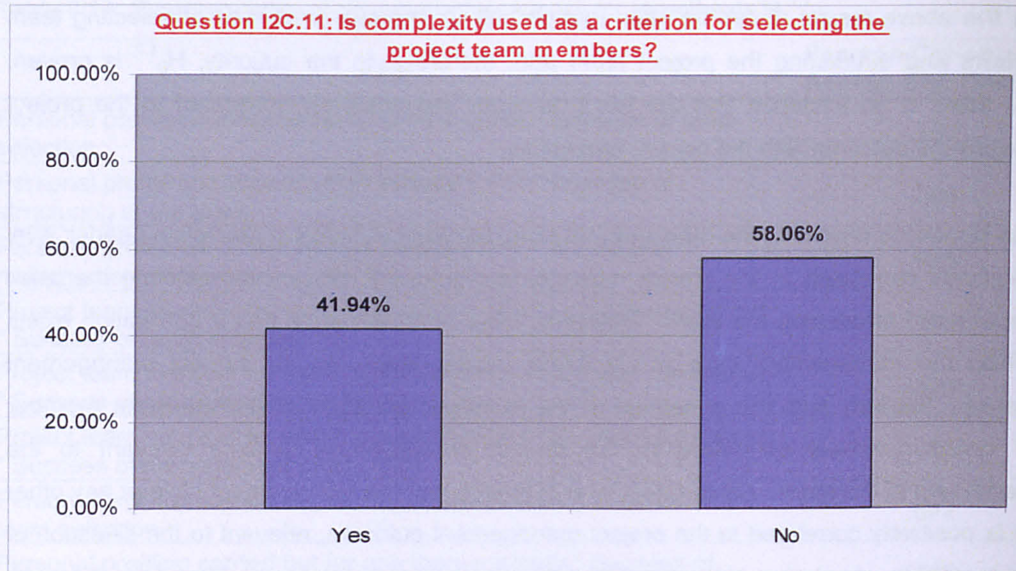



Figure 8.5 Response on the use of project complexity as criterion for selecting the project team members

Hypothesis 2.2

Hypothesis $H_1^{2.2}$ states that: 'Complexity characteristics are considered when structuring the project team(s)'.

Figure 8.6 depicts the frequency of response given by interviewees to the corresponding question.

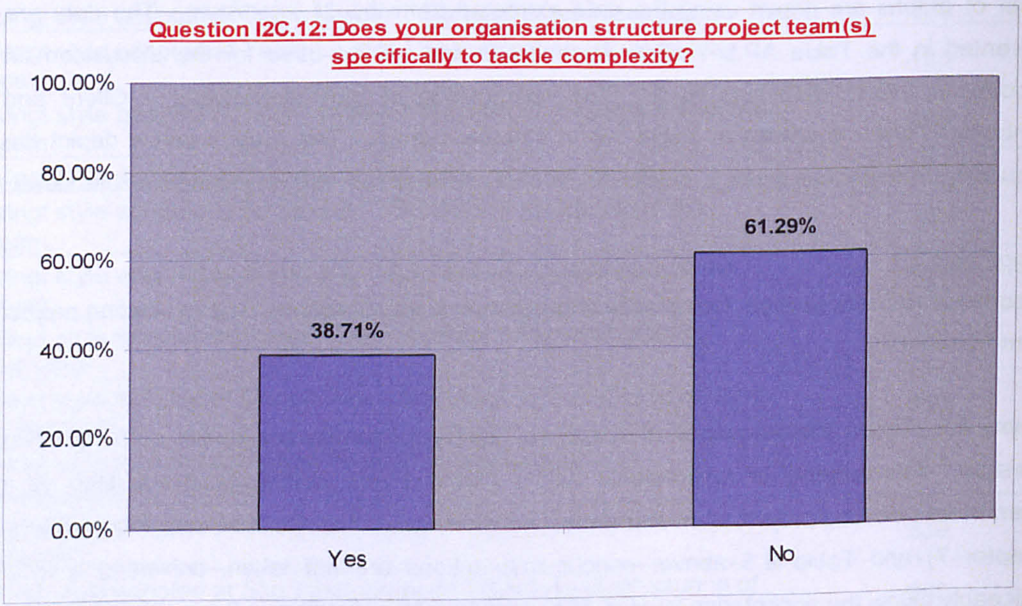



Figure 8.6 Response regarding structuring of the project organisation to tackle complexity

The majority of respondents (61%) indicated that complexity is not considered when structuring the project team. Additionally, results obtained from Figure 7.10 (in Chapter 7) and Table 8.4 above, concur that actions are not taken, achieving a level clearly below the acceptance level of 75%, and therefore Hypothesis 2.2 is refuted.

Hypothesis 2.3

Hypothesis $H_1^{2.3}$ states that: 'Complexity characteristics are taken into account when considering the management style to be followed on a project'.

Figure 8.7 depicts the frequency of response given by interviewees to the corresponding question.

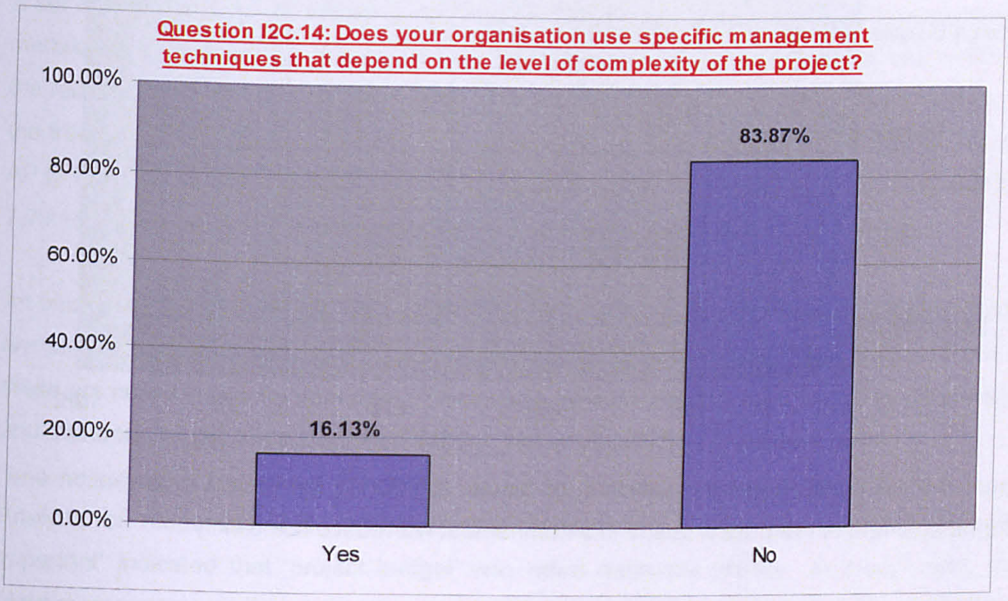



Figure 8.7 Response regarding the use of specific management techniques that depend on the level of complexity of the project.

The majority of respondents (by 84%) indicated that companies do not use any management techniques to overcome levels of complexity in projects. As shown in Figure 7.11 (in Chapter 7) and Table 8.5 above, the complexity characteristics are not even taken into account when considering the management style to be followed on the project. Actions taken achieve levels below the acceptance level of 75%, and therefore Hypothesis 2.3 is refuted.

As the analysis of results indicates, complexity *per se* is not defined nor addressed by companies or practitioners; therefore the results for the above hypotheses are not a total surprise. Complexity in general and, in particular that of interconnections, is a fairly 'young' topic in Project Management and it has also become the scapegoat as well as the reason for project failure. The interviews and the research strategy of this stage gave the opportunity, apart from examining the hypotheses, to present practitioners with the deciphered characteristics of complexity of interconnections. This served as an internal test to the investigation, not only for the understanding but also the level of concurrence of what was proposed, and, furthermore, not from just one level of PMs but from Site Managers to Project Directors. In addition to the above questions, interviewees were asked to respond to an overall statement regarding the sub-processes under investigation and the current approach in terms of considering the complexity of interconnections. Figure 8.8 depicts the responses obtained.

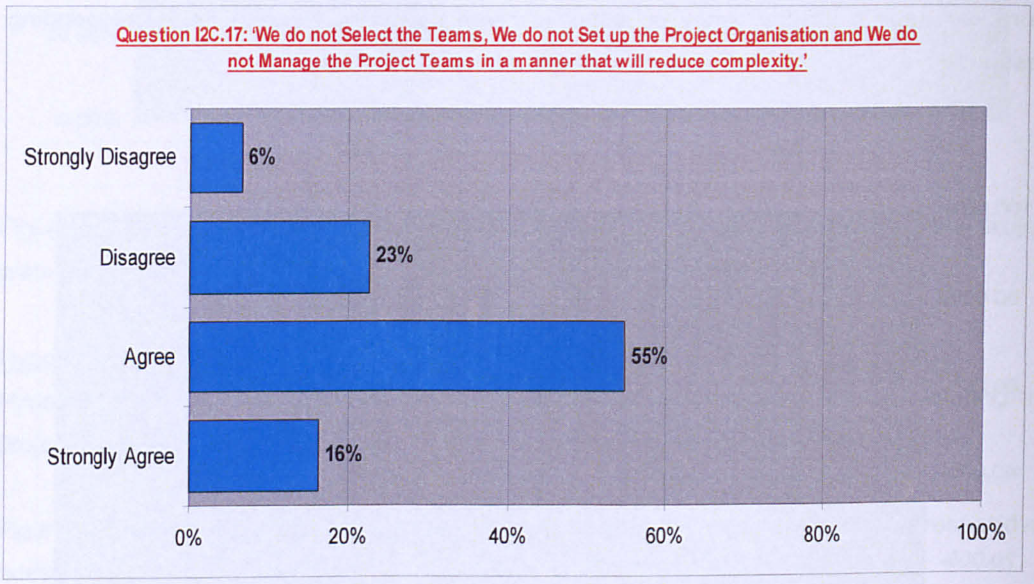



Figure 8.8 Response regarding selection of teams, structuring the project organisation and the management of the project teams in a manner that will reduce complexity

The graph provides a subjective yet very strong indication of the respondents' view regarding the use of the three sub-processes in order to reduce complexity. 71% of respondents agreed / strongly agreed with the statement.

#### Hypothesis H2.4

As the three sub-processes under investigation are part of the quality of the project management outcome, it was considered appropriate to examine the correlation between complexity of interconnections and the project performance. For this reason, Hypothesis 2.4 was developed and states that project complexity is inversely correlated to the project performance. The hypothesis is tested using the results from the five case studies, and as described previously, the purpose of the case studies was to identify replication (Yin, 2003).

The overall Figure 7.74 in Section 7.5.6, the individual case study graphs (see Figures 7.40, 7.48, 7.56, 7.64 and 7.72 in Chapter 7), and the analysis conducted in Section 8.4, provide a clear indication that there is an inverse correlation between project performance and complexity. Strengthening the argument further, there is replication, not only between the case studies / projects which are in the same project phase, i.e. construction, but also between the projects at different stages. Therefore Hypothesis H2.4 is accepted.

Apart from replication between the results from the case studies, which covered all three main project stages, the output resembled that of underdamped vibrating systems - an already established area of dynamics. The results also established that reasons for delay from the three sub-processes were identified by the project teams as contributing to the drop in performance thus providing an additional link to the complexity of interconnections.

## 8.6 *Effect of Moderating Variables*

A set of five moderating variables – project duration, budget, type, location and procurement method were considered in the postal questionnaires in order to understand if they influence the relationship between the independent and dependant variables. The analysis focuses on the frequency of responses obtained in the results depicted in Table AP.D-7.100 and Figures AP.D-7.76, AP.D-7.77 and AP.D-7.78, as well as the detailed Figures AP.D-7.79.1 to AP.D-7.79.15 (all in Appendix D), where results are presented by sample strata.

An immediate observation from the overall responses is that none of the moderating variables are considered critical for the three sub-processes under investigation, and only very few of these are considered very important. The results indicate a percentage response below 50% and therefore, as per the acceptance criteria, these will only be commented upon.

Analysis of responses that considered the effect of the moderating variables as 'very important' indicated that 'project budget' was rated moderate (46%). In more detail, the highest response is for the sub-process of management style, indicating that PMs', particularly the Contractors', management style (see Figure AP.D-7.79.11 in Appendix D) is affected by the project budget.

In terms of the effect of the project budget on setting up the team (selection and structuring of team), it is the Client PMs that identify the variable as affecting moderately the processes (44%, see Figure AP.D-7.79.7 in Appendix D), indicating the prevalence of the control paradigm in performing selection and structuring of project teams. When selecting team members, a factor that is considered very important by Client PMs, is 'project type', see Figure AP.D-7.79.5 in Appendix D. This indicates the Client concern about the teams that will come together to deliver their project. In terms of structuring the team, it is the Contractor PMs (see Figure AP.D-7.79.9 in Appendix D) that considered 'procurement method' as having a very important effect. This indicates the industry's concern and current drive to move out of competitive tendering.

Generally, responses by Client and Contractor PMs, who indicated that moderating variables have a very important effect, did not have excessive variance, apart from the two cases reported above – project type affecting selection of team members and procurement method affecting structuring of the team.

## *8.7 Analysis of other statistical results*

Analysis of the results obtained from carrying out regression analysis, correlations and factor analysis with SPSS, which are shown in Chapter 7 and Appendix D, are expanded below and discussed in the Chapters that follow.

### 8.7.1 Regression analysis

The regression analysis results presented in Tables 7.101, 7.102 and 7.103 (in Chapter 7) represent a 'mechanistic' model that can be created from the relationship between the respective independent and dependent variables. By using an appropriate level of input from the three independent variables of Selecting the Team (2s13), Structuring the Team (3q2) and the Management Style (4q5DL&TL and 4q5Sprv2STM), the success of the respective project management outcome (dependent variable) can be predicted.

From the results presented in Table 7.101, the following regression analysis model is generated that can be used as a predictor for a successful project management outcome for selecting team members:

Success of Team Selection Project Outcome =0.205 + 0.114(A) – 0.049(B) + 0.015(C) + 0.005(D) + 0.037(E)

Where: A = 2q13; B = 3q2; C = 3q7;
D = 4q5DL&TL; E = 4q5Sprv2STM

From the results presented in Table 7.102 (in Chapter 7), the following model is generated for a successful project management outcome for structuring the team:

Success of Structuring the Team Project Outcome =0.150 + 0.043(A) – 0.039(B) + 0.061(C) + 0.042(D) + 0.021(E)

Where: A = 2q13; B = 3q2; C = 3q7;
D = 4q5DL&TL; E = 4q5Sprv2STM

From the results presented in Table 7.103, the following model is generated for a successful project management outcome for the management style to be followed:

Success of Management Style of the Team Project Outcome =0.239 + 0.124(A) – 0.038(B) + 0.128(C) + 0.001(D) + 0.026(E)

Where: A = 2q13; B = 3q2; C = 3q7;
D = 4q5DL&TL; E = 4q5Sprv2STM

In order to be able to utilise the above models as predictors, these will need to be tested further by conducting case studies and verifying the results.

The remaining models, for the other four project management outcome factors, are presented together with the tabular reports in Appendix D (see Tables AP.D-7.104 to AP.D-7.107).

### 8.7.2 Factor Analysis

From the factor analysis Tables 7.108.1, 7.108.2 and 7.108.3 (in Chapter 7), the interrelationship between the variable objects was extracted, thereby determining the underlying factors. Further to the detailed points raised in section 7.7.2 (in Chapter 7), factor analysis indicates a strong correlation between successful and acceptable outcome and at three component levels for the three sub-processes under investigation. In particular there is always a strong correlation in the first component between the management style followed for the different structure levels, (Discipline Leader to Site Team member) and the successful / acceptable project outcome, despite the fact that Hypothesis 1.1.3 was not proven. Also for a successful outcome there is a very strong correlation in the second and third elements for considering the PM's profile during the selection process and the lowest level at which the project team is defined.

Similarly the other two sub-processes (selecting the team members and structuring the team) have strong correlations with the management style at different levels, as well as strong correlations at the second and third component with profiling used as part of the selection process and structuring. There are also a number of moderate correlations, at different components, with the most important one in Table 7.108.2 in Chapter 7, where, for a successful project outcome in terms of structuring the team, there is only a moderate correlation with the lowest level at which the project team is defined.

In terms of the other project management outcome sub-processes – monitoring and control, reporting, conflict resolution and efficient use of resources - see Tables AP.D-7.108.4 to AP.D-7.108.7 in Appendix D, there are strong correlations at the first component with the management style followed at different organisational levels. Some of the sub-processes also have strong correlations at the first component with structuring of the team. However, for selection of PMs and team members, correlations are only at lower level components.

## *8.8 Validation process*

As described in the Research Method Chapter, results were to be validated by conducting saturation interviews. Therefore, during the months of May to August 2009, seven interviews, or 23% of the interviewed population, were conducted with PM practitioners, from Project Director to PM level, of which two were employed by client organisations and five from contractor organisations. Following on from the presentation of the research objectives and the results, a question and answer session followed and, finally, the interviewees were asked to complete the validation questionnaire (see Appendix F 6.1). The findings from the responses obtained are described below.

### 8.8.1 Validation of Research Findings

All interviewees agreed, 100% response, that the results obtained regarding the current project management practice in the areas investigated, as well as that of complexity of interconnections, are a true representation of the current status. In particular interviewees confirmed that characteristics of the complexity of interconnections are not considered when performing the selection of team members and structuring the project team processes, or when considering the management style to be adopted.

Thus, results from the validation interviews primarily achieved saturation and confirmed PM practitioner acceptance of the findings. They also demonstrated the validity of the descriptive and inferential statistical results obtained and the respective hypotheses.

## *8.9 Summary*

In this chapter, analysis of the results obtained was conducted in response to the research objectives.
Statistical significance of sampling and the generalisation of findings were established; indeed it was shown that the response from the stratified sample represents a PM population of up to 150,000. As the sample was equally spread in representing both Client and Contractor PMs, it provided the benefit of reflecting diverse opinions on the sub-processes investigated.

The analysis of results obtained confirmed that construction projects still operate in a more complex and dynamic environment, which has, however, become friendlier. Despite this and the fact that PM practitioners are aware and given guidance about team selection techniques, these are not used at any level within the project team. In particular personal profiling is not used at all and the sub-process of selecting team members remains one that is based on subjective criteria. When structuring project teams and although respondents indicated that the sub-process is performed to the lowest project levels, when statistically examined, the findings could not be validated. Also established that PM practitioners continue to implement structures labelled in the literature as being unsuitable for construction, e.g. as matrix and functional. In terms of the management style adopted, again practitioners indicated that the egalitarian and situational styles are followed; however, no statistically significant results could confirm the response that these are implemented to the lowest project organisational level. Analysis of results also ascertained that 'selection of team members' and the 'management style followed' are within the top three sub-processes which contribute towards a successful project management outcome. However current levels of implementation achieve only acceptable success. Ranking of the structuring of project team(s) sub-process trailed below 'monitoring and control' and the acceptability of its outcome, which was the lowest of the three sub-processes investigated, is fairly disquieting considering the wealth of literature available.

With regard to the investigation on complexity, analysis of results has established that there is no clarity or definition. Organisations identify complexity as technical, time or commercial. However, PM practitioners consider a number of soft issues, such as interconnections, communication, team structure, as sources of complexity. Furthermore, the analysis indicated that no tools are currently available for the management of the effects of complexity. For the sub-processes investigated, it was established that actions discussed with and taken by PMs do not consider the effects of the characteristics of complexity of interconnections, nor do they perform to a level that will enable the management of its effects.

The examination of the effects of complexity of interconnections upon the project performance, through five case studies and for all stages of the project lifecycle, established an inverse correlation. Results portrayed an average drop of 40% for the case studies in construction, which is significant considering all the recent drives towards improving performance. Complexity characteristics linked directly to reasons for delay established unequivocal links between performance and complexity of interconnections. Replication was established and, in addition, the graphical output resembled that of underdamped transient motion, which confirms the literature reviewed regarding the non-linearity of projects.

Statistical output, descriptive as well as inferential, was used to perform hypothesis testing and, as indicated, Hypothesis 1 and 2 together with their sub-hypotheses were refuted, with the exception of Hypothesis 2.4, which investigated the correlation between the effects of complexity of interconnections on the project performance. Thus, the following were established:

- The available techniques for setting up (selecting and structuring) project teams and the management style in construction projects are not implemented down to the lowest project organisation level.
- With the current techniques and approach by PM practitioners, project management outcome does not correlate positively with the implementation of team set up (selection and structuring) processes down to the lowest project organisation level and the management style.
- Complexity of interconnections characteristics are not taken into account when selecting project team members, structuring the team or considering the management style to be followed.
- The effects of complexity of interconnections have an inverse correlation with the project performance.

The above will be discussed further in the following chapter.

# Chapter 9 - Discussion

## 9.1 Introduction

This chapter discusses the findings from the implementation of the multi-methodology research. The reasons behind deciding on a multi-methodology research approach are initially reviewed in order to set the scene and the context of the subject. Discussion and review of the postal questionnaire results against the literature review, follows in section 9.2, since this phase is about understanding the current status of the three processes under investigation. In Section 9.3, the reasons behind researching the complexity of interconnections are discussed, together with the analysis of the quantitative results obtained from the 31 interviews conducted with project management practitioners. The findings are also compared with points covered in the literature review. Results regarding the project management outcome from the postal survey and the five case studies are discussed in Section 9.4, together with the effects of complexity of interconnections. Finally, in the last two sections of the chapter the analogy established between the findings from the case studies and existing theory and the results from the validation interviews are discussed.

## 9.2 Setting the scene

In setting the scene, a discussion will be conducted regarding the importance of the research multi-methodology and the quantitative results obtained from the stratified sampling.

### 9.2.1 The methodology

In order to understand construction, there is a need to implement more than one research methodology (Dainty, 2007) and interweave quantitative and qualitative techniques, which will enable measurement, understanding of peoples' behaviours and a detailed examination of intricate issues. Through the multi-methodology, a progressive approach was implemented in order to establish causation of the complexity of interconnections, which occurs when performing the three project management sub-processes under investigation, as well as the effect these will have on the project management outcome / performance of the project. In particular:

- The survey sought to establish the levels of compliance with theory for the three sub-processes under investigation,
- The interviews sought to establish how the construction industry perceives complexity in general, any tools or processes available to practitioners and any guidance given by their companies. Also they aimed to identify and understand the acceptance and applicability in construction of the 16 complexity characteristics defined by Lucas (2000b), to establish how these can be considered in project management and, in particular, enable the management of the complexity introduced by interconnections from the three topics

investigated. Thus, a framework of operation using the proposed actions as a tool to manage complexity through its characteristics can be established.

- Through the five case studies, to portray how causes derived from the effect of the complexity characteristics on the three sub-processes affect the project performance.

Thus, the testing of Hypothesis H1.1, including its sub-hypotheses, through postal questionnaires was considered as a step which would allow the validation of some aspects of the literature review, including many similar studies. Therefore results from testing Hypothesis 1.1 will be considered as confirming or refuting what has been regarded as common knowledge by practitioners and other authors (Morris, 1994; Ogunlana 2002; Raiden et al., 2004; Green, 2006; Thomas and Mengel, 2008), as well as allowing triangulation with previous deductions.

The significance of the methodology also lies with the fact that both sides of the construction project were considered and included in the survey – Client and Contractor PMs - as both perform tasks relevant to the areas under investigation. The participation of 91 PM practitioners, from Site Managers to Project Directors, added particular weight to the quantitative part of the multi-methodology, as well as enabling generalisation of the findings for the UK construction industry. Even more significant is the fact that 84% of the respondents were very senior and 72% of the total number of respondents had more than 10 years experience thus presenting a true reflection of the practices implemented in the areas investigated through their extensive experience.

For Phase 2, the 31 interviews conducted explored the concept of complexity and again including Client and Contractor PMs whilst covering a broad range of professionals - from Site Management to Director status. They allowed for the establishment of a fair and wide view of practitioners' understanding of the subjects under investigation, as well as the development of a set of actions which were used for the creation of the framework for the management of the effects deriving from the complexity of the interconnections.

Apart from establishing repetition (Yin, 2003), the five case studies covered all phases in the project lifecycle enabling a wider examination and revelation of the effects of the complexity of interconnections on project performance, in terms of the sub-processes under investigation. Further discussion points, with regard to the case study results, will be given below.

### 9.2.2 The quantitative results

The significance of the quantitative method and the results obtained, apart from proving points already demonstrated by the literature review, lies with the need to:

- Establishing a base at the particular point at which the research was conducted;
- Ensure the timeliness of the research in these fast moving times;

- Ascertain what is happening now in terms of processes, as the project management practices move rapidly under the pressures of:
  - Being characterised as stuck in a time warp in the 60s (Morris, 1994);
  - Being a profession or an occupation (Turner, 2005; Gorog, 2006); and
  - Institutionalisation and certification (Crawford, 2005; Thomas and Mengel, 2008).

**On Selecting Team Members**

The process of selecting project team members is investigated, not as an "accept – reject" process, but as one which understands the individuals that come together to form a team / teams that will contribute to the successful delivery of the project, thus qualifying the fact that personal profiling was selected as a process to be investigated using postal questionnaires.

The quantitative results obtained from the postal survey confirm that personal profiling is not considered when selecting PMs or project team members and Hypothesis 1.1.1 was refuted. The two key steps in the formation of a project team, steps 2 and 3, as indicated in section 3.2.1, are clearly not implemented and no consideration is given to team design (Kozlowski and Ilgen, 2006).

Designing and setting up a team is not an easy task. Calling a work group a team and giving them duties and decision making responsibilities is not really the right start (Donovan, 1996). Before this is done, the team needs to be able to communicate, resolve conflicts and solve problems effectively. Appropriate behaviours, skills and processes for working together effectively need to be developed so that teams can be built which can then be empowered. Creating a team means bringing together people who will combine their efforts to create a product or service. The problem with the UK construction industry is that it is fragmented and operates through contractual arrangements between various parties/companies which come together under considerable 'environmental' pressures, as shown in Figure 7.3. Therefore there is no attempt, from within the construction companies, to establish a truly, integrated, team working approach.

By not following selection techniques, there is clearly more of a groupthink approach rather than teamthink, which confirms Donovan's (1996) and Belbin's (2000) points regarding a lack of necessary interdependence between team members.

In order to create a team environment and establish clusters, principally we need to examine the structure, the jobs, measures and rewards, so that we can create the necessary '*interdependence and autonomy that is glue for teamwork.... Team work does not just happen, it requires time and effort to develop and maintain*' (Donovan, 1996). This is obviously the challenge for construction because of the short term duration of projects and the current attitudes towards team-selection techniques, as evidenced in the quantitative results.

The survey indicated that, in terms of the selection criteria used by practitioners (see Tables AP.D-7.25 and AP.D-7.26 in Appendix D), these do not follow what has been described by Lao Tzu (Pheng, 1995), Thompson (1996) and Turner (1999). Personal development and profiles are almost totally ignored. Thus the benefits identified by Benton (2000), as well as the modern project requirements (Winter and Smith, 2006; Pells, 2007), are not considered. Technical and Capability skills prevail over those that are required to build teams. Known selection techniques, of which practitioners have also indicated an awareness, are not implemented (see Table 7.17). Therefore benefits identified (Lawrence and Martin, 2001; Cattell and Schuerger, 2003; Belbin, 2004) are not conveyed to projects. In fact the research findings confirm what has been highlighted in literature by Green (2002, 2006), Ogunlana et al. (2002), Raiden et al. (2004), Egan (2005) and Pells (2007). In particular the findings confirm Egan's (2005) conclusion that no selection techniques are followed. Thus, the quantitative results are confirmed and triangulated by recent studies conducted by others.

In terms of the project environment, which has been extensively discussed in project management literature (Mintzberg, 1979; Lansley, 1994; Shirazi et al., 1996), findings indicate that it is not valued and the complex phenomenon of team formation (Dal Forno and Merlone, 2005) remains deficient. Subjective criteria for PM and project team member selection still prevail (Ogunlana et al., 2002; Raiden et al., 2004) and the 'system' insists on not considering soft issues relevant to staffing.

Thompson (1996) suggests that homogeneous teams are allocated on simple, straightforward projects and heterogeneous teams on complex projects. However, as the results indicate, if there is no selection process how will it be possible to identify who can be a member of a homogenous or heterogeneous team and the respective types of projects? Within the classification given by Thompson, there is also a notion that complexity in projects can only be a technical issue, *therefore complexity is overcome by putting together small teams*. However, this approach does not consider the fact that the larger the number of teams, the bigger the number of interconnections and therefore the greater the likelihood of an increase in the complexity of interconnections. Therefore it can be seen that some proposed actions act as a factor that increases the complexity of interconnections without considering its effects.

In general, as shown in Figure 8.4 and Tables 8.7 and 8.8, the survey results indicate that there are no statistically significant results that can confirm that practitioners use team selection at any level.

In terms of the effect of the moderating variables (see also in Appendix D, Table AP.D-7.100 and Figures AP.D-7.76, AP.D-7.79.1 to AP.D-7.79.5), none have been identified as being critically influential. When reviewing the factors by strata, the Client PMs have suggested

Project Type (42%) as having a 'very important' influence on the sub-process of selecting team members, whereas the Contractor PMs have identified Budget (46%) as a 'very important' moderating factor. The former obviously represents the Client PMs' concern about the people that will join their team and deliver the project to the requirements. The latter, however, represents the Contractor PMs' concern that budget restricts the process (Green, 2002), and, therefore, compromises will have to be made. The results also indicate that selecting team members is not considered as a 'tool' for responding to the complex environment (Thamhain, 2004a; Benton, 2006). For this reason the multi-methodology turned towards understanding the issues of complexity.

Finally, the quantitative results also confirm what was feared by Belbin (2000:7), namely that the word 'teamwork' *'became an invitation to all and sundry to shelter under the mantle. To proclaim a belief in teamwork became a safe way for those in middle management and in personnel functions to gain general approval'*.

**On Structuring Project Teams**

The significance of the sub-process of project organisational structures identified in the literature review, is confirmed by the results obtained from the direct questions in the survey. Respondents indicate with a 65% majority, that the responsibility for setting up the overall project structure is with the Client PM or the Contractor Project Director. For the lower levels, see Appendix D Tables AP.D-7.34 to AP.D-7.36, the responsibility lies with the PM. However, this concentration of 'power', in terms of setting up the project structure, reinforces Donovan's point (1996) that construction has remained enclosed and the concept of '*self-directed work teams*' has yet to be implemented.

Responses also indicate that the industry has not embraced new forms of organisation. The industry remains fixed to the 'matrix' and 'functional' approaches of structuring, as can be seen in Table 7.39. This fixity, despite the fact that samples were from different environments, indicates that, when structuring project organisations, the environment is not considered and, therefore, the benefits identified (Hughes, 1989; Belbin, 2000; Moore, 2002; Andersen, 2003) do not transpire. Belbin (2000) describes how, when the teamwork principles are implemented at the lowest level, not only do they produce results, but it also shows in the people's conduct, persona and behaviour, '*If jobs are not formulated to hang together as a dynamic entity within a coherent system, the effectiveness of the whole will be severely weakened*'.

Perhaps an encouraging sign is that 27% of the respondents (see Table 7.39) have indicated that at construction team level the 'Team' approach to structuring is implemented. This limited 'excitement' however, is lessened by the high level of 'Don't knows', which at the professional level of respondents should be considered disappointing, emphasizing Moore's (2002) point that construction does not ask 'how should we go about organising'.

Although construction has decentralised (Panas, 2006) in order to adapt to the complex environment (Mintzberg, 1973; Lansley, 1994), it does not follow an organic approach to structuring that will enable it to operate in a dynamic environment (Lansley, 1994). Hypothesis 1.1.2 was refuted, thus confirming the Shirazi et al. (1996) findings that construction does not organise itself to improve the management of its project, which draws attention to the fact that for more than a decade there has been no improvement. Powerful concepts such as Social Network Theory (SNA) and Actor Network Theory (Tichy et al., 1979; Loosemore, 1998; Mead, 2001; Blackburn, 2002; and Behrend, 2006) could provide extensive benefits to the way the industry organises and delivers projects. Table AP.E-9.1, in Appendix E, provides a summary of the SNA properties, attributes and other characteristics which are used in the supplementary findings / propositions of this research regarding 'finite structures' (see Appendix F_6.3).

The industry, as will also be shown below, remains fixed to the transactional approach of structuring, with all the problems that this entails (Walker, 1996; Shirazi et al., 1996; Moore, 2002; Busby and Hughes, 2004). Statistical tests also performed, see Tables 8.9, 8.10 and 8.11, confirm that there is no evidence that project structuring is defined to the lowest levels, thus confirming the literature review findings (Winter and Smith, 2006; Green, 2006).

As indicated earlier, in terms of the effect of the moderating variables (see Appendix D, Table AP.D-7.100 and Figures AP.D-7.77, AP.D-7.79.6 to AP.D-7.79.10), none have been identified as being critically influential. When reviewing the factors by strata, the Client PMs have identified Project Duration and Budget, 44% and 46% respectively, as having a very important impact on the sub-process of structuring the project team, whereas the Contractor PMs have identified Project Budget and Procurement Method, 43% and 41% respectively, as a very important, influential, moderating factor. The former obviously represents the Client PMs concern about tightness of time and cost affecting the resourcing that will be done by contractors and therefore the required levels of people that will join their team and deliver the project. The latter, however, represents the Contractor PMs' concern that budget and the procurement method restricts the process (Shirazi et al., 1996; Moore, 2002) and therefore compromises will have to be made to the structuring of the project.

**On Management Style**

The analysis of results, as shown in Table 7.40 Chapter 7, indicates with an overwhelming majority that no formal decision is taken regarding the management style to be followed on projects from either the Client or Contractor. This, as highlighted by Gardner (2006), contradicts the current leadership requirements, which want the PM to consider how to lead and mobilise the inter-disciplinary teams and utilise the peoples' skills.

In terms of the management style followed during the execution of the projects, responses indicate that a combination of the 'situational' and 'egalitarian' styles is followed (see Table 7.41 in Chapter 7 and tables AP.D-7.41.1 and AP.D-7.41.2 in Appendix D) but not at a statistically acceptable level according to the criteria set. Interrogating the responses given regarding the style followed at the various organisational levels, the results establish that the prevailing style is egalitarian, with the exception of that at the level of Site Team members, which is one of standard processes and control. This provides further support for Donovan's (1996) argument regarding lack of self-directed work within construction. The behavioural paradigm has not yet found its way to the lowest levels of the project organisation, despite the fact that middle level managers display a more 'extraordinary vision of the future' (Parlington, 2003). The findings also confirm points made by Green (2006) regarding the management approach at the lower organisational levels and the formation of glass ceilings.

Correlating the above results with those extracted from Tables AP.D-7.43.1 to AP.D-7.43.5 in Appendix D, which present the prevailing culture per project organisational level, provides clear evidence that both Client and Contractor PMs implement a strict hierarchical approach (Whatley, 1994) with people throughout the structure being in 'structured places'. The structured approach minimises team flexibility and integration and PMs are not 'in the system' but 'on the system' (Edum-Fotwe and McCaffer, 2004). PMs still consider themselves as the orchestra conductors (Handy, 2000), instead of accepting the new metaphor of jazz (Harris, 2006) and ultimately that the evanescent nature of projects requires a management style which will be fit for leading successfully non-linear, complex adaptive systems (Moore, 2002). Another discouraging point from the above-referenced tables is that the level of 'Don't Knows' remains at around 20%, again problematic given the years of experience of the sample.

In terms of the effect of the moderating variables (see Appendix D, Table AP.D-7.100 and Figures AP.D-7.78, AP.D-7.79.11 to AP.D-7.79.15) none have been identified as being critically influential. When reviewing the factors by strata, both Client and Contractor PMs identified Project Budget, by 44% and 46% respectively, as having a very important influence on the management style to be followed. This is a direct indication that transactional interactions affect the management approach.

## 9.3 Exploring complexity

In this section the reasons for covering the topic of interconnections, as well as the qualitative results extracted from the 31 interviews, are discussed.

### 9.3.1 Why Interconnections

Deterministic / decomposition models of project management are failing the practitioners (Morris, 1994; Williams, 1999 and 2002; Bertelsen, 2004). In addition standardisation, certification and passive sources of information impose more 'restrictions' (Crawford, 2005; Rees, 2006; Thomas and Mengel, 2008) even though the '*normative*' model of professional preparation has failed (Jaafari, 2007a). The state of flux in which the practice of project management finds itself (Soderlund, 2004; Turner, 2005; Gorog, 2006; Thomas and Mengel, 2008) does not help and amongst other things new '*fads and fashions*' are added with, for example, the introduction of 'the College of *Complex Project Management' and another set of* competencies (Whitty and Maylor, 2009).

Over the years, a number *of authors* (Thompson, *1967; Applebaum, 1982; Walker, 1996;* Baccarini, 1996; Williams, 1999; Lucas, 2000b; Moore, 2002; Stacey, 2002; Thomas and Mengel, 2008) have highlighted the importance of interconnections between organisations, parties, systems *and individuals* and more particularly its significance in the construction industry, which is highly dependant on all the above as well as having to consider them in an evanescent environment.

Complexity theory totally acknowledges the inability to comprehend the whole through an understanding of the parts, and instead aims to understand the whole through the interaction of its parts. Therefore as proposed in the literature review, and in particular in the case of project management, we need to consider the complexity of interconnections, which exists everywhere in social, cultural, technical, behavioural and other inter-relationships. Moore (2002) concurs with Lucas (2000b) and Baccarini (1996) in that internal and external interconnections cause complexity and the more interconnections, the higher the complexity. Particularly for PMs, Moore (2002) states that they should be prepared to accept and use positively the change that will occur at some point in the duration of a project when the 'imposed' organisational structure will be made redundant as the project develops its own 'life'. As early as 1972, Morris, referenced by Shirazi et al. (1996), argued that, in order to reduce uncertainty and complexity in construction, projects should be structured using a semi-autonomous approach, with managerial attention focusing on the interrelations of the organisation sub-systems.

Correlations have also been made earlier between the construction industry and complex adaptive systems, in terms *of how these consist of many relatively independent* parts which are highly interconnected and interactive (Breuner, 1995) and which are considered under the theory of complexity (Lucas, 2000a; Stacey et al., 2002). Accepting that projects are streams of disturbances (Wild, 2001) *with incubating pathogens* (Busby *and Hughes, 2004), allows all* the parties to understand that they are 'in for a ride', working with the others for:

> The management of transient, dynamic and complex adaptive systems/agents, so as to deliver the expected change within certain parameters which are set by seemingly ordered and stable environments.

The fluctuations within the projects and their inevitable crises and uncertainties (De Mayer et al., 2002) can be guided or regulated if means are introduced to enable the management of the disturbances and the crises. The new paradigms and metaphors should enable PMs to devise bifurcations and introduce autonomous agents as the means to manage the situation(s) and impede the introduction of chaotic flow, without stopping the disturbed flow. The introduction of such means, i.e. bifurcations, could be by design or by simply being considered within flexible adaptive systems of work. Teams, denoting here the management teams, have to know 'when', understand 'why', and manage the 'how' and 'what is needed' when considering introduction of the means. This is not to say that they will be able to foresee the future or that everything is pre-prepared and structured, but rather like good strategists/chess players, they should look ahead and be prepared with the means that will allow them to include crises as part of the required solution. During calmness (Wild, 2001), the team ponders the next possible obstacles, preparing the ground, moving the right pawns, perhaps preparing the next set of attractors and bifurcations.

Having identified the *general axioms of the complexity of interconnections* (Lucas, 2000b), it should be possible to consider these in terms of project management phraseology and therefore establish means to manage its effects. Deciphering and mapping complexity of interconnections characteristics, to be relevant to the project management processes, enables the development of the means and/or approach for minimising or maximising its *effect on projects. The parameterisation of these characteristics will enable a better* identification of actions, definition of the boundaries and the interweaving / reciprocity between the project management sub-processes.

### 9.3.2 The Qualitative Results

In order to introduce a new concept (set of characteristics) to practitioners, exploration of the basic understanding level is necessary, not only of the characteristics under investigation but also the topic of complexity in general, as well as that of the complexity of interconnections. Based on this approach, a set of interviews was planned as part of a multi-methodology. The aim was twofold:

- To examine the above; and
- To validate and arrive at the acceptance of using the characteristics as the means to manage the complexity of interconnections.

The 31 practitioners interviewed were again from different levels of the project management hierarchy (from Site Managers (3) to Project Directors (4)).

**Findings from the review of General Complexity**

From the responses to the interviews and the analysis, it is clear that, with the sampled strata, there is no definition given, nor any tools for managing the complexity of interconnections. The concentration of responses on the causes of task complexity causes (Girmscheid and Brockmann, 2008) confirms the practitioners' dependence on mechanistic means of managing projects. It is also interesting to note that the three lowest responses, in terms of identifying complexity, were those of management style and social and cultural causes. However, when asked to identify complexity factors that originate from the project organisation, respondents indicated clearly that issues such as interfaces, inappropriate organisational structure and management style are within the top six main reasons.

As noted previously, there was a distinct difference between company and individual practitioners' identification of the causes of complexity. Practitioners also showed a clear inclination towards soft issues. The vast majority of the interviewees agreed with the definition of complexity of interconnections, thus providing strong support to this research. Respondents also confirmed that, within their stratum, complexity characteristics are not considered when setting up project teams (selecting and organising) or for the management style to be followed. The interview findings demonstrate a clear disparity between academic and practitioner understanding of complexity. Even more interestingly, there is a gap between employers and practitioners, which could be due to individuals' awareness and understanding of project management issues that have not yet been raised at company level. Other project management sub-processes, e.g. Risk Management, planning, briefing, etc., are considered as tools for managing complexity and that is mostly on the task complexity side. This highlights further the need to develop tools which can be used by practitioners to manage complexity.

Finally, 71% of interviewees, as shown in Figure 8.8, agreed that the three sub-processes under investigation are not used in a manner that will reduce complexity. The response, although classed as subjective and therefore of no statistical significance, provides an indication of the practitioners' supportive view of this research.

**Findings from the investigation into Complexity Characteristics**

The purpose and the importance of adopting the particular methodology were described previously. The extensive interviews, for which the researcher is thankful to the participants, served the purposes for which they were planned.

Responses, described and analysed in detail in Chapters 7 and 8, identified low levels of managing the effects of the characteristics of complexity of interconnections when implementing the sub-processes under investigation and Hypotheses 2.1, 2.2 and 2.3 were refuted. In identifying actions to be taken to manage these effects, interviewees were able to comprehend the deciphered complexity characteristics, understand the correlation to their everyday activities and agree on the proposed actions. Proposed actions, discussed with and agreed by the interviewees, structured existing project management practices around the complexity characteristics thus providing a simple framework. Furthermore actions were not considered as another process which will require extensive effort. These allowed for:

- Phased and repeatable monitoring of actions / improvements undertaken;
- Providing a flexible and scalable indication of the levels of complexity management achieved for each sub-process;
- Flexibility in adding further actions / activities per characteristic;
- Ease-of-use of the framework provided for the extraction of reports / graphs; and
- Ease of cascading the use of the framework down to smaller teams.

The extensive graphic and tabular reports generated from the responses, shown in Chapters 7 and 8 and Appendix D, indicate clearly that:

- Actions taken were at the low to mediocre levels of managing the effects of the complexity of interconnections;
- Responses for the sub-process of selection of team members achieved a relatively low level of managing the effects of the complexity characteristics, despite responses in the general complexity questions identifying team interfaces and individuals' behaviour as the top factors of complexity, by 94% and 81% respectively (Figure AP.D-7.6 in Appendix D).

Finally, interviewees indicated that, during the project lifecycle, six to seven major teams are formed and disbanded (Figure 7.33). This finding, although it corresponded to a high organisational level (see section 8.3.2), gives a clear indication of the size of the problem that can be created if the characteristics of complexity of interconnections are not considered. This finding also gives an indication of the minimum number of times a framework, which will enable the management of the effects of complexity, will have to be used.

## *9.4 Linking Complexity and Project Performance*

The results from the quantitative analysis of the project management outcome, those from the five case studies and the analogies to existing theory, will be discussed in the sections below.

### 9.4.1 The Quantitative Results and the Findings

The analysis of the quantitative results, with regard to the contribution of the seven project management sub-processes to the quality of the project management outcome (Collins and Baccarini, 2004), indicated that practitioners rank highly the management style (72%) and the selection of the team members (67%) sub-processes (as shown in Table 7.45). With regard to the structuring of the project teams, responses indicated that it is considered as one that contributes as much as that of 'monitoring and control' or that of 'conflict resolution'. This is despite the fact that the majority of respondents indicated that their projects are structured down to the lowest level. There are also conflicting responses for the selection of the team members' sub-process, as the results indicated that no selection process or personal profiling is performed.

From the results obtained regarding percentage rate of success of the sub-processes under investigation (see Table 7.47), it is clear that respondents were not so satisfied with levels of achievement. The rate of success was mediocre - low (40%) for setting up teams (selection and structuring) and low (50%) for the success of the management style. The results depict the current level of use of the sub-processes not contributing towards a successful project management outcome. This point is also confirmed by the statistical analysis for which the results are shown in Table 8.14. Even monitoring and control, a sub-process so deeply rooted in the current approach to project management, has scored the lowest success rating of the seven sub-processes. Both strata, with regard to selection of team members and structuring of projects, have given similar responses to the levels of success, thus indicating that there is room for improvement from and for both sides of the project. Client PMs indicate a higher level of success for the management style followed which could be construed as a by-product of the friendlier approach to procuring projects. However, Contractor PM practitioners indicate that there is much more room for improvement. For this particular strata and since respondents included a much wider spread – from Site Manager to Project Director, it can be construed as an indication that improvements to the sub-process are required both internally (within the contractor project team) as well as externally (between client, contractor and subcontractor).

Thus, an apparent shift towards the behavioural paradigm, followed by a drive towards the softer issue of an egalitarian style of management, continues to be underpinned by the control mechanisms. This, due to a lack of more appropriate and supportive processes, could be seen as the practitioners' response to a complex and dynamic environment, an attempt to comply with a proceduralised project management environment, or finally as a response to the Traveller's Dilemma (Basu, 2007).

## 9.4.2 The Case Studies Results and the Findings

The detailed case studies results and analysis presented in Chapters 7 and 8 undoubtedly confirm replication (Yin, 2003). As can also be observed (see Figures 7.40, 7.48, 7.56, 7.64, 7.72, and 7.74 in Chapter 7), as the effect of the complexity of interconnections increases, or is not managed, project performance decreases. This effect is also presented in a simplified graphical form depicting 'Cumulative Duration Planned' and 'Cumulative Duration Achieved' against time (see Figures 7.41, 7.49, 7.57, 7.65, 7.73 in Chapter 7). Tabular reports, as well as graphs, depicting weekly and cumulative frequency of complexity characteristics causing delay, per case study, have been included in Appendix D. From Tables 7.99 and 8.6, it can be seen that, for the two monthly reporting periods during which the case studies were conducted, almost all the complexity characteristics occurred as a cause of delay. Another characteristic of all five case studies was the commonality of causes of delay regardless of the project phase. This gives a clear indication that complexity of interconnections affects team member selection and project organisational structure irrespective of the phase. Thus, the importance of the two sub-processes is elevated even further. However, as noted earlier, there is a distinct lack of reasons / causes of delay due to the management style. This can be explained by considering the Traveller's Dilemma (Basu, 2007), which explores the irrational choices made by people when they have to choose for their own benefit, exposure or protection, as opposed to the benefit of their company / project.

The case study results indicate a significant percentage drop in project performance for both the case studies in construction, 57% drop, (see Figure 8.2) as well as that for all case studies, 39% drop, (see Figure 8.3). This raises a number of points regarding practitioner PMs and their daily work, particularly how it can be improved and the levels of training and tools available that will enable them to project manage projects successfully and satisfactorily. Some more generic points are also raised from the case study results, for example:

- What has happened in the last 15 years, since the Latham report, in terms of improving performance of projects in construction projects?
- Has complexity of interconnection increased considerably in the construction industry in the last 15 years?
- If project management has remained stuck in a time warp in the 60s (Morris, 1994) due to the influence of the machine metaphor (Morgan, 1997), how would new initiatives such as PRINCE 2 and certification improve performance?

The results indicate a direct link between project performance and induced complexity of interconnections and the investigation examined the causes of delay due to each individual characteristic for the three sub-processes. However, the characteristics of complexity of interconnections are / should be common to all other project management sub-processes, e.g. monitoring and control or efficient use of resources, etc. Thus, as can be seen in Tables AP. D-7.68 in Appendix D and 8.6, more than one characteristic can have the same cause of delay (e.g. R08) and similarly, the same cause of delay could belong to more than one sub-process (e.g. R28). Therefore there can easily be other sub-processes contributing to the drop of performance recorded. The overall drop recorded does not change, but the contributory factors could simply be wider than those presented in this investigation.

Understanding how each complexity characteristic affects each sub-process and identifying actions so that it can be managed, as described by the interviews process, enables PM practitioners to take precautionary steps at the appropriate time. The quantitative results identified the importance as well as the contribution of the three sub-processes towards the project management outcome and were discussed in section 9.4.1 above. Complexity of interconnections was examined in section 9.3.2 and, in particular, the importance of the findings / results from the interviews highlighted the requirement for additional actions that will improve the management of each complexity characteristic. Finally the case studies proved Hypothesis 2.4 which states that the effect of the complexity of interconnections is inversely correlated to the performance of the project. Therefore management of its characteristics and the implementation of appropriate actions can only improve the outcome.

## 9.5 Analogies to Existing Theories

Insight and experience, when formulating Hypothesis 2.4, conjured that the anticipated graphical output from the effect of complexity of interconnections on project performance would be similar to that of an exponentially decaying curve ($e^{-x}$). However, as case study data were extracted and analysed, it became apparent that, due to corrective actions taken by project managers, the curve resembled more that of an underdamped transient motion. Thus the results prove, through the well established theory of vibration analysis and control systems, the higher order and non-linearity of project management. The correlation should enable some combined work between the two different disciplines, in order to establish the variables and how these could be 'translated' into simple project management terminology. With the above in mind, some simple thoughts that can be used for further discussion are presented below.

From the statistical correlations in the Analysis Chapter, a model can be generated where, by using the appropriate levels of natural frequency, the complexity characteristics are used as damping devices ('dampers'). The value allocated to each damping device and for the corresponding project management sub-process will be generated from the radar graphs which were developed from the interviews. Within other functions, 'dampers' will also be used for managing the effects of the complexity characteristics. The whole approach could resemble the treatment prescribed by psychiatrists who by using a range of different medicines that counteract each other achieve the required outcome. Therefore, and using the vibration control formula as a guide, a solution will be to:

a) Minimise the circular frequency element $[\sin(\omega(\sqrt{(1-\zeta^2 t)})+a)]$,

b) Identify the values of the damping ratio ($\zeta$) and natural frequency ($\omega$), which then

c) Will make the exponential decay function to equal A (see formula 2 in section 8.4).

Thus: $Ae^{(-\zeta\omega t)} = A$

In project management this idealistically is interpreted as performance at 100%, or otherwise 0% drop in performance. Therefore, from the above it can be deduced that:

$e^{(-\zeta\omega t)} = 1$ which $\therefore$ $(-\zeta\omega t) = 0$

However, the variables t and $\omega$ cannot be equal to zero, as every system has a natural frequency and the element of time is one of the basic factors in the project life cycle.

$\therefore$ $\zeta = 0$

This indicates that those stages that are, in their majority, governed by the exponential decay function should have the damping ratio equal to zero.

In terms of the circular frequency function, this will also have to be equal to zero (0), which means that the lag between the displacement vector and the force vector is zero (0).
So:

$\sin(\omega(\sqrt{(1-\zeta^2 t)}) + a) = 0$

If from the above $\omega \neq 0$ and $\zeta = 0$

$\Rightarrow$ $\omega(\sqrt{(1-\zeta^2 t)}) + a = \omega(\sqrt{(1-0)}) + a = \pm\omega + a$

So $\sin(\pm\omega + a) = 0$, and

$\therefore$ $(\omega + a) = 0$ $\Rightarrow a = -\omega$ (1), or

$(-\omega + a) = 0$ $\Rightarrow a = \omega$ (2)

From equation (1) above, theory indicates that we have a critically damped system, towards which most of the systems are aiming. However, in project terms, the above can be graphically depicted as shown below.

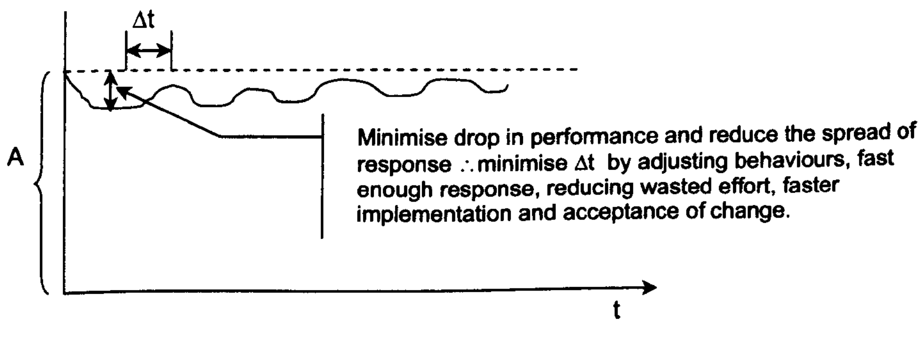



Figure 9.1. Graphical depiction of underdamped control systems curve applied to project performance

Therefore from the above it can be seen that with some elemental thinking a number of simple actions can be taken to define different variables for understanding non-linearity and then develop the means to help the practitioners reduce the effect of any type of influence on the project management performance.

## 9.6 Summary

From the literature review, a gap was established in managing the effects of the complexity of interconnections in construction projects. The three sub-processes of selecting project team members, structuring the team and the management style followed (as part of the management of the team) were selected to be investigated and an elaborate research design was developed.

The current status of implementation of each sub-process was investigated and results confirmed the literature findings that the processes are not implemented and, furthermore, that these are not employed down to the lowest project organisation level.

The research also established that the two main parties involved in construction projects - clients and contractors - neither define complexity nor provide PMs with any tools for its management. Other project management sub-processes, e.g. planning, risk management, commercial tasks, are considered by practitioners as those necessary to manage complexity.

Complexity of interconnections and its characteristics were investigated in depth, in terms of the three sub-processes and the effect on the project performance. A gap was identified in the level of actions taken by PM practitioners through the three sub-processes to manage the effects of characteristics and these had a detrimental impact on the project performance thus establishing an inverse correlation between the two variables. Furthermore the results determined that the effects of complexity on project performance, after the project team response, resemble that of an underdamped vibration control system. Thus providing evidence and complementing existing knowledge regarding current inferences on the non-linearity of project management.

All the findings were validated by PM practitioners who also agreed with the need for the development of a framework which would enable the management of the effects of the complexity of interconnections characteristics on the sub-processes of selecting team members, structuring the team and the management style followed.

The framework developed from this research and its validation will be described in the recommendations chapter.

# Chapter 10 – Recommendations

## *10.1 Introduction*

This chapter presents the recommendations arising from the investigations into the effects of the complexity of interconnections on the sub-processes of selecting project team members, structuring the project team and the management style followed in the UK construction industry. The research enabled an in-depth review of all four topics, their current status and some of the latest thinking. The investigations also established also the need for a framework that will allow practitioner PMs and companies involved in construction, to address and manage the complexity of interconnections through its characteristics.

Since the framework is the product of the research conducted and presented in the previous chapters, all the relevant processes are presented within this chapter. Thus, initially the objectives and the selection process of the framework are presented and this is then followed by the description of the framework, its characteristics, use and the output produced. Having developed the framework for managing complexity of interconnections, the framework validation process and the results are depicted and analysed and conclusions drawn from the comments received.

In addition to the framework, and from an extensive review of the results obtained, it has been possible to introduce a section that briefly describes some supplementary findings from this research which are elaborated further in the relevant appendix.

Finally, the limitations of this research are also presented.

## *10.2 Framework Selection*

The research results identified the need for the development of a framework which would enable the management of complexity of interconnections. Having established the need, a set of objectives are defined for the framework, which are as follows:

- To enable PM practitioners to identify the current status and the actions required to be taken for managing the effects of the complexity of interconnections.
- To develop a tool that will be re-useable and transferable to the project teams.
- To enable flexibility and adaptability to project issues / conditions.

The options considered are:

- A questionnaire framework,
- Flowcharts with actions,
- The worded process approach.

It should be noted that the acceptance of the questionnaire by the PM practitioners, in addition to the ease of use during the interviews, contributed to this being considered a possible choice together with the two other options for designing a suitable framework. The interview questionnaire for the complexity characteristics was designed with a dual purpose. The primary purpose was to enable ease of understanding of the complexity characteristic and its deciphered project management terminology. The secondary purpose was to allow for the identification and acceptance, by the PM practitioners, of actions to be taken for the management of each complexity characteristic. Both the questionnaire and the pick lists are shown in Appendix C-3.3.

The objectives enabled the development of a set of selection criteria for evaluating the different options available. The criteria are used in the decision matrix process in order to evaluate the three options considered and select the most suitable solution. The results, together with the selection criteria are shown in Table 10.1.

Table 10.1 Decision matrix for selecting the preferred tool for the framework

| | Criteria and Weight of each Criteria | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ease of Use | Continuity of Monitoring achievement | Flexibility | Direct link to Characteristics | Supporting implementation by Phase | Singularity of actions | Graphical presentation | Repeatability | Result |
| **Options** | 4 | 5 | 5 | 5 | 3 | 3 | 4 | 5 | |
| Questionnaire | 2*4=8 | 3*5=15 | 3*5=15 | 3*5=15 | 3*3=9 | 2*3=6 | 3*4=12 | 3*5=15 | 95 |
| Flow Charts | 2*4=8 | 2*5=10 | 2*5=10 | 3*5=15 | 2*3=6 | 2*3=6 | 1*4=4 | 2*5=10 | 69 |
| Worded process | 1*4=4 | 1*5=5 | 2*5=10 | 2*5=10 | 1*3=3 | 1*3=3 | 1*4=4 | 1*5=5 | 44 |

Note:

Option rating: 1 = Low, 2 = Medium, 3 = High Criterion weight: 1 = Low to 5 = High

The decision matrix indicates that the use of the interview questionnaire as the basis for the development of a framework is the most suitable solution. Based on the above, the decision was taken to proceed with the development.

## *10.3 Framework for Managing Complexity of Interconnections*

During the interviews it was established that the questionnaire structure, and in particular the linking of questions to the actions to be taken, enabled ease of use and understanding. Therefore using the functionality of MS Excel it was possible to link the point raised from the complexity characteristic to the actions and then to allocate an appropriate score. For each characteristic, the scored and weighted actions had been discussed and agreed by the PM practitioners during the interviews, providing the means to manage complexity of interconnections for each the sub-processes. Thus, the simple functionality of the software enabled the aggregation of scores and their transfer to the appropriate worksheet for the creation of graphs and reports.

From the practical side, and indeed for constructive use, it was decided that the framework for managing the complexity of interconnections (F4MCI) should enable the PM practitioner to:

- Easily identify actions required to improve the outcome;
- Establish the current level of managing the effects of complexity interconnections;
- Establish a long-term plan for actions required using the activities indicated in the framework, thus enabling the PM practitioner to improve the management of the complexity characteristic;
- Discuss the required actions with Senior Management;
- Discuss and cascade the use of the framework to the Project Teams for implementation;
- Be prepared for the introduction of the next project team(s);
- Extract graphical and tabular reports;
- Add further actions to the existing ones, in order to address more (if any) project specific issues.

## 10.3.1 Use of the Framework

The framework is designed to be used at any time during the project life cycle and, as previously described, the main objective is to identify the current status and the actions required for managing the effects of the complexity of interconnections. Each complexity characteristic is described and PM practitioners are prompted to indicate what actions they take to manage its effects on each one of the three sub-processes - selecting team members, structuring the project team and the management style they consider should be followed. Chosen actions are scored automatically and the results for each characteristic are aggregated. The framework instantly generates a graphical output together with a tabular report indicating the level(s) achieved. Results, as established during the interviews, are assumed as acceptable if they achieve an average score greater than 75%. Through the outputs, PM practitioners are advised if their scores are 'very low' and require extensive actions, 'acceptable' but require some further actions and finally if they are managing the effect of the complexity characteristic upon the sub-process.

Having established the current status and by examining the actions that will allow them to improve the level(s) achieved, PMs can identify what is required and how these actions can be accomplished. For each characteristic and sub-process, a plan can be established which can be agreed by Senior Management as well as the project teams. The introduction of new teams to the project can also be planned and team leaders can be given the framework to establish their required actions and report back to the PM. The advantages of the proposed framework are as follows:

- Ease of use. The software is readily available and easy to operate as a tool which PM practitioners have at their discretion and for which they are responsible;

- Ease of identifying actions against the complexity characteristic. This will link the problem with the required action;
- Provides weighted actions to overcome or support the effect of the complexity characteristic. Thus giving emphasis to more important actions that will allow the achievement of required level of results;
- Providing flexibility by allowing for additional actions to be introduced if and when required;
- It can be easily cascaded to the teams at the lower project organisation levels;
- During the execution, it does not allow the user to deviate. Proposed actions are against and for the corresponding characteristic;
- Provides continuous monitoring as well as supporting implementation by phase and by various organisational levels. This ensures a continuous improvement process;
- As the project progresses and new teams come on board, the framework can be used to identify and plan actions for the new team, as well as those that are already there;
- It enables the PM practitioners to work on each individual characteristic rather than aggregating actions (combining actions for a number of characteristics);
- Graphical as well as tabular results can be extracted and discussed with others and further actions can be identified and planned; and
- The result – the radar graph – is highly visual therefore making problem-solving easier (Keller, 1985).

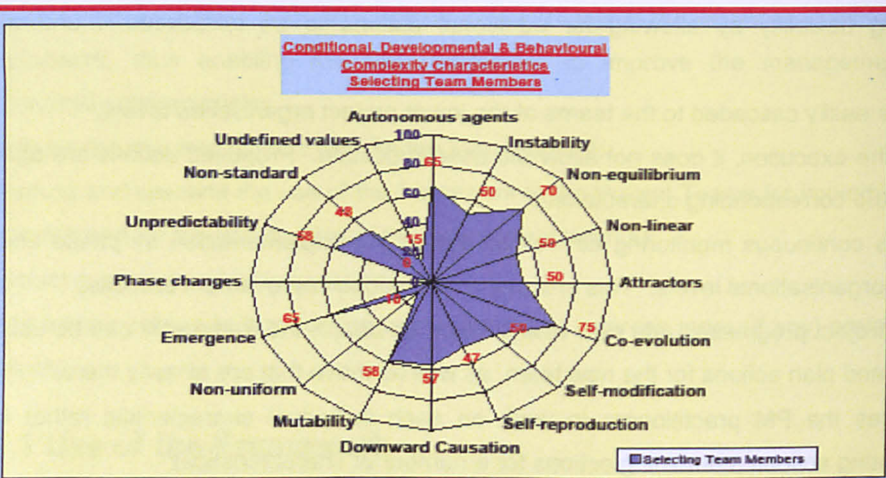
Despite the fact that other current project management tools and techniques have become memes (Whitty, 2005) which are easy to dispute or not follow, the framework with its flexibility can be updated continuously to encompass new developments in the processes addressed. Furthermore the framework can be used by the PM practitioner to identify areas of further career development which can be targeted against the results obtained and those planned for the duration of the project.

The attached CD contains the executable file which PM practitioners can use to manage the effects of the complexity of interconnections through the sub-processes investigated.

### 10.3.2 Framework Output

A sample of the framework's graphical and tabular outputs, described in Section 10.3.1, is shown in Figure 10.1. As a physical output, from running the F4MCI, Figure 10.1 describes the current level of managing complexity through the sub-process of selecting team members (similar graphical outputs can be produced for structuring project teams and the management style adopted). In this particular report / output none of the complexity characteristics are managed to an acceptable level. Therefore, and as described in the previous section, the output allows the PM, who has performed the required review through F4MCI, to understand how does she/he can manage each complexity characteristic and, by revisiting the actions section of the F4MCI she/he can decide on the level of actions required to be taken in order to manage the effects o complexity characteristics on the project.

**Complexity Characteristics' Management report**




**Selecting Team Members**

| Characteristic | Score | Comment on management of complexity characteristic |
|---|---|---|
| Autonomous agents | 65 | is not managed, more actions required |
| Instability | 50 | is not managed, more actions required |
| Non-equilibrium | 70 | is not managed, more actions required |
| Non-linear | 50 | is not managed, more actions required |
| Attractors | 50 | is not managed, more actions required |
| Co-evolution | 75 | is managed, some more actions are required |
| Self-modification | 50 | is not managed, more actions required |
| Self-reproduction | 47 | is not managed, more actions required |
| Downward Causation | 57 | is not managed, more actions required |
| Mutability | 58 | is not managed, more actions required |
| Non-uniform | 10 | is not managed, more actions required |
| Emergence | 65 | is not managed, more actions required |
| Phase changes | 0 | is not managed, more actions required |
| Unpredictability | 58 | is not managed, more actions required |
| Non-standard | 48 | is not managed, more actions required |
| Undefined values | 15 | is not managed, more actions required |

Figure 10.1 Combined framework output indicating levels achieved for managing complexity of interconnections by characteristic for the sub-process of selecting team members.

## 10.4 Validation Process

As described in the Research Method Chapter, results were to be validated by conducting saturation interviews. Therefore, during the months of May to August 2009, seven interviews, or 23% of the interviewed population, were conducted with PM practitioners, from Project Director to PM level, of which two were employed by client organisations and five from contractor organisations. Following on from the presentation of the complete research objectives and the results, interviewees were taken through the concept and functionality of the proposed framework. Live examples were given, using their responses to questions raised by the framework, and the outputs to their response were presented instantly. A question and answer session followed and, finally, the interviewees were asked to complete the validation questionnaire (see Appendix F-6.1). The findings from the responses obtained are presented and discussed below.

### 10.4.1 Validation of the Framework

Interviewees were requested to respond to a number of questions / statements regarding the framework developed and then select their response from a Likert scale from 1 (poor) to 5 (excellent). The questions asked and the responses obtained from all interviewees are averaged and indicated in Figure 10.2.

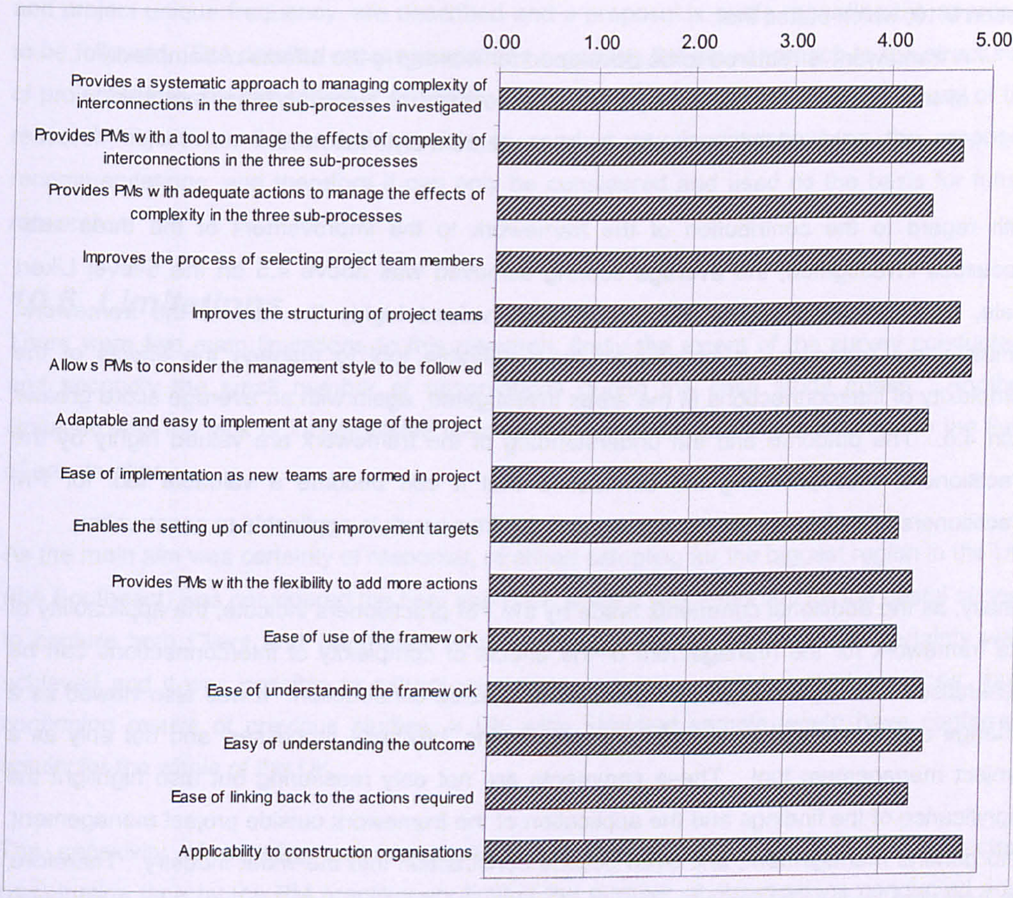



Figure 10.2. Average scoring of interviewees' response for the validation of the framework

All interviewees also indicated that the use of the framework is recommended for the UK construction industry. Other comments received were:

- 'The framework should be recommended to all organisations not only construction',
- 'It could easily be a consultants' tool with which he can implement and monitor change',
- 'Opportunity – Value as business process review almost more than project management tool',

- 'It could easily support and become part of implementing company-wide project management processes',
- 'It allows me to monitor my professional progress'.

### 10.4.2 Analysis of Validation Results

As described in Section 8.8.1, the results obtained from the validation interviews primarily achieved saturation and confirm PM practitioner acceptance of the findings and demonstrated the validity of the descriptive and inferential statistical results. Furthermore, as shown in Figure 10.2, all the questions posed achieved an average considerably above 3 on the Likert scale and thereby proving each point as well as the validity of the framework. Consequently, the validation and usefulness of the framework developed prove Hypothesis 3 as described in section 6.10, which states that:

> A framework is required to be developed for managing the effects of complexity of interconnections caused by the sub-processes of selecting team members, structuring the project team and the management style followed.

With regard to the contribution of the framework to the improvement of the three sub-processes investigated, the average scoring achieved was above 4.5 on the 5-level Likert scale, thus indicating clearly that practitioners valued highly the use of the framework. Similarly, the framework is considered as a valuable tool to manage the effects of the complexity of interconnections in the areas investigated, again with an average score greater than 4.5. The outcome and the understanding of the framework are valued highly by the practitioners, thus providing the confidence that it can become a valuable tool for PM practitioners and all interviewees agreed that the framework is applicable to construction.

Finally, as the additional comments made by the PM practitioners indicate, the applicability of the framework for the management of the effects of complexity of interconnections can be generalised and implemented to organisations outside construction. It was also viewed as a 'change agent', as well as a tool for implementing 'business processes' and not only as a project management tool. These comments are not only reassuring but also highlight the significance of the findings and the application of the framework outside project management, into general management, and even outside construction into the wider industry. Therefore, as accepted by the PM practitioners, the framework developed can improve the three areas investigated and contribute towards the enhancement of the project management outcome.

## *10.5 Supplementary findings*

The literature review on the subjects under investigation and the results from the implementation of the research design, allowed for a number of supplementary findings to be extracted from this research. Therefore, in addition to the framework, a supplementary proposal will be made focusing in particular on the weakest one of the three sub-processes –

structuring of the project team. The reason for this decision being that the author concurs with Moore (2002) - who professes that construction does not question '*How are we structuring ourselves to deal with this project*'. The quantitative results have supported this argument indicating that construction does not structure project teams to the appropriate level. As pointed out by the case study results, through the reasons for delay, improving the structure of the project team and managing the effects of complexity of interconnections will improve the quality of the project management outcome and therefore the project performance.

A number of new concepts in the structuring of project teams e.g. finite structure, testing of cluster mesh using Finite Element theory, establishing of project functions and individuals' and project unique frequency, are described and a proposal is made regarding the approach to be followed. The detailed recommendations regarding the new approach to the structuring of project teams are expanded in Appendix F-6.3. However, as this topic was not part of the research objectives, it was not possible to conduct any investigations on the proposed recommendations, and therefore it can only be considered and used as the basis for future research.

## 10.6 Limitations

There were two main limitations to this research, firstly the extent of the survey conducted, and secondly the small number of observations during the case study phase. Another limitation was the lack of industry-wide data on the population of PM practitioners in the field of construction.

As the main aim was certainty of response, stratified sampling for the biggest region in the UK (the Southeast) was considered the best approach since it was important for the postal survey to capture both Client and Contractor PMs. Although the aim for response certainty was achieved and it was possible to extract very clear deductions about current practices, thus confirming results of previous studies, a UK wide stratified sample would have conferred results for the whole of the UK.

The sensitivity of carrying out observations on management style and the restricted participation time by the PM practitioners limited the number of observations conducted and the establishment of causes of delay due to the management style followed. Although the observations can be considered as influencing the observed, if PM practitioners had more time available, it would have been possible for the author to comment and establish a link between the case study findings and the postal survey results.

Finally, the limitation of the data available regarding the PM population in the UK Construction industry, is an indication of the problem relating to whether project management is considered a profession or an occupation. Unless there is a wider recognition of the PM's role as a profession, establishing an accurate number of professionals that can be used for wider surveys will not be possible. However, regarding this research, statistical results conferred conclusions reached by other investigations, thus these can have a wider implementation in the field of project management.

## 10.7 Summary

The research objectives were achieved and the results from the investigation established the need for a framework that will enable the management of the effects of complexity of interconnection.

The decision to use the interview questionnaire as a base for the framework was compared against two other methods and validated using the decision matrix process and the objectives were defined. MS Excel was used for the development of the framework because of its inherent simplicity and flexibility. A validation process, for both the research findings and the framework, was defined and performed by conducting interviews with PM practitioners to a saturation point. Respondents concurred with the research findings and the framework developed was validated with high scoring by all interviewees. The acceptance of the framework thus proved Hypothesis 3 which supported the requirement for a framework that will manage the effects of complexity of interconnections onto the sub-processes of selecting project team members and structuring the project teams and when considering the management style to be followed.

In addition to the framework, developed and validated, supplementary findings regarding the approach to structuring project teams were considered and new concepts were proposed. These will, however, require further examination and validation.

A limiting factor to this research was the unavailability of robust data regarding the PM practitioner population.

The conclusions to this research are drawn in the following chapter.

# Chapter 11 – Conclusions and Further Research

## 11.1 Introduction

The overall aim of this research was to investigate the effect of complexity of interconnections on the project performance through the sub-processes of selecting team members and structuring the project team as well as the management style(s) followed, and thus develop a framework which will enable the management of these effects. Such an investigation will enable the construction industry to understand the effects and implications of the complexity of interconnections on the project management outcome through the three sub-processes. The framework will enable the management of these effects and thus contribute towards the improvement of the project performance.

In order to establish such a framework there is a need to understand the current status of the implementation of these sub-processes and their contribution towards a successful project management outcome; establish levels of understanding and consideration of complexity, in particular that of interconnections when implementing the three sub-processes; identify the effect of complexity of interconnections on the project performance; and, finally, determine the actions that can be taken to manage these effects. These were reflected in the research objectives which were: to determine how far down the project organisational level techniques for selecting team members are implemented and team structure and management style defined; to investigate if the current approach for selecting members, structuring the teams and the management style followed consider the effects of complexity; to examine how complexity which arises from the interconnections affects project performance; to identify the necessary tasks that will need to be undertaken when selecting, structuring and managing project team members and which will be used for the management of the complexity of interconnections; to develop a framework that will support the sub-processes of selecting team members and the structuring of the teams as well as deciding on the management style to be followed. All of which will enable the management of the complexity of interconnections, thereby contributing towards the improvement of the project outcome.

The conclusions reached are presented in this chapter in conjunction with the recommendations made in the previous chapter. A number of recommendations are also made for further research.

## 11.2 Conclusions

The literature review indicated that project failures continue to hamper the construction industry and basic project management processes are not only unimplemented, but lately have also been criticised for not responding to the modern demands of project management. The traditional approach to project management is challenged by developments in technology, the global economy, rapid changes in society and the exponential increase in knowledge and levels of complexity. Additionally the issue of a theoretical base that will enable project management to be established as a profession is also raised as a concern. Furthermore there are calls for project management to be transformed from an activity based on a control paradigm to a behavioural one giving more emphasis to the 'soft features' of the projects - teams and individuals, organising teams, behavioural issues, managing stakeholders - whilst keeping an eye on the 'hard' ones - control of time, cost and contractual and commercial issues.

Work in chaos and complexity theory, conducted earlier in other fields, is now reaching project management because of its extensive non-linearity and in an attempt to expand the knowledge base which will enable PMs to manage complexity in projects.

Interconnections in projects have always been identified as an area that requires the attention of the PMs and, in the last decade, as a cause of complexity. However, work on the characteristics of complexity of interconnections and understanding how these, through the project management processes, affect the project had not been performed. One of the main findings of this research was the effect complexity of interconnections has on the project performance through the project management processes of selecting team members, structuring the team and the management style followed. Having established the relationship between the complexity of interconnections and the project performance, the essence of this research was to create a framework that would enable PM practitioners to manage the effects of the complexity of interconnections that stem from the sub-processes of selecting team members, structuring the teams and the management style followed.

A summary of the research findings are presented in the following four sections.

### 11.2.1 Current status of the processes investigated

Three areas that contribute to the project management outcome were investigated in response to the first objective, in terms of the current approach adopted by PM practitioners and the level of contribution these make towards a successful outcome:

- Selecting project team members;
- Structuring the project team; and
- The management style followed (as part of the management of the team process).

Although there was considerable evidence from existing literature that the processes are not implemented, it was considered necessary to establish the current status of implementation. The research has demonstrated that PM practitioners in the UK construction industry and from both sides of the project - *client and contractor - do not implement* selection of team members techniques, or consider the project structure and the management style to be followed. In particular results have shown that PM practitioners do not implement any team member selection techniques for any of the project levels. The process remains subjective, as indicated in earlier studies, despite the fact that PM practitioners are aware of, and are given guidance on, techniques available. In terms of structuring the project teams to the lowest level and the management style to be followed when delivering a project, again there were no statistically significant results to suggest that PM practitioners give these factors any consideration.

Investigating the contribution of the areas examined to the success of the project management outcome highlighted that PM practitioners considered only the management style as delivering, in the majority, successful results. The selection of team members and structuring of the team sub-processes were considered as delivering only an acceptable level of outcome, demonstrating the need for considerable improvement. In particular the latter trailed noticeably behind a number of the other project management sub-processes, despite the weight given to the subject by institutions and the literature.

The results supported earlier literature findings and established a base for expanding the investigations into the subject of complexity. However, a conclusion that can be drawn from the findings is that, unless the sub-processes investigated are implemented appropriately, and to the lowest level, and PM practitioners are not only given guidance but are driven and supported in their implementation, the success of the project management outcome will not achieve the highest level.

### 11.2.2 Processes investigated and Complexity

In response to the second objective and having established a baseline for the status of the sub-processes investigated, it was necessary to establish a similar datum line for complexity and most importantly the consideration given by PM practitioners to complexity characteristics when the two sub-processes and the management style are implemented. The results indicated that there is no clarity on the definition of complexity, despite the fact that the theory of complexity in projects and their management has been around for more than ten years. Risk management, planning and contracts are misconstrued as complexity management tools. Companies identify project size, tasks, procurement method, programme and communications as the sources of complexity. However, PM practitioners consider 'softer' issues such as team interconnections, communications and inappropriate and inflexible organisational structures as the source of complexity. In general complexity is not considered when carrying out activities in the areas investigated.

In response to the forth objective, the characteristics of complexity of interconnections were deciphered to enable ease of understanding by PM practitioners and sets of actions were developed that will enable the management of complexity of interconnections through its characteristics. The proposed actions, taken from theory as well as day-to-day project management actions, in each of the three areas investigated were presented to and agreed by PM practitioners. Research findings established that actions currently taken by PM practitioners, client or contractor, do not cater for the management of the effects of the complexity characteristics on each sub-process. Thus, a gap was identified for developing the means that will enable PM practitioners to manage the effects of complexity of interconnections on the sub-processes of selecting team members, structuring the project team and the management style followed. However, the relationship between complexity of interconnections and project performance, particularly the causes of delay attributed to the three processes investigated, needed to be established. This is described in the next section.

### 11.2.3 Complexity and Project Performance

The heuristic hypothesis, which suggests that as complexity increases, performance drops, is nothing new in the practitioners' world and the relationship is depicted graphically as a type of an exponential decay function (such as $e^{-x}$). However, and in response to the third objective, this hypothesis is central to this research and is examined specifically because the investigation focused on the complexity of interconnections and the project management outcome, which is central to project performance.

Five case studies were conducted in construction projects, which covered all stages of the project life cycle. Causes of delay, based on the three sub-processes investigated, were considered and the results proved the inverse correlation between complexity of interconnections and project performance. Replication was established between all five case studies with some minor variations for the projects in early design and commissioning.

The results indicated a considerable overall average drop in performance of 39%, as complexity of interconnections increased significantly. The projects that were in construction exhibited an overall average drop of 57%. Identifying the exact percentage contribution of the sub-processes investigated towards the overall 39%, or the 57% drop in performance is not possible at this stage of the research as a number of other project management sub-processes may have contributed as well. Analysis of the causes of delay indicated the dependence of project performance on the sub-processes investigated and the 16 complexity characteristics. However, the interlinked properties of the characteristics and those of the reasons for delay did not allow for establishing singularity of results, or otherwise overcoming the difficulty of identifying singular characteristics as causes of the drop in performance. Furthermore the detection of the significant drop in performance is attributed to the fact that the case studies sought and extracted details that do not appear frequently otherwise expressed as 'the devil is in the detail'.

In considering the current approach to the three areas investigated, it can be argued that the effect of not implementing these, as proven earlier, has a considerable impact and is interrelated throughout the complexity characteristics. Also the non-linearity of project management is reflected through the effect of the complexity characteristics. Once again, a requirement is identified for developing a framework that will enable the management of the effects of complexity by means of its characteristics. Deciphering and mapping the complexity characteristics to the project management processes will enable the consideration and development of the means, as well as the approach, for managing its effects on projects. This will be described in the following section.

In addition to establishing the correlation between complexity and project performance, the relationship resembled the well established behaviour of vibration control systems (non-linear systems) and particularly that of underdamped systems. This provides the basis for further research, as will be discussed below, on the non-linearity of projects by examining possible solutions based on systems control theory.

### 11.2.4 Framework for Managing Complexity of Interconnections

This research identified a gap and, in response to the fifth objective, proposes the use of a Framework for Managing Complexity of Interconnections (F4MCI). Through its characteristics, the aim of the framework is to support the PMs by providing the means to manage the impact of the complexity of interconnections on the sub-processes of selecting team members, structuring the team and the management style followed.

Using a simple software solution, a framework was developed based on work done during Part 1 of Phase 2 (the interviews). The framework enables PM practitioners to identify actions to be taken, establish levels of managing the effect of complexity in the respective sub-processes and plan the implementation of further actions, all of which will improve the management of complexity as well as allowing the extraction of reports. Moreover, it can be used by all project team levels thus enabling the PM to cascade actions required down to team leader level and establish a coordinated approach for managing complexity of interconnections.

One of the most important properties of the framework is its flexibility, allowing it to expand and cover the project as well as the PM's specific requirements since 'no two PMs think the same way'. The fact that it can be handed down to the lower levels ensures that the teams are also able to use the same tools to manage the effects of complexity, thus breaking the barriers / 'glass ceilings' between management teams and delivery teams. The in-built flexibility also allows for it to be expanded to include the remaining project management sub-processes. However, it should be noted that, as the case studies results have shown for the topic of management style followed, any external but direct observation will affect both the observed and the outcome. Therefore the research methodology implemented will need to be considered carefully.

The research results and the framework were validated by PM practitioners and the feedback obtained concerning the research results was compelling. This reinforces points made earlier regarding PMs requiring a change in the sub-processes investigated. Practitioners not only validated the framework, but indicated that it can be used in a number of different manners, including supporting general management. Thus the functionality of the framework was generalised.

In addition to supporting PM practitioners to manage the effects of complexity, the framework provides the means for another push towards not only an organised approach for managing complexity of interconnections, but also to the behavioural paradigm. Furthermore it will support project management to shift from a 'nice-to-have' to a 'must-absolutely-have' paradigm.

## *11.3 Recommendations for further research*

This research into the complexity of interconnections for the sub-processes of selecting project team members and structuring the project team as well as the management style followed confirmed, as well as uncovered, a number of issues in the project management of construction projects. Two of these issues have been resolved with specific proposals, however, a number of further research projects have been generated and are described below.

### 11.3.1 Extending the Framework

The framework for the management of complexity of interconnections through its characteristics will need to be developed further to cover the remaining project management processes e.g. monitoring and control, efficient use of resources, etc. By developing a complete framework that covers all sub-processes, PMs and Teams will be able to address performance issues and manage the effects of complexity of interconnections holistically, thereby allowing the complete measurement of the contribution of the project management outcome towards the project performance. It is highly likely that a number of actions taken for each sub-process will be combined and therefore simplifying the implementation. Thus, for example, when addressing the characteristics of non-linearity or emergence, actions taken for the sub-process of project structuring could be similar to those for resourcing. The framework developed for managing the complexity of interconnections (F4MCI) can easily accommodate such expansion and provide a one-stop-shop and integrated solution for the PMs and the teams.

### 11.3.2 Project performance

As mentioned in the previous section, the establishment of a complete framework will allow for the improvement of the project management outcome and thus the project performance. However, this will need to be tested by carrying out longitudinal case studies which will monitor performance of 'project management outcome' for all project management processes and also investigate how, and at what level, each sub-process contributes to the overall performance. The case studies will establish a theoretical base for the linking of each sub-process to the project performance, allowing for further improvements to theory and practice as well as the definition of performance.

### 11.3.3 Implementation of basic processes

Quantitative results from this investigation, and in particular those regarding the level of project management outcome considered by the practitioners as only 'acceptable', raised concerns regarding implementation practices. Therefore there is a need to perform further detailed reviews and wider sampling in order to establish reasons for this low level of acceptance. It should also be possible for Universities (as external bodies), in cooperation with construction companies, to conduct case studies regarding the implementation of basic project management processes and understand the reasons why PM practitioners are not implementing proven techniques. Identifying the cause will enable the development of solutions acceptable to both practitioners and company Senior Management who will need to consider internal general management processes.

### 11.3.4 Project Performance and Underdamped Systems

The discovery of similarities between project performance curves and the underdamped dynamic systems theory opens up a number of avenues for using existing concepts to understand the behaviour of the dynamic and unstable project management environment. Further research into the similarities could be:

- To establish an approach that will identify variables which can be used in known systems formulae, thus enabling PMs to manage and improve project performance;
- To support the establishment of project management axioms based on the systems dynamics theories, thus providing a further theoretical basis for supporting project management as a profession.

### 11.3.5 Expanding on the Supplementary Findings

Finally, and as described in Appendix F-6.3, further research could be conducted which will prove and expand the Finite Structure approach by using Finite Element Analysis (FEA) to test the dynamics of structuring project teams. Additional research into the variables identified and the proposed cluster mesh could be expanded upon and, by setting up the project structure in a Finite Element environment, it can be tested under different / simulated conditions. For example, loading the structure / mesh with specific strains it should be possible to simulate complexity, change, uncertainty or any other forms of pressures (or temperatures), thus testing the strength of the individual nodes, the cluster or group of clusters. Longitudinal case studies could test the Finite Structure approach, using FEA software, on 'live' projects enabling the direct comparison as well as input from practitioners.

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# APPENDICES

# Appendix A – Chapter 2 – Project Management, Management Style & Outcome

Table AP.A-2.1. A comprehensive list and brief information on leadership theories (based on Turner and Muller, 2005)

| Leadership School | Approach | Traits | PM Traits |
|---|---|---|---|
| TRAIT | Effective leaders share common traits. Leaders are born | | |
| | | (Kilpatrick and Lock, 1991)<br>1) Drive & Ambition | (Turner, 1999)<br>1) Problem solving ability |
| | | 2) The desire to lead and influence others | 2) Results orientation |
| | | 3) Honesty and Integrity | 3) Energy and Initiative |
| | | 4) Self-Confidence | 4) Self-confidence |
| | | 5) Intelligence | 5) Perspective |
| | | 6) Technical Knowledge | 6) Communication |
| | | | 7) Negotiating Abilities |
| BEHAVIOURAL | Effective leaders adopt certain styles, or behaviours. Leaders can be made. | | |
| | | (Adair, 1983; Blake & Mouton, 1978; Hersey & Blanchard, 1988; Slevin, 1989; Tannenbaum & Schmidt, 1958 | |
| | | 1)Concern for people or relationships | |
| | | 2) Concern for production | |
| | | 3) Use of Authority | |
| | | 4) Involvement of the team in decision-making (formulating decisions) | (Turner, 1999) - based on parameters 4 to 6 identified: |
| | | 5) Involvement of the team in decision-taking (choosing options) | Bureaucratic, Autocratic, |
| | | 6) Flexibility versus the application of rules | Democratic, Laissez-faire |
| CONTINGENCY | What makes an effective leader would depend on the situation | | |
| | | Assess the characteristics of the leader | |
| | | Evaluate the situation in terms of key contingency variables | |
| | | Seek a match between the leader and the situation | |
| | | *Path-Goal theory* (House, 1971) | |
| | | Directive leaders | |
| | | Supportive leaders | |
| | | Participative leaders | |
| | | Achievement-oriented leaders | |

| | | |
|---|---|---|
| | | to be matched to Environmental & Subordinate Contingency factors: |
| | | Environmental Factors: |
| | | Task structure |
| | | Formal authority system |
| | | Work group |
| | | Subordinate Contingency Factors: |
| | | Locus of control |
| | | Experience |
| | | Perceived ability |
| | | (Fiedler, 1967) |
| | | Depending on the favourability of the leadership situation, identified three variables to determine the favourability: |
| | | Leader-member relations: *(degree to which the leader is trusted and liked by members)* |
| | | Task structure: *(degree of clearness of a task and its instructions)* |
| | | Position power: *(leader power by virtue of organisational position)* |
| | | (Fiedler, 1967) - Least Preferred Co-worker (LPC) score |
| | | In very favourable and very unfavourable situations he assigns Task-oriented Leaders (having low LPC score) |
| | | In moderately favourable situations he assigns *Participative Leaders* (having high LPC score) |
| VISIONARY or CHARISMATIC | Arose from the study of successful business leaders | |
| | | (Bass, 1990) |
| | | **Transactional leadership:** |
| | | Emphasises contingent rewards, rewarding followers for meeting performance targets |
| | | Manages by exception, taking action when tasks are not going as planned |

| | | | |
|---|---|---|---|
| | **Transformational leadership:** | | |
| | Exhibits charisma, developing a vision, engendering pride, respect and trust | | |
| | Provides inspiration, motivating by creating high expectations and modelling appropriate behaviours | | |
| | Gives consideration to the individual, paying personal attention to followers and giving them respect and personality | | |
| | Provides intellectual stimulation, challenging followers with new ideas and approaches | | |
| EMOTIONAL INTELLIGENCE | The leader's Emotional Intelligence has a greater impact on his or her success as a leader - and the performance of his or her team - than does the leader's intellectual capability | | |
| | (Goleman, Boyatzis & McKee, 2002) Identified four dimensions: | | |
| | Personal **Competence &** | **Competencies** | |
| | Self-awareness | Emotional self-awareness | |
| | | Accurate self-awareness | |
| | | Shelf-confidence | |
| | Self-management | Emotional self-control | |
| | | Transparency | |
| | | Adaptability | |
| | | Achievement | |
| | | Initiative | |
| | | Optimism | |
| | Social **Competence &** | **Competencies** | |
| | Social awareness | Empathy | |
| | | Organisational Awareness | |
| | | Service | |
| | Relationship management | Inspirational leadership | |
| | | Influence | |
| | | Developing others | |
| | | Change catalyst | |
| | | Conflict Management | |

| | | | |
|---|---|---|---|
| | | Building bonds | |
| | | Teamwork and collaboration | |
| | Identified six Leadership styles<br>1. Visionary | 2. Coaching | 1 to 4 will foster resonance |
| | 3. Affiliative | 4. Democratic | |
| | 5. Pacesetting | 6. Commanding | 5 and 6 will foster dissonance |
| COMPETENCY | Competencies can be learnt, so leaders can be made, not just born. Different combinations of competencies can lead to different styles of leadership. Competencies can be technical or intellectual in nature, or emotional.<br>Competence can be defined as knowledge, skills and personal characteristics that deliver superior results (Boyatzis, 1982, Crawford, 2003) | | |
| | Four types of competence:<br>1) Cognitive,<br>3) Behavioural | 2) Emotional<br>4) Motivational | |
| | (Dulewicz & Higgs, 2003)<br>Suggest three types of competence<br>Intellectual (IQ) | - Cognitive | Critical analysis and Judgment, Vision and Imagination, Strategic Perspective |
| | Managerial skill (MQ) | - Cognitive | Engaging, Communication, Managing Resources, Achieving Empowering, Developing, |
| | Emotional (EQ) | - Behavioural, Emotional, Motivational | Self-awareness, Motivation, Emotional resilience, Influence, Sensitivity, Intuitiveness, Conscientiousness |
| | Style (and Charisma)<br>1) Engaging (E), 2) Involving (I), | 3) Goal-oriented | |

Table AP.A-2.6. Comparison between EI and Lao Tzu's teachings on management competencies

| Coleman et al (2002) | Lao Tzu' teachings (Pheng, 1995) |
|---|---|
| **Self-awareness**<br>1. Emotional self-awareness | • A down to earth PM knows where he stands and knows what he stands for. |
| 2. Accurate self-awareness | • Silence is a great source of strength. |
| 3. Self-confidence | • Effective action arises out of silence and a clear sense of being.<br>• Silence is a great source of strength.<br>• By knowing how things work, the good PM will also know the importance of staying flexible. |
| **Self-management**<br>4. Self-control | • Silence is a great source of strength. |
| 5. Transparency | |
| 6. Adaptability | • The wise PM who understands when to listen, when to act and when to withdraw can work effectively with nearly everyone, even with the most difficult and sophisticated team members. |
| 7. Achievement | • The wise PM should help the others find their own success. |
| 8. Initiative | • The wise PM sees things almost before they happen. |
| 9. Optimism | |
| **Social Awareness**<br>10. Empathy | • The intelligent PM knows how other people behave.<br>• The wise PM does not intervene unnecessarily. His presence is felt but often his building team runs itself. |
| 11. Organisational awareness | • Knowing how polarities work, the wise PM does not push to make things happen but instead allows processes to unfold of their own accord. |
| 12. Service | • The wise PM should help the others find their own success. |
| **Relationship Management**<br>13. Inspiration | • It may puzzle people at first to see how little a good PM actually does and yet how much gets done.<br>• A good PM should interfere as little as possible. The fewer the rules the better. Rules reduce freedom and responsibility. Every law will create an outlaw. |
| 14. Influence | • The wise PM who understands when to listen, when to act and when to withdraw *can work effectively* with *nearly everyone*, even with the most difficult and sophisticated team members. |
| 15. Developing others | • The wise PM should help the others to find their own success. |
| 16. Change Catalyst | • The rigid PM may be able to lead repetitive and mechanical exercises but he will never be able to cope with lively team processes. As a rule, whatever is fluid, soft and yielding will overcome whatever is rigid and hard. What is soft is strong. |
| 17. Conflict Management | • The PM should never seek a fight. If a fight comes to him, he should yield and step back. |
| 18. Teamwork & Collaboration | • The wise PM does not take all the credit for what happens and has no need for fame.<br>• Being open and attentive is more effective than being judgemental. |

# Appendix B – Chapter 5 – Complexity

Pictorial view of strange attractors as presented by Lucas (2005)

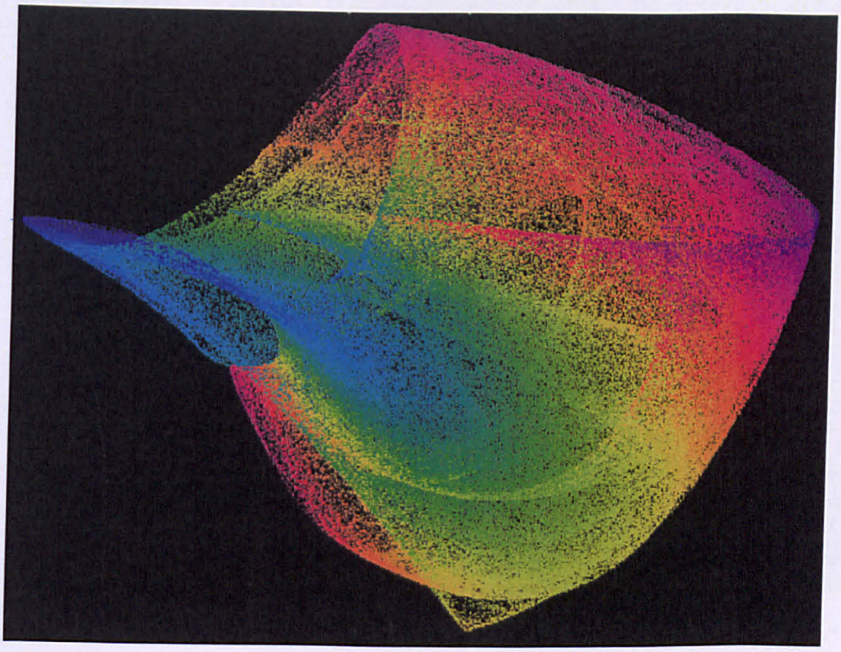


Figure 5.1 Dense strange attractor

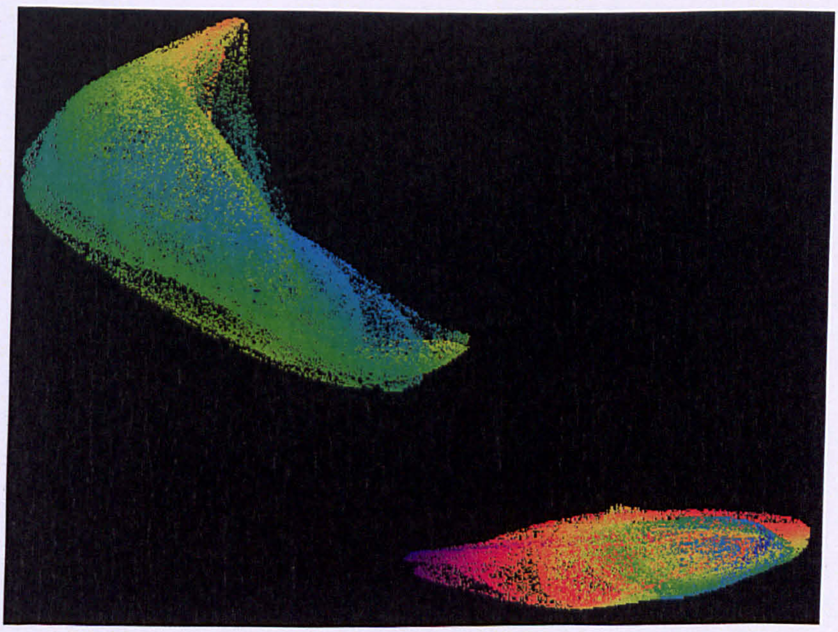


Figure 5.2 Disjoint Dense strange attractor

Figure 5.3 Tracery strange attractor

# Appendix C – Chapter 6 Research Methodology

**List of Contents of Appendix C**

# Appendix C-3.1 – Postal Questionnaire and note to respondents

# SURVEY QUESTIONNAIRE ON PROJECT MANAGEMENT TECHNIQUES

**Purpose and Notes** ☐

This survey is part of a research project at the University of Loughborough.
The objectives of the survey are:

1. To examine and confirm the implementation levels of the current available techniques for selecting the project team members and structuring the teams, and the management style.
2. To examine the correlation between project outcome (in terms of the quality of the project management process) and project team formation and management style.

There are five parts to this questionnaire.
Part 1 is to ascertain the composition of survey respondents; Parts 2 - 5 are to collect data for achieving the two objectives mentioned above.
It should be noted that in the case of selection of project team members the following words are used interchangeably, 'selection', 'allocation', 'appointment'.

**Notes for Completing the Questionnaire**

This questionnaire was constructed using MS Word 2003 and in particular the 'Form' tool was used to enable a faster and easier response.
The 'Form' tool can be accessed through one of the tool bars, which can be selected from the tool bars dropdown menu (available when you point your mouse in the tool bar area and press right click). When the 'Form' tool bar appears make sure the 'Lock' sign is highlighted. If it is not highlighted then simply click on the lock. This will allow you to take advantage of this utility and you can either click on the boxes to put a cross or in very few cases to view a short dropdown menu from which you will be able to make your selection.

**Definitions**

| | |
|---|---|
| **Selection of team**. The process used to identify and allocate personnel to project teams. | **Structuring the team**. The process of creating the organisational structure of the project. |
| **Management style**. The style adopted by the Project Manager on the project. | **Project type**. Projects for the different types of Industries (e.g. Utilities, Petrochem, etc). |
| **Personal profiling**. Otherwise known as behavioural profiling. | |

**Project Outcome**. A successful project outcome (success criteria) consists of two components, the *product* success and the *project management* success (Collins & Baccarini, 2004). The former represents the criteria used in terms of the final product, whereas the latter with the project process. Project Management success focuses on the project process which in turn has three main criteria:

| | |
|---|---|
| • Time, Cost and Quality; | • Satisfying project stakeholders' needs where they relate to the project management process (Collins & Baccarini, 2004) |
| • Quality of Project Management process:<br>➢ Project under control all the time, Accurate and timely reporting, Monitoring and controlling, Accuracy of forecasting, Appropriate change control methodology<br>➢ Efficient resource usage | ➢ Project Leadership, governance and management, stakeholder management,<br>➢ Selection of team, structuring of project organisation, management style, conflict resolution. |

**Project environment** is defined as those conditions and interactions that prevail between the project components and influence the decision making process.
Project components are divided into internal and external. For example, internal components are the type of project organisation and the interdependence of the units, the objectives and goals, the personnel technical, behavioural and managerial skills, the availability of personnel. The external are the stakeholders (including the Client as the user of the outcome), the suppliers, the political, social as well as the technical component, the industrial relations and any regulatory restraints.

Please note most of the above definitions, for ease of use, are repeated in the attached questionnaire.

| | | |
|---|---|---|
| Would you be interested in receiving a summary of the survey outcomes? | Yes ☐ | No ☐ |

Please return the completed in questionnaire by email, post, or fax to:

| By post | By Email | By Fax |
|---|---|---|
| Mr. D. Antoniadis<br>7 Grandison Road<br>Worcester Park<br>Surrey KT4 8LU | dimitris@antoniadis.freeserve.co.uk or<br>D.Antoniadis@lboro.ac.uk or<br>dimitris_antoniadis@baa.com | (++)44 (0)20 8330 3354 |

**Please note**
The questionnaire is designed to be completed by either Client or Contractor/Supplier personnel working on projects.
A number of questions could be addressing one or the other side but in most cases both sides.
You are kindly asked to complete all questions to the best of your knowledge ticking one box only, unless otherwise indicated by the text.

# SURVEY QUESTIONNAIRE ON PROJECT MANAGEMENT TECHNIQUES

**Part 1 – General / Demographics**

**Please indicate the type of your company**

Client ☐ Contractor/Supplier ☐ Consultant ☐

**Please indicate the size of the Project/Construction Management arms/unit in your company in terms of 'number of employees'**

Less than 50 ☐ Between 50 and 100 ☐ More than 100 ☐

**Please indicate the size of projects your company mainly undertakes:**

| Less than £5M | Between £5 and £25M | Between £25 and £100M | More than £100M |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ |

**Please enter the name of your company (optional)**

**Please indicate your job title**

| Project Director | Senior Project Manager | Project Manager | Assistant Project Manager | Site Manager / Supervisor | Other |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please indicate your years of experience**

| 5 or less | Between 6 and 10 | Between 11 and 15 | Over 15 |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ |

**Please indicate your academic qualification**

Post Graduate / Degree ☐ HND / HNC ☐ Other ☐

Other, please specify

**Please indicate your professional status**

| Chartered | Member of APM | Member of PMI | Member of Other Institutions | Other | None |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please indicate your Project Management certification level**

| | |
|---|---|
| APM - Introductory ☐ | APM_APMP ☐ |
| APM - Practitioner ☐ | APM – Certificated PM ☐ |
| None ☐ | Other ☐, please specify |

**Part 2 – Selection of Project team members**

*In this section you are asked to consider questions regarding the selection / allocation of project personnel.*

1) **Does your organisation offer you guidance in selecting project team** Yes ☐ No ☐ **members?**

2) **Are you aware of any known techniques/methods of personal** Yes ☐ No ☐ go to Q6 **profiling?**

3) **Please complete the table below, regarding personal profiling techniques.**

| | Belbin | Myers Briggs | Margerison & McCann | 16PF | None / No | Other |
|---|---|---|---|---|---|---|
| **a)** Tick those techniques you have heard of | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **b)** Are any of these being used in your company? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **c)** Which one(s) have you used? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

If Other for Q3a please specify
If Other for Q3b please specify
If Other for Q3c please specify

4) **Please indicate for which project team members personal profiling has been carried out, within your company.**

| Project Manager | Discipline Leaders (Design or Construction Manager) | Team Leaders (Design team, Site Manager) | Supervisors (Design or Site) | Team Members (Design, or Site) | Other |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other, please specify | | | | | |

*Now please think specifically about the selection of Project Managers. (If you are a Project Manager indicate how you are usually appointed to/ given a project).*

5) **In your company, is personal profiling considered, as part of the selection process, when appointing Project Managers to a project?** (*Belbin, Myers Briggs, etc*)

Yes ☐ No ☐ Don't Know ☐

6) **Think of your most recently completed project. Considering the conditions and the interactions that prevailed between the project components (internal and external) & the project environment, which influenced your decisions, please use the three basic characteristics to describe the project environment.** *(For more details please refer to definitions).*

*The three characteristic dimensions of the project environment are:*
*<u>Static to Dynamic</u> defines the range / degree to which the internal and external components remain the same or are in a continuous change mode during the life of the project.*
*<u>Simple to Complex</u> defines the range / degree to which the scope of work is clear and the factors to which the internal and external components of the project are dependant upon require few and similar or many and varied decisions.*
*<u>Friendly to Hostile</u> defines the characterisation of the interactions between the internal and external components to the project.*

| | More | | | | More | |
|---|---|---|---|---|---|---|
| Static | ☐ | ☐ | ☐ | ☐ | ☐ | Dynamic |
| Simple | ☐ | ☐ | ☐ | ☐ | ☐ | Complex |
| Friendly | ☐ | ☐ | ☐ | ☐ | ☐ | Hostile |

7) **For your most recently completed project indicate the level of consideration given to the criteria shown below when selecting the <u>Project Manager</u>.**
*Please see below descriptions of the scales to be used*

| *Very Little* | *Little* | *Important* | *Very Important* | *Critical* |
|---|---|---|---|---|
| *Very little contribution to the selection process, it did not affect the execution of any activities or the sequence of them* | *The contribution was insignificant, the selection process was not affected, actions were not delayed* | *Considered important and that it will reflect in the timely execution of tasks and decision-making* | *One of the fundamental contributors to the execution of tasks and decision-making, which led to the outcome* | *If not considered the project outcome would not have been achieved* |

| | Very Little | Little | Important | Very Important | Critical |
|---|---|---|---|---|---|
| Availability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Capability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Technical Skill | ☐ | ☐ | ☐ | ☐ | ☐ |
| Management Skill | ☐ | ☐ | ☐ | ☐ | ☐ |
| Leadership Skill | ☐ | ☐ | ☐ | ☐ | ☐ |
| Experience | ☐ | ☐ | ☐ | ☐ | ☐ |
| Previous performance | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project environment | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| Personal Development Plan | ☐ | ☐ | ☐ | ☐ | ☐ |
| Personal profiling | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other, please specify | ☐ | ☐ | ☐ | ☐ | ☐ |

8) **For your most recently completed project indicate the level of consideration given to the criteria shown below when selecting <u>project team members</u> for the organisational level immediately below you, e.g. if you are the PM consider the question in terms of the level reporting to you.**
*Please see below descriptions of the scales to be used*

| *Very Little* | *Little* | *Important* | *Very Important* | *Critical* |
|---|---|---|---|---|
| *Very little contribution to the selection process, it did not affect the execution of any activities or the sequence of them* | *The contribution was insignificant, the selection process was not affected, actions were not delayed* | *Considered important and that it will reflect in the timely execution of tasks and decision-making* | *One of the fundamental contributors to the execution of tasks and decision-making, which led to the outcome* | *If not considered the project outcome would not have been achieved* |

| | Very Little | Little | Important | Very Important | Critical |
|---|---|---|---|---|---|
| Availability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Capability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Technical Skill | ☐ | ☐ | ☐ | ☐ | ☐ |
| Experience | ☐ | ☐ | ☐ | ☐ | ☐ |
| Previous performance | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project environment | ☐ | ☐ | ☐ | ☐ | ☐ |
| Personal Development Plan | ☐ | ☐ | ☐ | ☐ | ☐ |
| Personal profiling | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other, please specify | ☐ | ☐ | ☐ | ☐ | ☐ |

9) **Do your site supervisors select their team members?**

Yes ☐ No ☐ go to Q12 Don't Know ☐ go to Q12 N/A ☐ go to Q12

10) **Do the site supervisors use any selection process techniques?**

Yes ☐ No ☐ go to Q12 Don't Know ☐ go to Q12 N/A ☐ go to Q12

**11) Indicate which of the following techniques/methods your supervisors use/consider for selecting team members?** (*Tick all appropriate)*

| Direct Interview | Agency Interview | Recommendation | Personal profiling | Other |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

Other, please specify:

**12) What do your contractors (suppliers) / subcontractors provide in terms of project team member information?**
*Please select those applicable from the list below*

| CV | Personal profiling | Nothing | Other |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ Please specify: |

**13) For your most recently completed project consider the questions below and indicate to what organisational level did you, or others on your behalf, ...** (*for details of the structure please see Fig 1 in instructions or the next page*)

| | Discipline Leaders | Team Leaders | Supervisor | Team Member | Other |
|---|---|---|---|---|---|
| a) Carry out selection of team members? | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) Carry out personal profiling? | ☐ | ☐ | ☐ | ☐ | ☐ |

If Other, please specify: a)

b)

**14) For your most recently completed project please answer the following?**

| | Yes | No | Don't Know |
|---|---|---|---|
| a) Did your subcontractors follow a team selection process? | ☐ | ☐ | ☐ |
| b) Were there any team forming techniques carried out? | ☐ | ☐ | ☐ |
| c) Was any personal profiling carried as part of the above? | ☐ | ☐ | ☐ |

**15) Indicate the level of influence each of the project variables shown below would have on the project team selection process.**
*Please see below descriptions of the scales to be used*

| *Very Little* | *Little* | *Important* | *Very Important* | *Critical* |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| *Does not cause concern to, or influences the project, it will not affect the decision to be made, or the next step* | *Will cause concern, or little influence but it can be overcome with no other problems* | *Will hinder and possibly cause future problems and it may delay the next action* | *Will cause problems to, or influence the next action with possibly detrimental consequences* | *Not able to carry out the next step, or make the required decision* |

| | Very Little | Little | Important | Very Important | Critical |
|---|---|---|---|---|---|
| Project duration | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project budget | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project location | ☐ | ☐ | ☐ | ☐ | ☐ |
| Procurement method | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project type (Industry) | ☐ | ☐ | ☐ | ☐ | ☐ |

*Are there any comments you wish to make regarding Part 2 – Selection of Project team members?*

Comments:

**<u>Part 3 – Structuring of Project teams</u>**

*In this section you are asked to consider questions regarding the structuring of your project teams.*

**1) Consider the questions in the table below and reply in terms of the norm in your company:**

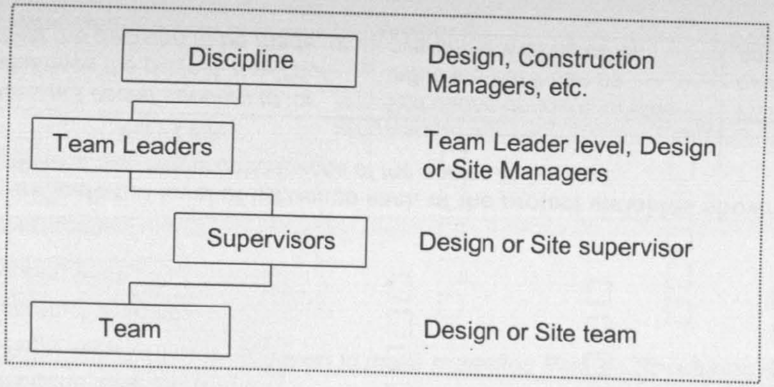
| | Project Director | Project Manager | Team Leaders | Supervisors | Other |
|---|---|---|---|---|---|
| a) Who defines the overall project structure? | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) Who defines the design team structure? | ☐ | ☐ | ☐ | ☐ | ☐ |
| c)Who defines the Site team structure? | ☐ | ☐ | ☐ | ☐ | ☐ |

Other, please specify

**2) When designing the project organisation, please indicate down to what level do you, as the PM, define the structure?**

*Assume the structure shown in Fig. 1 below is a simplified / typical project structure:*

| | |
|---|---|
| Supervisor level | ☐ |
| Team member level | ☐ |
| Other, please specify | ☐ |




**3) For the typical project stages indicate what would be the lowest organisational level you would design the project structure:**
(*Please tick all appropriate boxes*)

| Project Stage \ Level | Discipline Leader | Team Leader | Supervisors | Design Teams | Site Teams |
|---|---|---|---|---|---|
| Feasibility | ☐ | ☐ | ☐ | ☐ | ☐ |
| Design | ☐ | ☐ | ☐ | ☐ | ☐ |
| Construction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Commissioning | ☐ | ☐ | ☐ | ☐ | ☐ |
| Handover | ☐ | ☐ | ☐ | ☐ | ☐ |

**4) In your projects are the designers'/contractors'/subcontractors' teams integrated (that is working together, completing tasks as one team)?**

Yes ☐ No ☐ Not always ☐ Don't know ☐

**5) Please indicate the lowest organisational level at which your project team members work as one team but could be reporting to different line managers.**

| Discipline Leaders | Team Leaders | Supervisor | Design Team | Site Team | Other |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

If Other, please specify

6) **Please consider your most recently completed project and answer the following questions:**

| | Yes | No | Don't Know |
|---|---|---|---|
| a) Was the initial project structure defined? | ☐ | ☐ | ☐ |
| b) Was the project structure re-defined to fit the different stages? | ☐ | ☐ | ☐ |
| c) Was the structure communicated to all? | ☐ | ☐ | ☐ |
| d) Did you request your contractors / subcontractors to provide detailed structure? | ☐ | ☐ | ☐ |

7) **For your most recently completed project indicate down to what level was the structure defined?**

| Discipline Leaders | Team Leaders | Supervisor | Design Team | Site Team | Other |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

If Other, please specify:

8) **For the same project indicate how the following project teams were organised.**

| Team \ Structure | Matrix | Functional | Network | Team | Mixture | Don't Know |
|---|---|---|---|---|---|---|
| Discipline level team | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Design team | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Construction team | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Support team | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

9) **Indicate the level of influence each of the project variables shown below has on the project organisational structure.**
*Please see below descriptions of the scales to be used*

| *Very Little* | *Little* | *Important* | *Very Important* | *Critical* |
|---|---|---|---|---|
| *Does not cause concern to, or influences the project, it will not affect the decision to be made, or* | *Will cause concern, or little influence but it can be overcome with no other* | *Will hinder and possibly cause future problems and it may delay the next* | *Will cause problems to, or influence the next action with possibly* | *Not able to carry out the next step, or make the required decision* |

| the next step | problems | action | detrimental consequences | |
|---|---|---|---|---|

| | Very Little | Little | Important | Very Important | Critical |
|---|---|---|---|---|---|
| Project duration | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project budget | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project location | ☐ | ☐ | ☐ | ☐ | ☐ |
| Procurement method | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project type (Industry) | ☐ | ☐ | ☐ | ☐ | ☐ |

*Are there any comments you wish to make regarding Part 3 – Structuring of Project Teams?*

Comments:

**Part 4 – Management Style**

*In this section you are asked to consider questions regarding the management style followed in your projects.*

**1) Is a formal decision made regarding the management style to be followed on a project?**

Yes ☐ No ☐ Not always ☐ Don't know ☐

**2) Who within your organisation decides on the management approach?**

| The Project Director | The Team Leaders / Supervisors | The Project Manager | Standard Company process | Other |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

Other, please specify

**3) Consider your most recently completed project. Please select from the list below the closest description of the overall management style adopted.**

A) Decisions were made after there had been a discussion with the project team – egalitarian approach. ☐

B) Decisions and actions to be taken were dictated to the project team with no consultation. ☐

C) Decisions were made by the teams, who were allowed to manage themselves. ☐

D) Decisions based on standardised processes, procedures and rules. ☐

E) Emphasis was given to perfection and the technical approach rather than an outcome which satisfies the requirements, thus resulting in less delegation and trust on work done by others. ☐

F) The management style varied according to the stages of the project, changing and/or adjusting according to the situation. ☐

G) Emphasis given to systems of control, efficiency and productivity. ☐

H) Emphasis was given to project team members' well-being, their involvement and development rather than your own career progression. ☐

J) Emphasis was given to the medium to longer term objectives of the organisation, rather than the immediate needs of the client. ☐

K) Combination of and from the above ☐

Other, please specify ☐

**4) For the same project please indicate the management style adopted at each level.**
(*Please use the descriptions from Q3 above and enter the corresponding letter, e.g. A, B, C, etc.* ).

| | Style | Don't know or Other (*please specify*) |
|---|---|---|
| At Discipline level | | |
| At Team leader level | | |
| At Supervisor level | | |
| At Design team member level | | |
| At Site team member level | | |
| At project support team level | | |

**5) For the corresponding project organisation levels indicate the culture that describes best your most recently completed project.**

| **Prevailing Culture** | Discipline Leaders | Team Leaders | Supervisors | Design Team members | Site Team members |
|---|---|---|---|---|---|
| People are in structured places | ☐ | ☐ | ☐ | ☐ | ☐ |
| Objectives are set the rest is up to individuals | ☐ | ☐ | ☐ | ☐ | ☐ |
| Members of groups distribute work amongst themselves | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| No clear pattern | ☐ | ☐ | ☐ | ☐ | ☐ |

6) **Please indicate the level of influence each of the project variables shown below has on the management style on your project.**
*Please see below descriptions of the scales to be used*

| *Very Little* | *Little* | *Important* | *Very Important* | *Critical* |
|---|---|---|---|---|
| *Does not cause concern to, or influences the project, it will not affect the decision to be made, or the next step* | *Will cause concern, or little influence but it can be overcome with no other problems* | *Will hinder and possibly cause future problems and it may delay the next action* | *Will cause problems to, or influence the next action with possibly detrimental consequences* | *Not able to carry out the next step, or make the required decision* |

| | Very Little | Little | Important | Very Important | Critical |
|---|---|---|---|---|---|
| Project duration | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project budget | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project location | ☐ | ☐ | ☐ | ☐ | ☐ |
| Procurement method | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project type (Industry) | ☐ | ☐ | ☐ | ☐ | ☐ |

*Are there any comments you wish to make regarding Part 4 – Management Style?*

Comments:

**<u>Part 5 – Project Outcome and Organisation</u>**

*In this section you are asked to consider questions regarding project outcome and give your views on some generic statements.*

1. **The following are necessary components/sub-processes of the Project Management process. Please rank these in order of importance in delivering higher quality project management process:**
*(Click on each box to select required ranking between 1, being the lowest, to 10 being the highest)*

| Project Management sub-process | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Team selection | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Organisation / Structure of the team | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Management of the team | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring and Control of the project | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reporting | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Conflict resolution | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Efficient usage of resources | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other, please specify | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

2. **Please rate the degree of success of your most recently completed project on the following criteria.**

| Project Management sub-process | Unsuccessful | Acceptable | Successful |
|---|---|---|---|
| Team selection | ☐ | ☐ | ☐ |
| Structure of the team | ☐ | ☐ | ☐ |
| Management of the team | ☐ | ☐ | ☐ |
| Monitoring and Control | ☐ | ☐ | ☐ |
| Reporting | ☐ | ☐ | ☐ |
| Conflict resolution | ☐ | ☐ | ☐ |
| Efficient usage of resources | ☐ | ☐ | ☐ |
| Other, please specify | ☐ | ☐ | ☐ |

3. **Consider a project where the quality of the project management process was <u>successful</u>. Indicate the contribution of the following project management sub-processes towards the project outcome.**
*Please see below descriptions of the scales to be used.*

*Definition of the term '**successful project**': A successful project is considered as one that: a) was completed and commissioned in time, to cost and the quality targets, b) satisfied the project owner's and project teams' (incl. stakeholders') requirements relevant to the project, c) the quality of the project management processes, (followed) were to the satisfaction of all the project stakeholders.*

| *Very Little* | *Little* | *Important* | *Substantial* | *Excellent* |
|---|---|---|---|---|
| *Poor or very little contribution to the project, it did not affect the execution of any activities or the sequence of them* | *The contribution was insignificant, actions and activities although affected were not delayed* | *The importance of the process was reflected in the timely execution of tasks and decision-making* | *The process was one of the fundamental contributors to the execution of tasks and decision-making, which led to the outcome* | *Without this process the project outcome wouldn't have been achieved* |

| | Very little | Little | Important | Substantial | Excellent |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Team selection | ☐ | ☐ | ☐ | ☐ | ☐ |
| Structure of the team | ☐ | ☐ | ☐ | ☐ | ☐ |
| Management of the team | ☐ | ☐ | ☐ | ☐ | ☐ |
| Monitoring and Control of the project | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reporting | ☐ | ☐ | ☐ | ☐ | ☐ |
| Conflict resolution | ☐ | ☐ | ☐ | ☐ | ☐ |
| Efficient usage of resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other - specify | ☐ | ☐ | ☐ | ☐ | ☐ |

**4. Please indicate your level of agreement or disagreement to the following statements:**

a) Peoples' potential at work often remains unrealised.

| Strongly Agree | Agree | Indifferent | Disagree | Strongly Disagree |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

b) Peoples' performance is constrained by the way the project organisational structure is set up.

| Strongly Agree | Agree | Indifferent | Disagree | Strongly Disagree |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

c) One of the Project Manager's key jobs is to enable people to work well together.

| Strongly Agree | Agree | Indifferent | Disagree | Strongly Disagree |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

d) One of the Project Manager's responsibilities is to understand how peoples' behaviour will affect the team's output.

| Strongly Agree | Agree | Indifferent | Disagree | Strongly Disagree |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

e) It is the responsibility of the team manager to carry out role allocation / assignments according to the team member's preferences and then bring these together to the benefit of the whole / project.

| Strongly Agree | Agree | Indifferent | Disagree | Strongly Disagree |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

*I would appreciate any comments regarding the questionnaire, your views on the three major topics, or any other thoughts you might have.*

| Comments: |
|---|
| |

**THANK YOU VERY MUCH FOR YOUR CO-OPERATION AND THE VALUABLE TIME YOU HAVE GIVEN ME**

Please see instruction for returning this questionnaire or email it to:
D.Antoniadis@lboro.ac.uk

# Appendix C-3.2 – General Complexity questionnaire for Interviews

# General Complexity Questions – Phase 2

**I2C.1. Does your organisation give a definition for complexity?**

| | |
|---|---|
| Yes ☐ | No ☐ go to Q3 |

**I2C.2. What is the definition?**

**I2C.3. How does your organisation identify complexity (the characteristics)?**

| | | | |
|---|---|---|---|
| Project Size | ☐ | Tasks involved | ☐ |
| Project Duration | ☐ | Social | ☐ |
| Procurement method | ☐ | Cultural | ☐ |
| Project Resource | ☐ | Number of parties | ☐ |
| Communications | ☐ | Management style | ☐ |
| Structure of project team | ☐ | Client environment | ☐ |
| Structure of project | ☐ | Programme (schedule) | ☐ |
| Clarity of Brief | ☐ | | ☐ |

**I2C.4. Do you use any tools / techniques to identify complexity?**

| | |
|---|---|
| Yes ☐ | No ☐ go to Q6 |

**I2C.5. What are these tools / techniques?**

**I2C.6. In your view, what are the measures required to be taken to minimise complexity?**

**I2C.7. What are the complexity factors/characteristics that originate from the project organisation/structure?**

| | | | |
|---|---|---|---|
| Not experienced team members | ☐ | Lack of communication | ☐ |
| Lack of induction | ☐ | Clarity of goal / target | ☐ |
| Lack of training | ☐ | Headless chicken - style | ☐ |
| Individual's behaviour | ☐ | No motivation | ☐ |
| Individual's career ambitions | ☐ | Lack of attractors | ☐ |
| Lack of Team environment | ☐ | Rigidity in the structure | ☐ |
| The right person in the right position | ☐ | People are in fixed places | ☐ |
| Fixity of task for individuals | ☐ | Inappropriate Organisational Structure | ☐ |
| Phase of project affects individuals | ☐ | Inappropriate Work Structure | ☐ |
| Teams do not self-organise | ☐ | Inappropriate Management style | ☐ |
| Team interfaces within and outside | ☐ | | ☐ |

**I2C.8. How much do you agree with the following definition of complexity:** *'complexity is caused by the interactions of structures / systems not of the objects that are interacting*"?

| | |
|---|---|
| Strongly Agree | Agree |
| ☐ | ☐ |
| Disagree | Strongly Disagree |
| ☐ | ☐ |

**I2C.9. How would you go about managing/minimising complexity if it is defined as above?**

**I2C.10. Are any components of the project organisation, as investigated in this research – e.g. selection of team members, setting up of the team structure and management approach, used as means to minimise complexity?**

| | |
|---|---|
| Yes ☐ | No ☐ |

**I2C.11. Is complexity used as a criterion for selecting the project team members?**

| | |
|---|---|
| Yes ☐ | No ☐ |

**I2C.12. Does your organisation structure project team(s) specifically to tackle complexity?**

| | |
|---|---|
| Yes ☐ | No ☐ |

**I2C.13. If Yes, how do they do that?**

**I2C.14. Does your organisation use specific management techniques that depend on the level of complexity of the project?**

| | |
|---|---|
| Yes ☐ | No ☐ go to Q16 |

**I2C.15. If yes, what are these?**

**I2C.16. In an increasingly complex environment, are you, in your view, following the appropriate organisational framework to deliver projects successfully?**

| | |
|---|---|
| Yes ☐ | No ☐ |

**I2C.17. How much do you agree with the following statement:**
*'We do not Select the Teams, We do not Set up the Project Organisation and We do not Manage the Project Teams in a manner that will reduce complexity.'*

| Strongly Agree | Agree |
|---|---|
| ☐ | ☐ |
| Disagree | Strongly Disagree |
| ☐ | ☐ |

**I2C.18. Do you measure project team performance?**

| | |
|---|---|
| Yes ☐ | No ☐ go to Q20 |

**I2C.19. How do you do that?**

**I2C.20. Do you set targets to the teams?**

| | |
|---|---|
| Yes ☐ | No ☐ go to **END** |

**I2C.21. How frequently do you monitor these targets? (weekly, fortnightly, monthly, quarterly)**

**I2C.22. Do you identify the reasons for increase or decrease of performance?**

| | |
|---|---|
| Yes ☐ | No ☐ go to **END** |

**I2C.23. Do you record and analyse the reasons?**

| | |
|---|---|
| Yes ☐ | No ☐ go to **END** |

**I2C.24. What corrective actions do you take for the whole team?**

**I2C.25. What corrective actions do you take for individuals?**

# Appendix C-3.3 – Complexity Characteristics questionnaire by sub-process (including pick lists)

**Characteristic: C1) Autonomous agents**

Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system.

**Q_SLC1Sel:**
Down to what level is the selection of the project team members going?

go to worksheet **SLC1Sel**

**Q_SLC1Str:**
Down to what level do you (or ask for) define the structure of the team?

Use scales and ranking in worksheet **SL .ppt** and enter selection in the adjecent box

**Q_SLC1Mng:**
a) Does your mngt style accommodate for Autonomous Agents?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

b) What mngt style is rolled down the project levels?

go to worksheet **MngtStl**

**Characteristic: C2) Instability**

Stepped evolution(s) or catastrophes do occur in projects. Attractors (see definition) appear (currently unintentionally) and become system parameters and which will attract and avoid chaotic behaviour of the project system.

**Q_SLC2Sel:**
Do you allow for the transfer of responsibility to more appropriate people?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Q_SLC2Str:**
Do you identify these roles in the project structure, or the processes?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Q_SLC2Mng:**
Does your mngt style accommodate for the apportionment of authority to experts?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Characteristic: C3) Non-equilibrium**

The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment.

**Q_SLC3Sel:**
Do you select individuals to perform the role of attractor?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Q_SLC3Str:**
a) Do you identify / establish attractors within the project structure?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

b) Down to what level do you introduce attractors?

Use scales and ranking in worksheet **SL .ppt** and enter selection in the adjecent box

**Q_SLC3Mng:**
Does your mngt style accommodate for the existence of attractors?

| Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Characteristic: C4) Non-linear** | | | | | | |
| Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behaviour. | | | | | | |
| Q_SLC4Sel: Down to what level do you select or train individuals to be able to perform in a team environment? | | Use scales and ranking in worksheet SL .ppt and enter selection in the adjecent box | | | | |
| Q_SLC4Str: Does your proj. structure allow for the building of team work and down to what level? | | Use scales and ranking in worksheet SL .ppt and enter selection in the adjecent box | | | | |
| Q_SLC4Mng: a) Does your mngt style accommodate the understanding of individuals as complex systems and enabling teamwork? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What mngt style do you follow to allow for the building of a team environment throughout the project organisation? | | go to worksheet MngtStl | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Characteristic: C5) Attractors** | | | | | | |
| Simple systems (individuals) come together and many times self-organise to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. | | | | | | |
| Further explanation: The top-2-bottom hierarchical structure allows only for the identification of lines of responsibility. However, complexity (defined as the study of interconnections of systems) identifies as one of the characteristics the need/existence of attractors, which are / could be construed as individuals who when required become the poles of attraction. So we have individuals, that could easily not be the line managers, who because of their capabilities, abilities, behavioural attributes are assigned to be 'attractors' is a certain situation arises. | | | | | | |
| Q_SLC5Sel: Does the existence of attractors allow you/project to self-organise? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Q_SLC5Str: a) Do you allow for self-organisation and the existence of attractors in you project? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) Down to what level? | | Use scales and ranking in worksheet SL .ppt and enter selection in the adjecent box | | | | |
| Q_SLC5Mng: Does your mngt style accommodate for the existence of attractors? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Characteristic: D1) Co-evolution**

The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment. This is self-evident in the Project Management world.

Further explanation: Individuals within teams and teams within projects co-evolve and initially attempt to understand each other in order to understand the requirements and fit into the wider project environment

**Q_SLD1Sel:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a) Do you take any measures to allow for this to happen, or do you let the teams work this out? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What measures do you take to allow for co-evolution when selecting the team members? | go to worksheet SLD1bSel | | | | | |

**Q_SLD1Str:**

What level of flexibility do you instil in the project structure to allow for co-evolution of the teams? — go to worksheet SLD1Str

**Q_SLD1Mng:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a) Does your mngt style accommodate for the parties in the project evolving with each other? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What mngt style do you follow to allow for the co-evolution of the teams? | go to worksheet MngtStl | | | | | |

**Characteristic: D2) Self-modification**

Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle.

**Q_SLD2Sel:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| Is there a managed process where individuals and teams are introduced, and then continuously educated around the project and its outcome? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Q_SLD2Str:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a) Is this beneficial for the project structure or not? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What steps do you take to enable / restrict this in the project structure? | go to worksheet SLD2bStr | | | | | |

**Q_SLD2Mng:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a) Does your mngt style accommodate for managing and coordinating self-modification of individuals and teams through learning? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What mngt style do you follow to allow / support the self-modification of the teams? | go to worksheet MngtStl | | | | | |

**Characteristic: D3) Self-reproduction**

The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different teams may require different organisational structure. Similarly the Mngt style is copied/imposed throughout.

**Q_SLD3Sel:**

What actions are taken to promote good practice, etc. — go to worksheet SLD3Sel

**Q_SLD3Str:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| Do you vary the proj. org. structure to fit the project stage, or is does this vary for each team and the work req'd by the team? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Q_SLD3Mng:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| Is the mngt style the same throughout the mngt level on your project? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Characteristic: D4) Downward Causation**

The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole.

Further explanation: A number of structures that are set up at project level that indicate the systemic features of the project affect the existence, the properties / requirements of the project parts themselves. Therefore the standard project management structures, WBS, OBS, CBS, etc. as well as the informal project structures (everyday communication, etc.) affect the existence and input by individuals and teams.

**Q_SLD4Sel:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a)Is the selection process affected by the systemic / project features? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) If yes is this followed / considered throughout the project life-cycle or is it taken for granted? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

c) How do you instigate/confirm or carry out the selection process based on the project structures (and which ones)? — go to worksheet SLD4cSel

**Q_SLD4Str:**

a) Indicate the frequency (number of times) with which new teams would have to form and disband in the life of the project — Use structure indicated in worksheet SL .ppt and enter selection in the adjecent box

b) Down to what organisational level do the standard project structures cascade? — go to worksheet SLD4Str and worksheet SL .ppt

**Q_SLD4Mng:**

Mngt style affects implementation of processes and structures. What mngt style do you implement to accommodate the effect of downward causation? — go to worksheet MngtStl

**Characteristic: D5) Mutability**

It is typical of random mutations to occur in Projects. Project Management has to identify and manage them.

Further explanation: Considering the 'individual' as a system, it is highly likely that random internal changes will occur during the life cycle of the project and these will have an effect on the project through the individual's performance. These internal changes could be beneficial or detrimental and could be caused by either internal, to the project, reasons (e.g. team members' behaviours), or the individual's employer (e.g. promotion or demotion), or personal. Perhaps these changes are / could occur at a macro – project unconscious - level, or even a micro – deliberate – level. It is obvious that beneficial random internal changes will improve the individual's performance, whereas detrimental random internal changes will reduce performance. And whereas beneficial changes could be management led, detrimental changes could remain esoteric and could take longer to be recognized.

**Q_SLD5Sel:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a) Do you consider the effects of random changes on team members | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

b) What measures do you take to minimise, or maximise, the effect(s)? — go to worksheet SLD5bSel

**Q_SLD5Str:**

| | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
|---|---|---|---|---|---|---|
| a) Do you consider the effects of random changes on project structure | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

b) What measures do you take to minimise, or maximise, the effect(s)? — go to worksheet SLD5bStr

**Q_SLD5Mng:**

Do you consider the effects of random changes on the mngt style and what measures do you take to minimise, or maximise, the consequence(s)? — go to worksheet SLD5Mng

**Characteristic: D6) Non-uniform**

The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped.

Further explanation: Each person brings its own attributes to the project at the level it operates. The more specialist the level the more autonomy the individual or the team gets thus giving diversity in the rule. As personnel moves from project to project and as all influences from the various factors affect the individual(s) the individuals become carriers and evolve as they move along. No project is the same and no individual can keep on doing the same thing. Individuals evolve through the project life-cycle and through the projects giving diversity in rule or task space. This diversity improves the outcome, as the individual(s) are attempting to achieve a higher status, or benefit.

**Q_SLD6Sel:**

| | | | | | | |
|---|---|---|---|---|---|---|
| Do you encourage individuals to diversify in your project? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLD6Str:** Does your project structure encourage diversity? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLD6Mng:** a) Does your mngt style accommodate for diversity? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What mngt style do you follow to encourage diversity? | go to worksheet MngtSti | | | | | |

**Characteristic: D7) Emergence**

This again is the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Q_SLD7Sel:** a) When selecting team members do you consider the emergence characteristic? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) How do you combine individuals' characteristics to create an overall emergence? | go to worksheet SLD7bSel | | | | | |
| **Q_SLD7Str:** In your project structure do you accommodate for emergence? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLD7Mng:** a) Does your mngt style accommodate for individuals and teams coming together to perform as a whole? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What mngt style do you implement to encourage emergence? | go to worksheet MngtSti | | | | | |

**Characteristic: D8) Phase changes**

As far as the individual is concerned this characteristic highlights the importance of feedback processes for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' 'properties' attributes. These could either be the standard phase changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property.

| | 1st Part | | | | 2nd Part | | |
|---|---|---|---|---|---|---|---|
| **Q_SLD8Sel:** Do you have project related performance feedback to the individuals in your team and are you requesting the other project members to do the same? | Don't Know | Yes | No | | Yes | No | Don't Know |
| | ☐ | ☐ | ☐ | | ☐ | ☐ | ☐ |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Q_SLD8Str:** Does your project structure accommodate for changes which are a consequence of feedback mechanisms, (incl. suppliers performance feedback?) | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLD8Mng:** a) Does your mngt style accommodate for feedback to individuals and teams in order to enable phase-changes? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) What mngt style do you implement to encourage the set up and running of feedback processes? | go to worksheet MngtSti | | | | | |

**Characteristic: B1) Unpredictability**

This represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on the projects (see also pathogens and incubation period, IJPM ref. needed here).

| | | | | | | |
|---|---|---|---|---|---|---|
| **Q_SLB1Sel:** How do you inform (and carry out throughout the duration) team members and down to what level? | Project Induction | Team Induction | Task Induction | Quarterly briefings | Monthly briefings | Weekly briefings |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLB1Str:** Does the project structure have the flexibility to accommodate changes due to unpredictability? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLB1Mng:** How did the mngt style change from the initial stages of the project? | go to worksheet SLB1Mng | | | | | |

**Characteristic: B2) Non-standard**

Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status.

Further explanation: Complexity requires for systems to have the characteristic of 'non-standard' in order to be able to evolve from homogenous systems into dynamic self-organised ones. Each individual (or team) that will come to the project (as a homogenous system) will dynamically develop self-organising structures in order to adjust/adapt to the environment. It could also be said that members of project teams should possess the characteristic of non-standard, which means that they should be able to evolve from homogenous ones into self-organising in order to adapt to the project environment.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Q_SLB2Sel:** a) Do you consider the characteristic of 'non-standard' when you select the project team members? (See under 'Further explanation') | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b) How do you do this so that they can adapt to the new project environment and self organise? | go to worksheet SLB2bSel | | | | | |
| **Q_SLB2Str:** Do you support this evolutionary structure within your project structure? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Q_SLB2Mng:** Does the mngt style allow for the flexible approach required? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Characteristic: B3) Undefined values**

Identifying the system's/project's interfaces with the environment as the external stakeholders (re. W. Hughes 11 external factors see CME paper & my further thoughts on this subject) this characteristic identifies the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the

Further explanation: Regarding selecting the team members, and in particular for several roles within the team, the influencing factor of the project interfaces should identified and introduced in the selection criteria process. These individuals should be able to act as attractors when the interfaces are specified and should be supporting the process. They are the project agents who work with the team to delineate the Undefined values.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Q_SLB3Sel:** a) Does your company, during the project team selection process, identify the effect of interfaces on the project against specific roles? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes | |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| b) Do you include specific criteria in the selection process? | Yes ☐ | go to worksheet SLB3bSel | | | | | No ☐ |

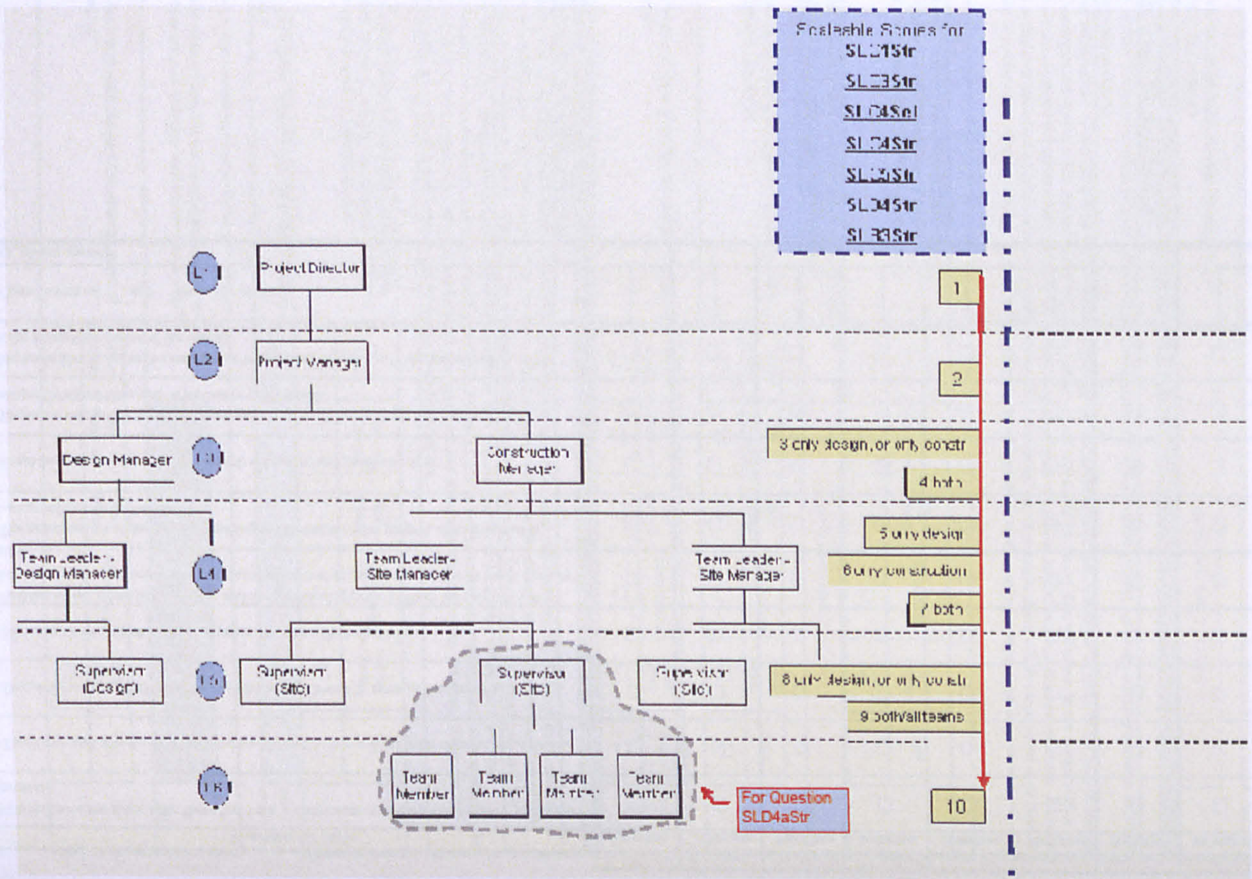
| | | | | | | |
|---|---|---|---|---|---|---|
| **Q_SLB3Str:** Down to what organisational level does training on the influence and management of interfaces stop? | Use scales and ranking in worksheet SL .ppt and enter selection in the adjecent box | | | | | |
| **Q_SLB3Mng:** Does the mngt style support the management of interfaces? | Don't Know | No / Does not | Not always | Sometimes | Most times | Yes |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

# Sample of Pick lists and actions

MngtSt

| Management Style | SLC1bMng | SLC4bMng | SLD1bMng | SLD2bMng | SLD4Mng | SLD6bMng | SLD7bMng | SLD8bMng |
|---|---|---|---|---|---|---|---|---|
| | Selection | Selection | Selection | Selection | Selection | Selection | Selection | Selection |
| A) Decisions were made after there had been a discussion with the project team – egalitarian approach. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| B) Decisions and actions to be taken were dictated to the project team with no consultation. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| C) Decisions were made by the teams, who were allowed to manage themselves. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| D) Decisions based on standardised processes, procedures and rules. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| E) Emphasis was given to perfection and the technical approach rather than an outcome which satisfies the requirements, thus resulting in less delegation and trust on work done by others. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| F) The management style varied according to the stages of the project, changing and/or adjusting according to the situation. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| G) Emphasis given to systems of control, efficiency and productivity. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| H) Emphasis was given to project team members' well-being, their involvement and development rather than your own career progression. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| J) Emphasis was given to the medium to longer term objectives of the organisation, rather than the immediate needs of the client. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| K) Combination of and from the above | | | | | | | | |
| Other, please specify | | | | | | | | |

SL . ppt



Project Director
Project Manager
Design Manager
Construction Manager
Team Leader - Design Manager
Team Leader - Site Manager
Team Leader - Site Manager
Supervisor (Design)
Supervisor (Site)
Supervisor (Site)
Supervisor (Site)
Team Member
Team Member
Team Member
Team Member
L2
L4
1
2
4 both
7 both
9 both/all teams
10
For Question SLD4aStr

**Question SLB2bSel**

| Selection | |
|---|---|
| A. Individuals are asked to participate in: | |
| A.1 Induction | ☐ |
| A.2 Workshops | ☐ |
| A.3 Lunch & Learn sessions | ☐ |
| A.4 Weekly combined talks / meetings | ☐ |
| B. Establishing roles which will promote and support the transformation from homogeneous to self-organising throughout the duration of the project. | ☐ |
| C. Selecting individuals that can operate flexibly in a changing environment | ☐ |

| Combination | Score | Combination | Score | Combination | Score | Comb | Score | Comb | Score | C | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 1.59% | | | | | | | | | | |
| A1 A2 | 6.35% | A2 | 3.17% | | | | | | | | |
| A1 A2 A3 | 14.29% | A2 A3 | 12.70% | A3 | 7.94% | | | | | | |
| A1 A2 A3 A4 | 26.98% | A2 A3 A4 | 25.40% | A3 A4 | 22.22% | A4 | 11.11% | | | | |
| A1 A2 A3 A4 B | 55.56% | A2 A3 A4 B | 46.03% | A3 A4 B | 42.86% | A4 B | 34.92% | B | 20.63% | | |
| A1 A2 A3 A4 B C | 100.00% | A2 A3 A4 B C | 85.71% | A3 A4 B C | 79.37% | A4 B C | 73.02% | B C | 58.73% | C | 31.75% |
| A1 A2 A3 A4 C | 62.70% | A2 A3 A4 C | 60.32% | A3 A4 C | 53.17% | A4 C | 45.24% | | 2 | | 1 |
| A1 A2 A3 B | 37.30% | A2 A3 B | 35.71% | A3 B | 30.16% | | 4 | | | | |
| A1 A2 A3 B C | 77.78% | A2 A3 B C | 68.25% | A3 B C | 65.87% | | | | | | |
| A1 A2 A3 C | 50.79% | A2 A3 C | 47.62% | A3 C | 43.65% | 8 | | | | | |
| A1 A2 A4 | 20.63% | A2 A4 | 15.87% | | | | | | | | |
| A1 A2 A4 B | 41.27% | A2 A4 B | 37.30% | | | | | | | | |
| A1 A2 A4 B C | 74.60% | A2 A4 B C | 75.40% | | | | | | | | |
| A1 A2 A4 C | 51.59% | A2 A4 C | 49.21% | | | | | | | | |
| A1 A2 B | 28.57% | A2 B | 26.19% | | | | | | | | |
| A1 A2 B C | 61.90% | A2 B C | 61.11% | | | | | | | | |
| A1 A2 C | 39.68% | A2 C | 38.10% | 16 | | | | | | | |
| A1 A3 | 11.90% | | | | | | | | | | |
| A1 A3 A4 | 23.02% | | | | | | | | | | |
| A1 A3 A4 B | 40.48% | | | | | | | | | | |
| A1 A3 A4 B C | 76.19% | | | | | | | | | | |
| A1 A3 A4 C | 57.14% | | | | | | | | | | |
| A1 A3 B | 33.33% | | | | | | | | | | |
| A1 A3 B C | 66.67% | | | | | | | | | | |
| A1 A3 C | 44.44% | | | | | | | | | | |
| A1 A4 | 13.49% | | | | | | | | | | |
| A1 A4 B | 36.51% | | | | | | | | | | |
| A1 A4 B C | 71.43% | | | | | | | | | | |
| A1 A4 C | 48.41% | | | | | | | | | | |
| A1 B | 23.81% | | | | | | | | | | |
| A1 B C | 57.94% | | | | | | | | | | |
| A1 C | 34% | 32 | | | | | | | | | |

63

**Question: SLB3bSel**

| Criteria for Selection | Selection |
|---|---|
| 1. Positions that are highly affected are identified: | |
| a. Only up to PM level | ☐ |
| b. Only down to Site Manager level | ☐ |
| c. Down to operative level for certain projects | ☐ |
| 2. Selection criteria for specific roles do exist | ☐ |
| 3. Processes and individuals are expected to use them | ☐ |
| 4. Continuous central support exists | ☐ |
| 5. Training is provided | ☐ |
| 6. Central support to develop interface management exists | ☐ |

**Question: SLD4cSel**

| Scale | Selection |
|---|---|
| Simply identify resource demand and request allocation of personnel | ☐ |
| Looking at each package (no WBS, or OBS) and identifying team leaders according to their skill and profile | ☐ |
| Looking at each package (no WBS, or OBS) and identifying individuals according to their skill and profile | ☐ |
| Using the RAM as it is derived from the use the WBS / OBS matrix. Identifying down to companies (contractual level) | ☐ |
| Using the RAM as it is derived from the use the WBS / OBS matrix. Identifying down to team leaders and according to their skills | ☐ |
| Using the RAM as it is derived from the use the WBS / OBS matrix. Identifying down to individuals and according to their skills | ☐ |

| | | |
|---|---|---|
| A1 | Only Client Mngt Level | 0.0% |
| A2 | Client & Design Mngt Level | 2.5% |
| A3 | Client Mngt Level & Design down to LL | 3.0% |
| A4 | Client & Design & 1st Tier Mngt Level | 5.0% |
| A5 | Client & Design Mngt Level & 1st Tier down to Site Mngt Level | 7.5% |
| A6 | Client & Design Mngt Level & 1st Tier down to LL | 20.0% |
| A7 | Client Mngt & Design to LL & 1st Tier Mngt Level | 12.5% |
| A8 | Client Mngt & Design to LL & 1st Tier down to Site Mngt Level | 30.0% |
| A9 | Client Mngt & Design to LL & 1st Tier down to LL | 35.0% |
| A10 | Client & Design & All C's Mngt Level | 10.0% |
| A11 | Client & Design & 1st Tier & All C's Mngt Level | 15.0% |
| A12 | Client & Design Mngt Level & 1st Tier down to Site Mngt Level & All C's Mngt down to Site Mngt Level | 35.0% |
| A13 | Client & Design Mngt Level & 1st Tier down to Site Mngt Level & All C's LL | 55.0% |
| A14 | Client & Design Mngt Level & 1st Tier down to LL & All C's LL | 65.0% |
| A15 | Client Mngt & Design LL & All C's Mngt Level | 40.0% |
| A16 | Client Mngt & Design LL & 1st Tier & All C's Mngt Level | 50.0% |
| A17 | Client Mngt & Design LL & 1st Tier down to Site Mngt Level & All C's Mngt down to Site Mngt Level | 75.0% |
| A18 | Client Mngt & Design LL & 1st Tier down to Site Mngt Level & All C's LL | 80.0% |
| A19 | Client Mngt & Design LL & 1st Tier down to LL & All C's LL | 90.0% |

| | | |
|---|---|---|
| B1 | Only Client from Mngt level down to LL | 2.5% |
| B2 | Client down to LL & Design Mngt Level | 3.0% |
| B3 | Client down to LL & Design down to LL | 7.5% |
| B4 | Client down to LL & Design & 1st Tier Mngt Level | 10.0% |
| B5 | Client down to LL & Design Mngt Level & 1st Tier down to Site Mngt Level | 20.0% |
| B6 | Client down to LL & Design Mngt Level & 1st Tier down to LL | 35.0% |
| B7 | Client down to LL & Design to LL & 1st Tier Mngt Level | 30.0% |
| B8 | Client down to LL & Design to LL & 1st Tier down to Site Mngt Level | 37.5% |
| B9 | Client down to LL & Design to LL & 1st Tier down to LL | 45.0% |
| B10 | Client down to LL & Design & All C's Mngt Level | 15.0% |
| B11 | Client down to LL & Design & 1st Tier & All C's Mngt Level | 20.0% |
| B12 | Client to LL & Design Mngt & 1st Tier down to Site Mngt Level & All C's Mngt down to Site Mngt Level | 40.0% |
| B13 | Client down to LL & Design Mngt Level & 1st Tier down to Site Mngt Level & All C's LL | 60.0% |
| B14 | Client down to LL & Design Mngt Level & 1st Tier down to LL & All C's LL | 70.0% |
| B15 | Client down to LL & Design LL & All C's Mngt Level | 45.0% |
| B16 | Client down to LL & Design LL & 1st Tier & All C's Mngt Level | 55.0% |
| B17 | Client to LL & Design LL & 1st Tier down to Site Mngt Level & All C's Mngt down to Site Mngt Level | 80.0% |
| B18 | Client down to LL & Design LL & 1st Tier down to Site Mngt Level & All C's LL | 90.0% |
| B19 | Client down to LL & Design LL & 1st Tier down to LL & All C's LL | 100.0% |

| | | |
|---|---|---|
| C1 | Design & 1st Tier Mngt Level | 7.5% |
| C2 | Design Mngt Level & 1st Tier down to Site Mngt Level | 15.0% |
| C3 | Design Mngt Level & 1st Tier down to LL | 30.0% |
| C4 | Design & All C's Mngt Level | 15.0% |
| C5 | Design Mngt Level & All C's down to Site Mngt Level | 17.5% |
| C6 | Design Mngt Level & All C's down to LL | 20.0% |
| C7 | Design & 1st Tier & All C's Mngt Level | 15.0% |
| C8 | Design Mngt Level & 1st Tier down to Site Mngt Level & All C's Mngt down to Site Mngt Level | 35.0% |
| C9 | Design Mngt Level & 1st Tier down to Site Mngt Level & All C's LL | 57.5% |
| C10 | Design Mngt Level & 1st Tier down to LL & All C's LL | 67.5% |
| C11 | Design to LL & 1st Tier Mngt Level | 27.5% |
| C12 | Design to LL & 1st Tier down to Site Mngt Level | 35.0% |
| C13 | Design to LL & 1st Tier down to LL | 42.5% |
| C14 | Design LL & All C's Mngt Level | 40.0% |
| C15 | Design LL & All C's down to Site Mngt Level | 45.0% |
| C16 | Design LL & All C's down to LL | 47.5% |
| C17 | Design LL & 1st Tier & All C's Mngt Level | 52.5% |
| C18 | Design LL & 1st Tier down to Site Mngt Level & All C's Mngt down to Site Mngt Level | 77.5% |
| C19 | Design LL & 1st Tier down to Site Mngt Level & All C's LL | 87.5% |
| C20 | Design LL & 1st Tier down to LL & All C's LL | 92.5% |

| | | |
|---|---|---|
| D1 | 1st Tier Mngt Level | 5.0% |
| D2 | 1st Tier down to Site Mngt Level | 15.0% |
| D3 | 1st Tier down to LL | 25.0% |
| D4 | 1st Tier & All C's to Mngt Level | 7.5% |
| D5 | 1st Tier Mngt & All C's down to Site Mngt Level | 20.0% |
| D6 | 1st Tier Mngt & All C's down to LL | 30.0% |
| D7 | 1st Tier down to Site Mngt Level & All C's to Mngt Level | 35.0% |
| D8 | 1st Tier down to Site Mngt Level & All C's down to Site Mngt Level | 40.0% |
| D9 | 1st Tier down to Site Mngt Level & All C's down to LL | 65.0% |
| D10 | 1st Tier down to LL & All C's to Mngt Level | 60.0% |
| D11 | 1st Tier down to LL & All C's down to Site Mngt Level | 85.0% |
| D12 | 1st Tier down to LL & All C's down to LL | 100.0% |

SLD1Str

**Question SLD1Str**

| Structural flexibility | Selection | Communicational flexibility | Selection |
|---|---|---|---|
| 1. Teams within the same discipline are fixed on their task | ☐ | 11. There is no interaction between the different teams | ☐ |
| 2. Teams remain in a discipline role throughout the project | ☐ | 12. Teams do not exchange views / communicate between them | ☐ |
| 3. Teams remain in a functional role throughout the project | ☐ | 13. Teams do not know what each other are doing, need to do, will be doing. | ☐ |
| 4. Project structure is formed on a stage by stage basis – no overlaps | ☐ | 14. Exchange of views / Communication only happens at Discipline leader level | ☐ |
| 5. Overlaps are covered by allowing for the older structure to remain in place for a period of time to support the new members that will take the project forward to the next stage | ☐ | 15. Exchange of views / Communication only happens between Team leaders | ☐ |
| 6. Assigning roles / identifying individuals to act as Liaison Devices between the teams | ☐ | 16. Teams know what each other are doing, need to do, will be doing. | ☐ |
| 7. The project structure is supported by an Organisational Integration role | ☐ | 17. There is frequent exchange of views between the different teams | ☐ |
| 8. Team leaders rotate between the same discipline teams | ☐ | 18. Teams are briefed together on the upcoming tasks and | ☐ |
| 9. Teams within the same discipline are rotating | ☐ | 19. Discipline / Teams leaders discuss and resolve together general / project problems | ☐ |
| 10. Teams decide on the structure they will need (Moore D. 2002 p.183) | ☐ | 20. Teams discuss and resolve together general / project problems | ☐ |

**Structural**

No Flexibility — Complete Flexibility

| Bullet Point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rank | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Communicational**

No Flexibility — Complete Flexibility

| Bullet Point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rank | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

# Appendix C-3.4 – Description of complexity characteristics used for interviews

| | | A-Team Selection | B-Structure of Team | C- Mngt of Team | D- Monitor & Contro | E- Reporting | F- Conflict Resolutio | G- Usage of Resos |
|---|---|---|---|---|---|---|---|---|
| - $x_1$ | 1. **Autonomous agents** | X | X | X | | X | X | |
| - $x_2$ | 2. **Instability** | X | X | X | | X | X | |
| - $x_3$ | 3. **Non-equilibrium** | X | X | X | X | X | X | X |
| - $x_4$ | 4. **Non-linear** | X | X | X | X | X | X | X |
| - $x_5$ | 5. **Attractors** | X | X | X | X | X | X | X |
| - $x_6$ | 6. **Co-evolution** | X | X | X | X | | | X |
| - $x_7$ | 7. **Self-modification** | X | X | X | | X | | |
| - $x_8$ | 8. **Self-reproduction** | X | X | X | | X | | |
| - $x_9$ | 9. **Downward Causation** | X | X | X | X | X | | |
| - $x_{10}$ | 10. **Mutability** | X | X | X | | | | |
| - $x_{11}$ | 11. **Non-uniform** | X | X | X | X | X | X | X |
| - $x_{12}$ | 12. **Emergence** | X | X | X | X | | | |
| - $x_{13}$ | 13. **Phase changes** | X | X | X | X | | | X |
| - $x_{14}$ | 14. **Unpredictability** | X | X | X | X | | | |
| - $x_{15}$ | 15. **Non-standard** | X | X | X | | | X | X |
| - $x_{10}$ | 16. **Undefined values** | X | X | X | X | X | X | X |

| Group | Characteristics | Brief Description | Relevance to Construction | Further Explanation |
|---|---|---|---|---|
| Conditional | Autonomous agents | Complex systems are generally composed of independent or autonomous agents (not the identical parts often assumed in science). All of these agents are regarded as equally valuable in the operation of the system | Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | |
| | Instability | Over the long term stepped evolution or catastrophes will exist (similar to punctuated equilibria). Sudden swaps between attractors become possible as the system parameters approach the boundaries of the attractors | Stepped evolution(s) or catastrophes do occur in projects. Attractors (see definition) appear (currently unintentionally) and become system parameters and which will attract and avoid chaotic behaviour of the project system | |
| | Non-equilibrium | Energy flows will drive the system away from an equilibrium position and establish semi-stable modes as dynamic attractors | The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | It should be a combination of stakeholders as well as project team members that cause these 'energy flows' therefore we should be looking further than a simple stakeholder management |
| | Non-linear | Complex system outputs are not proportional to their inputs | Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behaviour. | |
| | Attractors | Self-organization relates to the presence in the system of dynamical attractors | Simple systems (individuals) come together and many times self-organise to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. So we have individuals, that could easily not be the line managers, who because of their capabilities, abilities, behavioural attributes are assigned to be 'attractors' is a certain situation arises. | The top-2-bottom hierarchical structure allows only for the identification of lines of responsibility. However, complexity (defined as the study of interconnections of systems) identifies as one of the characteristics the need/existence of attractors, which are / could be construed as individuals who when required become the poles of attraction. |
| Developmental | Co-evolution | The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment | This is self-evident in the Project Management world | Individuals within teams and teams within projects co-evolve and initially attempt to understand each other in order to understand the requirements and fit into the wider project environmen |
| | Self-modification | Parts can change their associations or connectivity freely - either randomly or by evolved learning procedures | Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle | As new teams enter the project environment new associations are created between individuals and teams. Managing and coordinating the self-modification of individuals and teams to the benefit of the project, through learning, will improve the project outcome |
| | Self-reproduction | Usually these systems have an ability to clone identical or edited copies | The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different teams may require different organisational structure. Similarly the Mngt style is copied/imposed throughout | |
| | Downward Causation | The existence and properties of the parts themselves are affected by the emergent properties (or higher level systemic features) of the whole | The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. | A number of structures that are set up at project level that indicate the systemic features of the project affect the existence, the properties / requirements of the project parts themselves. Therefore the standard project management structures, WBS, OBS, CBS, etc. as well as the informal project structures (everyday communication, etc.) affect the existence and input by individuals and teams |
| | Mutability | Random internal changes (mutations) or innovations typically occur in these systems. | It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | Considering the 'individual' as a system, it is highly likely that random internal changes will occur during the life cycle of the project and these will have an effect on the project through the individual's performance. These internal changes could be beneficial or detrimental and could be caused by either internal, to the project, reasons (e.g. team members' behaviours), or the individual's employer (e.g. promotion or demotion), or personal. Perhaps these changes are / could occur at a macro – project unconscious - level, or even a micro – deliberate – level. It is obvious that beneficial random internal changes will improve the individual's performance, whereas detrimental random internal changes will reduce performance. And whereas beneficial changes could be management led, detrimental changes could remain esoteric and could take longer to be recognized. |
| | Non-uniform | Each part evolves separately, giving a diversity in rule or task space | The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped. | Each person brings its own attributes to the project at the level it operates. The more specialist the level the more autonomy the individual or the team gets thus giving diversity in the rule. As personnel moves from project to project and as all influences from the various factors affect the individual(s) the individuals become carriers and evolve as they move along. No project is the same and no individual can keep on doing the same thing. Individuals evolve through the project life-cycle and through the projects giving diversity in rule or task space. This diversity improves the outcome, as the individual(s) are attempting to achieve a higher status, or benefit |
| | Emergence | The properties of the overall system will be expected to contain functions that do not exist at part level | This again is the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project | |
| | Phase changes | Feedback processes lead to phase changes, sudden jumps in system properties | As far as the individual is concerned this characteristic highlights the importance of feedback processes for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' 'properties' attributes. These could either be the standard phase changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property. | |
| Behavioural | Unpredictability | In such interacting systems a chaotic sensitivity to initial conditions can occur | This represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on the projects (*see also pathogens and incubation period, IJPM ref. needed here*). | |
| | Non-standard | … initially homogenous systems will develop self-organizing structures dynamically | Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | Complexity requires for systems to have the characteristic of 'non-standard' in order to be able to evolve from homogenous systems into dynamic self-organised ones. Each individual (or team) that will come to the project (as a homogenous system) will dynamically develop self-organising structures in order to adjust/adapt to the environment. It could also be said that members of project teams should possess the characteristic of non-standard, which means that they should be able to evolve from homogenous ones into self-organising in order to adapt to the project environment. |
| | Undefined values | The meaning of the system's interface with the environment is not initially specified and this must evolve | Identifying the system's/project's interfaces with the environment as the external stakeholders (re. W. Hughes 11 external factors see CME paper & my further thoughts on this subject) this characteristic identifies the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project | Regarding selecting the team members, and in particular for several roles within the team, the influencing factor of the project interfaces should identified and introduced in the selection criteria process. These individuals should be able to act as attractors when the interfaces are specified and should be supporting the process. They are the project agents who work with the team to delineate the Undefined values. |

# Appendix C-3.5 – Reasons for delay pick list for case studies

**Reasons for activity delays**

| Code | Characteristic | Reason |
|---|---|---|
| D300 | Self-reproduction | R01 - Lack of appropriate level of induction |
| C400, D301 | Non-linear, Self-reproduction | R02 - Lack of appropriate level of training |
| D700 | Emergence | R03 - Team cohesion |
| B300 | Undefined values – structure | R04 - Inter-team issue (please elaborate) |
| B310 | Undefined values – team | R05 - Team was not prepared (trained appropriately) to accept influences from the project environment |
| D100 | Co-evolution – team | R06 - Lack of Flexibility within the team |
| C100 | Autonomous agents | R07 - Extensive time taken to resolve a problem |
| C500, C300 | Attractors / Non-equilibrium | R08 - No expertise within the team – external input requested |
| C402 | Non-linear – structure | R09 - Structure of team required improvement |
| C420 | Non-linear – management | R10 - Authoritative approach caused problem in team |
| D400 | Downward causation - team selection | R11 - Team selection could have been better in terms of tackling the task |
| D410 | Downward causation – structure | R12 - Definition of work structure needed clarification |
| D420 | Downward causation – management | R13 - Line of command needed clarification |
| B100 | Unpredictability | R14 - Problem from initial stages of project re-surfaced and caused delay |
| B101 | Unpredictability | R15 - Problem with design |
| D110 | Co-evolution – structure | R16 - Communication between team and others |
| C210 | Instability - structure | R17 - Clarity of communication / instruction cause confusion to the team which took some time to react to the misunderstanding |
| C101, C310 | Autonomous Agents – team<br>Non-equilibrium - structure | R18 - Restriction in people availability did not allow for appropriate level of expertise |
| C211<br>D510<br>D511<br>D500<br>D520<br>D800 | Instability,<br>Mutability,<br><br><br><br>Phase changes | R19 - Unexpected activity due to:<br>R20 - Non-availability of material<br>R21 - Change in higher level programme<br>R22 - Causing an upset in the team (who probably did it again)<br>R23 - Caused by unreasonable insistence by others<br>R24 - Caused by not 'listening' to team feedback / expertise |
| | Instability | R25 - Due to a change that was not quickly accommodated in terms of: |

| | | |
|---|---|---|
| C200<br>C212 | | R26 - Team capability<br>R27 - Team structure |
| C301,<br>C311 | Non-equilibrium | R28 - Another activity (or part of) distracted the team who carried out both but with a decrease in the output of the planned activity |
| C401 | Non-linear | R29 - Team did not really perform together – synchronised |
| D101 | Co-evolution | R30 - Understanding between different teams |
| D200 | Self-modification | R31 - Not adequate flexibility between team members |
| D201 | Self-modification | R32 - Not adequate flexibility between teams |
| D520 | Mutability – management | R33 - Management style did not change to accommodate the change in the environment – the way things needed to be addressed |
| D501 | Mutability – team | R34 - Random changes in individuals have affected the performance of the team |
| D512 | Mutability – structure | R35 - A change in the team structure affected the performance |
| D600 | Non-uniform | R36 - Not enough individual diversity affected performance |
| D801 | Phase changes | R37 - Feedback mechanism between team members was not functioning |
| D810,<br>D820 | | R38 - Feedback mechanism between the team and others was not functioning |
| D821 | | R39 - Management style did not help/support the team feedback |
| B200 | Non-standard – team | R40 - Selection of individuals in team was not so successful, individuals did not really gel |
| B210 | Non-standard – structure | R41 - Team structure was to rigid and did not allow for the team to evolve |
| B220 | Non-standard – management | R42 - Management style needs to allow for more team freedom to evolve |

# Appendix C-3.6 – Listing of case study reasons for delay and complexity characteristics

| | | A-Team Selection | B-Structure of Team | C- Mngt of Team | D- Monitor & Contro | E- Reporting | F- Conflict Resolutio | G- Usage of Resos |
|---|---|---|---|---|---|---|---|---|
| $\delta - x_{1}$ | 1. Autonomous agents | X | X | X | | X | X | |
| $\delta - x_{2}$ | 2. Instability | X | X | X | | X | X | |
| $\delta - x_{3}$ | 3. Non-equilibrium | X | X | X | X | X | X | X |
| $\delta - x_{4}$ | 4. Non-linear | X | X | X | X | X | X | X |
| $\delta - x_{5}$ | 5. Attractors | X | X | X | X | X | X | X |
| $\delta - x_{6}$ | 6. Co-evolution | X | X | X | X | | | X |
| $\delta - x_{7}$ | 7. Self-modification | X | X | X | | X | | |
| $\delta - x_{8}$ | 8. Self-reproduction | X | X | X | | X | | |
| $\delta - x_{9}$ | 9. Downward Causation | X | X | X | X | X | | |
| $\delta - x_{10}$ | 10. Mutability | X | X | X | | | | |
| $\delta - x_{11}$ | 11. Non-uniform | X | X | X | X | X | X | X |
| $\delta - x_{12}$ | 12. Emergence | X | X | X | X | | | |
| $\delta - x_{13}$ | 13. Phase changes | X | X | X | X | | | X |
| $\delta - x_{14}$ | 14. Unpredictability | X | X | X | X | | | |
| $\delta - x_{15}$ | 15. Non-standard | X | X | X | | | X | X |
| $\delta - x_{16}$ | 16. Undefined values | X | X | X | X | X | X | X |

| Group | Characteristics | Brief Description | Relevance to Construction | Further Explanation |
|---|---|---|---|---|
| Conditional | Autonomous agents | Complex systems are generally composed of independent or autonomous agents (not the identical parts often assumed in science). All of these agents are regarded as equally valuable in the operation of the system | Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | |
| | Instability | Over the long term stepped evolution or catastrophes will exist (similar to punctuated equilibria). Sudden swaps between attractors become possible as the system parameters approach the boundaries of the attractors | Stepped evolution(s) or catastrophes do occur in projects. Attractors (see definition) appear (currently unintentionally) and become system parameters and which will attract and avoid chaotic behaviour of the project system | |
| | Non-equilibrium | Energy flows will drive the system away from an equilibrium position and establish semi-stable modes as dynamic attractors | The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | It should be a combination of stakeholders as well as project team members that cause these 'energy flows' therefore we should be looking further than a simple stakeholder management |
| | Non-linear | Complex system outputs are not proportional to their inputs | Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behaviour | |
| | Attractors | Self-organization relates to the presence in the system of dynamical attractors | Simple systems (individuals) come together and many times self-organise to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. So we have individuals, that could easily not be the line managers, who because of their capabilities, abilities, behavioural attributes are assigned to be 'attractors' is a certain situation arises. | The top-2-bottom hierarchical structure allows only for the identification of lines of responsibility. However, complexity (defined as the study of interconnections of systems) identifies as one of the characteristics the need/existence of attractors, which are / could be construed as individuals who when required become the poles of attraction. |
| Developmental | Co-evolution | The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment | This is self-evident in the Project Management world | Individuals within teams and teams within projects co-evolve and initially attempt to understand each other in order to understand the requirements and fit into the wider project environmen |
| | Self-modification | Parts can change their associations or connectivity freely - either randomly or by evolved learning procedures | Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle | As new teams enter the project environment new associations are created between individuals and teams. Managing and coordinating the self-modification of individuals and teams to the benefit of the project, through learning, will improve the project outcome |
| | Self-reproduction | Usually these systems have an ability to clone identical or edited copies | The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different teams may require different organisational structure. Similarly the Mngt style is copied/imposed throughout | |
| | Downward Causation | The existence and properties of the parts themselves are affected by the emergent properties (or higher level systemic features) of the whole | The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. | A number of structures that are set up at project level that indicate the systemic features of the project affect the existence, the properties / requirements of the project parts themselves. Therefore the standard project management structures, WBS, OBS, CBS, etc. as well as the informal project structures (everyday communication, etc.) affect the existence and input by individuals and teams |
| | Mutability | Random internal changes (mutations) or innovations typically occur in these systems. | It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | Considering the 'individual' as a system, it is highly likely that random internal changes will occur during the life cycle of the project and these will have an effect on the project through the individual's performance. These internal changes could be beneficial or detrimental and could be caused by either internal, to the project, reasons (e.g. team members' behaviours), or the individual's employer (e.g. promotion or demotion), or personal. Perhaps these changes are / could occur at a macro – project unconscious - level, or even a micro – deliberate – level. It is obvious that beneficial random internal changes will improve the individual's performance, whereas detrimental random internal changes will reduce performance. And whereas beneficial changes could be management led, detrimental changes could remain esoteric and could take longer to be recognized |
| | Non-uniform | Each part evolves separately, giving a diversity in rule or task space | The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped. | Each person brings its own attributes to the project at the level it operates. The more specialist the level the more autonomy the individual or the team gets thus giving diversity in the rule. As personnel moves from project to project and as all influences from the various factors affect the individual(s) the individuals become carriers and evolve as they move along. No project is the same and no individual can keep on doing the same thing. Individuals evolve through the project life-cycle and through the projects giving diversity in rule or task space. This diversity improves the outcome, as the individual(s) are attempting to achieve a higher status, or benefit |
| | Emergence | The properties of the overall system will be expected to contain functions that do not exist at part level | This again is the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project | |
| | Phase changes | Feedback processes lead to phase changes, sudden jumps in system properties | As far as the individual is concerned this characteristic highlights the importance of feedback processes for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' 'properties' attributes. These could either be the standard phase changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property. | |
| Behavioural | Unpredictability | In such interacting systems a chaotic sensitivity to initial conditions can occur | This represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on the projects (*see also pathogens and incubation period. IJPM ref. needed here*). | |
| | Non-standard | ... initially homogenous systems will develop self-organizing structures dynamically | Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | Complexity requires for systems to have the characteristic of 'non-standard' in order to be able to evolve from homogenous systems into dynamic self-organised ones. Each individual (or team) that will come to the project (as a homogenous system) will dynamically develop self-organising structures in order to adjust/adapt to the environment. It could also be said that members of project teams should possess the characteristic of non-standard, which means that they should be able to evolve from homogenous ones into self-organising in order to adapt to the project environment. |
| | Undefined values | The meaning of the system's interface with the environment is not initially specified and this must evolve | Identifying the system's/project's interfaces with the environment as the external stakeholders (re. W. Hughes 11 external factors see CME paper & my further thoughts on this subject) this characteristic identifies the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project | Regarding selecting the team members, and in particular for several roles within the team, the influencing factor of the project interfaces should identified and introduced in the selection criteria process. These individuals should be able to act as attractors when the interfaces are specified and should be supporting the process. They are the project agents who work with the team to delineate the Undefined values. |

| Coded Reasons of Delay | | | | | | | |
|---|---|---|---|---|---|---|---|
| Selecting the Team Delay Codes | | | Structuring the Team Delay Codes | | | Management of Team Delay Codes | |
| R07 | R18 | | | | | | |
| R25 | R26 | | R17 | R19 | R27 | | |
| R08 | R28 | | R18 | R28 | | | |
| R02 | R09 | R29 | | | | R10 | |
| R08 | | | | | | | |
| R06 | R30 | | R16 | | | | |
| R31 | R32 | | | | | | |
| R01 | R02 | | | | | | |
| R11 | | | R12 | | | R13 | |
| R22 | R34 | | R20 | R21 | R35 | R23 | R33 |
| R36 | | | | | | | |
| R03 | | | | | | | |
| R24 | R37 | | R38 | | | R38 | R39 |
| R14 | R15 | | | | | | |
| R40 | | | R41 | | | R42 | |
| R04 | | | R05 | | | | |

# Appendix C-3.7 – Explanatory note for calculating performance of case study projects

**Explanation for approach used to calculate performance on Case Study projects.**

**A)** The Simple Method

With this method performance of activities is calculated simply on the basis of (Duration Planned * Performance reported) and Total Performance is (Σ of Duration Achieved / Σ of Duration Planned) irrespective of the time elapsed for the activity to be completed.

For example in Case Study G1.3 activity SW13290:

| | |
|---|---|
| Duration | 10 Days |
| Planned Start Date | Wednesday 2-Jan-08 |
| Week Number | 1 |
| Actual Start Date | Wednesday 2-Jan-08 |
| Planned Finish Date | Tuesday 15-Jan-08 |
| Week Number | 3 |
| Actual Finish Date | Friday 15-Feb-08 |
| Time elapsed to completion | 33 Days |
| Week Number | 8 |

| Week (1) | Planned Duration (2) | Performance (3) | Du Achieved (4 = 2 * 3) | Total Performance (5 = Σ(4) / Σ(2)) |
|---|---|---|---|---|
| 2 | 3 | 83% | 2.5 | 83% |
| 3 | 5 | 50% | 2.5 | 62% |
| 4 | 2 | 50% | 1 | 60% |
| 5 | 0 | 0% | 0 | 60% |
| 6 | 0 | 0% | 0 | 60% |
| 7 | 0 | 0% | 0 | 60% |
| 8 | 0 | 100% | 4 | 100% |

Although it is simple to calculate and could be said that no resources are utilised during weeks 4 to 7, and that for activities of the critical path only Total / Free Float are reduced it does not take into account the overall effect on the project and also as per Collins & Bacarini (2004) the time element of the project outcome cannot be taken as successful.

**B)** The Time Elapsed Method

This method is more elaborate as it takes into account (see tabular report below) and emphasizes the effect of time lost, under utilisation of resources (idle time) and strain put on subsequent activities.

Using the above given activity data the calculations for performance based on time elapsed are shown below.

| Week (1) | Planned Duration (2) | % Progress (3) | Du Achieved (4 = 2 * 3) | Time Elapsed (5) | Performance based on Time Elapsed (6 = 4 / 5) | Total Performance (7 = Σ(4) / Σ(5)) |
|---|---|---|---|---|---|---|
| 2 | 3 | 83% | 2.5 | 3 | 83% | 83% |
| 3 | 5 | 50% | 2.5 | 5 | 50% | 62% |
| 4 | 2 | 50% | 1 | 5 | 20% | 46% |
| 5 | 0 | 0% | 0 | 5 | 0% | 33% |
| 6 | 0 | 0% | 0 | 5 | 0% | 26% |
| 7 | 0 | 0% | 0 | 5 | 0% | 21% |
| 8 | 0 | 100% | 4 | 4 | 100% | 31% |

This method although more elaborate it takes into account the overall consequences and indicates the effect of 'reasons for delay' on the activities and the overall in terms of project outcome.

# Appendix C-3.8 – Case Study Performance Log Template

# Case Study Performance Log Template

**Activities to be reviewed on w/e: ..................**

**From schedule issued on: ........................**

| Activity Number | Actual Start | Expected Finish | Actual Finish | % | Cum % | Reason(s) (Selected from pick list) |
|---|---|---|---|---|---|---|
| | | | | | | |
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## Appendix C-3.9 – Sample of Case Study progress report – Case Study G1.1.4 Report - 01Feb08

# Case Study Performance Log Template

**Activities to be reviewed on w/e: 01-Feb-08 wk7**

**From schedule issued on: Issue 2 10-Jan-08**

| Activity Number | Actual Start | Expected Finish | Actual Finish | % | Cum % | Reason(s) (Selected from pick list) |
|---|---|---|---|---|---|---|
| 19 | | | 28/1/108 | | | |
| 20 | | | 29/1/08 | | | |
| 22 | 1/2/08 | | | | | R23 |
| 25 delayed | | 22/2/08 | | | | Unforeseen steelwork – R20 |
| 36 from wk6 | | | 27/1/08 | | | |
| 41 | | 18/2/08 | | | | Check reason for massive delay from 30-Jan-08 |
| 42 | | | 27/1/08 | | | |
| 48 delayed | | | | | | |
| 60 from wk6 | 30/1/08 | | | | | Passengers in the area R07 |
| 72 | 28/1/08 | | | | | |
| 74 from wk6 | | 6/2/08 | | | | |
| 78 from wk6 | 23/1/08 | 5/2/08 | | | | |
| 83 | 28/1/08 | | | | | |
| 88 from wk6 | | | 1/2/08 | | | |
| 96 | | | 1/2/08 | | | |
| 102 | 5/2/08 | 19/2/08 | | | | Design revised R15 |
| 103 | 5/2/08 | | | | | Design revised R15 |
| 104 | Alternative design solution now proposed R15, R21 | | | | | |
| 109 | | | 28/1/08 | | | |
| 110 | 28/1/08 | | | | | |
| 115 forgotten | | 6/2/08 | | | | Lack of design resources R18 |
| 116 from wk6 | 29/1/08 | | | | | Design change R15 |
| 118 | 5/2/08 | | | | | Lack of design resources R18 |
| 121 | 5/2/08 | | | | | Design change R15 |
| 125 delayed | 5/2/08 | | | | | Design revised R15 |
| 126 | 5/2/08 | | | | | Design revised R15 |
| | | | | | | |
| | | | | | | |

# Appendix C-3.10 – Sample of Case Study Performance calculations – Case Study G1.1.4

## Calculations Based on Time Elapsed

| | Wk1 - 21-Dec-07 | | | | 5 | Wk2 - 28-Dec-07 | | | | 5 | Wk3 - 04-Jan-08 | | | | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 11 | 12 | 13 | 14 | 17 | 18 | 19 | 20 | 21 | 7 | 8 | 9 | 10 | 11 |
| | DUs plnd | Perf Rep | DU Ach'd | Cum Du Ac | Reason | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason |
| 8 | 15 | 100% | 15 | 100.00% | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 9 | 10 | 100% | 10 | 100.00% | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 12 | 10 | 0% | 0 | 0.00% | R15 | 5 | 0% | 0 | 0.00% | R15 | 5 | 0% | 0 | 0.00% | R15 |
| 15 | | | | | | | | | | | 3 | 0% | 0 | 0.00% | |
| 33 | 5 | 0% | 0 | 0.00% | R17, R23, R28 | 5 | 0% | 0 | 0.00% | R17, R23, R28 | 5 | 0% | 0 | 0.00% | R17, R23, R28 |
| 42 | 10 | 100% | 10 | 100.00% | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 47 | | | | | | | | | | | 3 | 0% | 0 | 0.00% | |
| 49 | | | | | | | | | | | 3 | 0% | 0 | 0.00% | |
| 53 | 15 | 100% | 15 | 100.00% | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 60 | 15 | 100% | 15 | 100.00% | | | | | | | | | | | |
| 73 | 15 | 100% | 15 | 100.00% | | | | | | | | | | | |
| 74 | | | | | | | | | | | 3 | 0% | 0 | 0.00% | R14, R21 |
| 78 | 10 | 40% | 4 | 40.00% | | 5 | 50% | 3.5 | 50.00% | | 5 | 60% | 4.5 | 60.00% | |
| 4 or 7 | | | | | | | | | | | | | | | |
| 5 or 9 | | | 0 | 0.00% | | | | 0 | 0.00% | | | | | | |
| 9 or 12 | | | | | | | | | | | | | | | |
| 10 or 12 | | | | | | | | | | | | | | | |
| 11 or 12 | | | | | | | | | | | | | | | |
| 12 or 12 | | | | | | | | | | | | | | | |
| 15 or 12 | | | | | | | | | | | | | | | |
| 16 or 12 | | | | | | | | | | | | | | | |
| 17 or 12 | | | | | | | | | | | | | | | |
| 18 or 12 | | | | | | | | | | | | | | | |
| 19 or 12 | | | | | | | | | | | | | | | |
| 20 or 12 | | | | | | | | | | | | | | | |
| 22 or 12 | | | | | | | | | | | | | | | |
| 25 or 12 | | | | | | | | | | | | | | | |
| 28 or 12 | | | | | | | | | | | | | | | |
| 29 or 12 | | | | | | | | | | | | | | | |
| 30 or 12 | | | | | | | | | | | | | | | |
| 33 or 12 | | | | | | | | | | | | | | | |
| 34 or 12 | | | | | | | | | | | | | | | |
| 35 or 12 | | | | | | | | | | | | | | | |
| 36 or 12 | | | | | | | | | | | | | | | |
| 39 or 12 | | | | | | | | | | | | | | | |
| 40 or 12 | | | | | | | | | | | | | | | |
| 41 or 12 | | | | | | | | | | | | | | | |
| 42 or 12 | | | | | | | | | | | | | | | |
| 43 or 12 | | | | | | | | | | | | | | | |
| 44 or 12 | | | | | | | | | | | | | | | |
| 47 or 15 | | | | | | | | | | | | | | | |
| 48 or 16 | | | | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | | | | |
| 60 or 35 | | | | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | | | | |
| 66 | | | | | | | | | | | | | | | |
| 69 or 51 | | | | | | | | | | | | | | | |
| 71 or 51 | | | | | | | | | | | | | | | |
| 72 or 51 | | | | | | | | | | | | | | | |
| 74 or 51 | | | | | | | | | | | | | | | |
| 76 or 51 | | | | | | | | | | | | | | | |
| 77 or 51 | | | | | | | | | | | | | | | |
| 78 or 51 | | | | | | | | | | | | | | | |
| 80 or 51 | | | | | | | | | | | | | | | |
| 82 or 51 & 55 | | | | | | | | | | | | | | | |
| 83 or 51 & 55 | | | | | | | | | | | | | | | |
| 88 | | | | | | | | | | | | | | | |
| 89 | | | | | | | | | | | | | | | |
| 90 or 61 | | | | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | | | | |
| 96 | | | | | | | | | | | | | | | |
| 97 | | | | | | | | | | | | | | | |
| 100 or 66 | | | | | | | | | | | | | | | |
| 101 or 66 | | | | | | | | | | | | | | | |
| 102 or 66 | | | | | | | | | | | | | | | |
| 103 or 66 | | | | | | | | | | | | | | | |
| 104 or 67 | | | | | | | | | | | | | | | |
| 109 | | | | | | | | | | | | | | | |
| 110 or 74 | | | | | | | | | | | | | | | |
| 115 | | | | | | | | | | | | | | | |
| 116 | | | | | | | | | | | | | | | |
| 118 | | | | | | | | | | | | | | | |
| 119 | | | | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | | | | |
| 124 | | | | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | | | | |
| 126 | | | | | | | | | | | | | | | |
| | 105 | | 84 | | | 35 | | 24 | | | 47 | | 24.5 | | |

| | Wk4 - 11-Jan-08 | | | | 5 | Wk5 - 18-Jan-08 | | | | 5 | Wk6 - 25-Jan-08 | | | | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 15 | 16 | 17 | 18 | 21 | 22 | 23 | 24 | 25 | 28 | 29 | 30 | 31 | 1 |
| | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | |
| 15 | 0 | 100% | 3 | 37.50% | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | | | | |
| 73 | | | | | | | | | | | | | | | |
| 74 | | | | | | | | | | | | | | | |
| 78 | 0 | 80% | 4 | 64.00% | | 0 | 100% | 4 | 66.67% | | | | | | |
| 4 or 7 | 3 | 100% | 3 | 100.00% | | | | | | | | | | | |
| 5 or 9 | 5 | 85% | 4.25 | 85.00% | R12 | 3 | 100% | 3.75 | 100.00% | | | | | | |
| 9 or 12 | 1 | 100% | 1 | 100.00% | R17 | | | | | | | | | | |
| 10 or 12 | | | | | | 4 | 90% | 3.6 | 72.00% | R28, R29 | | | | | |
| 11 or 12 | | | | | | 1 | 100% | 1 | 100.00% | | 1 | 100% | 1 | 100.00% | |
| 12 or 12 | | | | | | | | | | | 1 | 100% | 1 | 100.00% | |
| 15 or 12 | 3 | 60% | 1.8 | 60.00% | | 0 | 100% | 1.2 | 37.50% | | | | | | |
| 16 or 12 | | | | | | 5 | 100% | 5 | 100.00% | R29 | | | | | |
| 17 or 12 | | | | | | | | | | | 1 | 100% | 1 | 100.00% | |
| 18 or 12 | | | | | | | | | | | 4 | 100% | 4 | 100.00% | |
| 19 or 12 | | | | | | | | | | | | | | | |
| 20 or 12 | | | | | | | | | | | | | | | |
| 22 or 12 | | | | | | | | | | | | | | | |
| 25 or 12 | | | | | | 5 | 10% | 0.5 | 10.00% | R12, R16, R38 | 2 | 0% | 0 | 3.33% | R12, R16, R38 & R23 |
| 28 or 12 | 2 | 100% | 2 | 66.67% | R16 | | | | | | | | | | |
| 29 or 12 | | | | | | 4 | 90% | 3.6 | 80.00% | R12, R28 | | | | | |
| 30 or 12 | | | | | | 1 | 90% | 0.9 | 81.82% | R18 | 1 | 100% | 1 | 95.00% | R18 |
| 33 or 12 | | | | | | 3 | 90% | 2.7 | 81.82% | R09, R18 | | | | | |
| 34 or 12 | | | | | | | | | | | 2 | 100% | 2 | 100.00% | |
| 35 or 12 | | | | | | | | | | | 1 | 100% | 1 | 100.00% | |
| 36 or 12 | | | | | | | | | | | 2 | 95% | 1.9 | 95.00% | R16 |
| 39 or 12 | | | | | | 2 | 95% | 1.9 | 95.00% | R09, R16, R29 | 3 | 100% | 3.1 | 100.00% | |
| 40 or 12 | | | | | | 5 | 100% | 5 | 90.91% | R16 | | | | | |
| 41 or 12 | | | | | | | | | | | | | | | |
| 42 or 12 | | | | | | | | | | | | | | | |
| 43 or 12 | | | | | | | | | | | | | | | |
| 44 or 12 | | | | | | | | | | | | | | | |
| 47 or 15 | 1 | 100% | 1 | 100.00% | | | | | | | | | | | |
| 48 or 16 | 5 | 0% | 0 | 0.00% | R16, R29, R30, R32 | 5 | 0% | 0 | 0.00% | R14, R16, R29, R30, R32 | 5 | 25% | 3.75 | 25.00% | R14, R16, R29, R30, R32 |
| 55 | 3 | 100% | 3 | 100.00% | | | | | | | | | | | |
| 56 | 2 | 100% | 2 | 90.91% | R16, R17 | | | | | | | | | | |
| 58 | | | | | | 4 | 100% | 4 | 90.91% | R28, R32 | | | | | |
| 60 or 35 | 5 | 0% | 0 | 0.00% | R23 | 5 | 0% | 0 | 0.00% | R23 | 5 | 14% | 2.1 | 17.50% | R07, R23 |
| 61 | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | | | | |
| 66 | | | | | | 1 | 100% | 1 | 100.00% | | | | | | |
| 69 or 51 | | | | | | 5 | 100% | 5 | 94.34% | R14, R15 | | | | | |
| 71 or 51 | | | | | | | | | | | | | | | |
| 72 or 51 | | | | | | | | | | | | | | | |
| 74 or 51 | | | | | | | | | | | 5 | 40% | 2 | 40.00% | R03, R07 |
| 76 or 51 | | | | | | 1 | 100% | 1 | 100.00% | | | | | | |
| 77 or 51 | | | | | | | | | | | 2 | 100% | 2 | 100.00% | |
| 78 or 51 | | | | | | | | | | | 3 | 100% | 3 | 100.00% | R03, R07 |
| 80 or 51 | 5 | 90% | 4.50 | 90.00% | R21 | 5 | 100% | 5.5 | 100.00% | R21 | 5 | 100% | 5 | 100.00% | R21 |
| 82 or 51 & 55 | 5 | 0% | 0 | 0.00% | R21 | 5 | 0% | 0 | 0.00% | R28 | 5 | 0% | 0 | 0.00% | R28 |
| 83 or 51 & 55 | | | | | | 5 | 80% | 4 | 80.00% | R38, R30 | 5 | 95% | 5.5 | 95.00% | R38, R30 |
| 88 | | | | | | | | | | | | | | | |
| 89 | 5 | 0% | 0 | 0.00% | R07, R21 | 5 | 0% | 0 | 0.00% | R07, R21 | 5 | 0% | 0 | 0.00% | R07, R21 |
| 90 or 61 | 2 | 100% | 2 | 100.00% | | 5 | 100% | 5 | 100.00% | | | | | | |
| 95 | | | | | | | | | | | | | | | |
| 96 | | | | | | | | | | | | | | | |
| 97 | | | | | | 1 | 100% | 1 | 100.00% | | | | | | |
| 100 or 66 | | | | | | 3 | 100% | 3 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 101 or 66 | | | | | | | | | | | | | | | |
| 102 or 66 | 5 | 0% | 0 | 0.00% | R15 | 5 | 0% | 0 | 0.00% | R15 | 5 | 0% | 0 | 0.00% | R15 |
| 103 or 66 | | | | | | | | | | | | | | | |
| 104 or 67 | 5 | 0% | 0 | 0.00% | R07, R14, R21 | 5 | 0% | 0 | 0.00% | R07, R14, R21 | 5 | 0% | 0 | 0.00% | R07, R14, R16, R21 |
| 109 | | | | | | | | | | | | | | | |
| 110 or 74 | | | | | | | | | | | | | | | |
| 115 | | | | | | | | | | | 1 | 0% | 0 | 0.00% | R06, R08, R20 & R18 |
| 116 | 5 | 0% | 0 | 0.00% | R15, R16, R27, R30 | 5 | 0% | 0 | 0.00% | R15, R16, R27, R30 | 5 | 30% | 4.5 | 30.00% | R15, R16, R27, R30 |
| 118 | | | | | | | | | | | | | | | |
| 119 | | | | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | | | | |
| 124 | | | | | | | | | | | 1 | 0% | 0 | 0.00% | R06, R15, R21 |
| 125 | | | | | | | | | | | 5 | 20% | 1 | 20.00% | R06, R15, R21 |
| 126 | | | | | | | | | | | | | | | |
| | 62 | | 31.55 | | | 98 | | 62.65 | | | 85 | | 49.85 | | |

| | Wk7 - 01-Feb-08 | | | | 5 | Wk8 - 08-Feb-08 | | | | 5 | Wk9 - 15-Feb-08 | | | | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 11 | 12 | 13 | 14 | 15 | 18 | 19 | 20 | 21 | 22 |
| | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason | DUs plnd | Perf Rep | DU Ach'd | Cum Du Ach | Reason | DUs plnd | Perf Rep | DU Ach'd | Cum Du A | Reason |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | | | | |
| 73 | | | | | | | | | | | | | | | |
| 74 | | | | | | | | | | | | | | | |
| 78 | | | | | | | | | | | | | | | |
| 4 or 7 | | | | | | | | | | | | | | | |
| 5 or 9 | | | | | | | | | | | | | | | |
| 9 or 12 | | | | | | | | | | | | | | | |
| 10 or 12 | | | | | | | | | | | | | | | |
| 11 or 12 | | | | | | | | | | | | | | | |
| 12 or 12 | | | | | | | | | | | | | | | |
| 15 or 12 | | | | | | | | | | | | | | | |
| 16 or 12 | | | | | | | | | | | | | | | |
| 17 or 12 | | | | | | | | | | | | | | | |
| 18 or 12 | | | | | | | | | | | | | | | |
| 19 or 12 | 1 | 100% | 1 | 100.00% | | | | | | | | | | | |
| 20 or 12 | 1 | 100% | 1 | 100.00% | | | | | | | | | | | |
| 22 or 12 | 3 | 30% | 0.9 | 30.00% | R15, R16, R23 | 2 | 0% | 0 | 11.25% | R15, R16, R23 | 0 | 0% | 0 | 6.92% | R15, R16, R23 |
| 25 or 12 | 0 | 0% | 0 | 2.50% | R12, R16, R38 & R23 & R20 | 0 | 0% | 0 | 2.00% | R12, R16, R38 & R23 & R20 | 0 | 0% | 0 | 1.67% | R12, R16, R38 & R23 & R20 |
| 28 or 12 | | | | | | | | | | | | | | | |
| 29 or 12 | | | | | | | | | | | | | | | |
| 30 or 12 | | | | | | | | | | | | | | | |
| 33 or 12 | | | | | | | | | | | | | | | |
| 34 or 12 | | | | | | | | | | | | | | | |
| 35 or 12 | | | | | | | | | | | | | | | |
| 36 or 12 | 1 | 100% | 1.1 | 42.86% | R16 | | | | | | | | | | |
| 39 or 12 | | | | | | | | | | | | | | | |
| 40 or 12 | | | | | | | | | | | | | | | |
| 41 or 12 | 3 | 0% | 0 | 0.00% | R12, R30 | 0 | 0% | 0 | 0.00% | R12, R30 | 0 | 0% | 0 | 0.00% | R12, R30 |
| 42 or 12 | 2 | 100% | 2 | 100.00% | | | | | | | | | | | |
| 43 or 12 | | | | | | 1 | 100% | 1 | 100.00% | | | | | | |
| 44 or 12 | | | | | | 3 | 100% | 3 | 100.00% | | | | | | |
| 47 or 15 | | | | | | | | | | | | | | | |
| 48 or 16 | 5 | 35% | 3.25 | 35.00% | R14, R16, R29, R30, R32 | 5 | 45% | 4.25 | 45.00% | R14, R16, R29, R30, R32 | 5 | 55% | 5.25 | 55.00% | R14, R16, R29, R30, R32 |
| 55 | | | | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | | | | |
| 60 or 35 | 0 | 0% | 0 | 12.35% | R07, R23 | 0 | 0% | 0 | 9.55% | R07, R23 | 0 | 0% | 0 | 7.78% | R07, R23 |
| 61 | | | | | | 1 | 0% | 0 | 0.00% | R07, R12, R15, R23 | 0 | 0% | 0 | 0.00% | R07, R12, R15, R23 |
| 62 | | | | | | | | | | | 5 | 0% | 0 | 0.00% | R07, R12, R15, R23 |
| 64 | | | | | | 5 | 0% | 0 | 0.00% | R07, R12, R15, R23 | 5 | 0% | 0 | 0.00% | R07, R12, R15, R23 |
| 66 | | | | | | 5 | 0% | 0 | 0.00% | R07, R12, R15, R23 | 5 | 0% | 0 | 0.00% | R07, R12, R15, R23 |
| 69 or 51 | | | | | | | | | | | | | | | |
| 71 or 51 | | | | | | | | | | | | | | | |
| 72 or 51 | 5 | 40% | 2 | 40.00% | R12 | 5 | 30% | 1 | 30.00% | R12 | 0 | 50% | 2 | 33.33% | R12 |
| 74 or 51 | 5 | 0% | 0 | 20.00% | R03, R07, R29, R30 | 0 | 0% | 0 | 13.33% | R03, R07, R29, R30 | 0 | 60% | 3 | 25.00% | R03, R07, R29, R30 |
| 76 or 51 | | | | | | | | | | | | | | | |
| 77 or 51 | | | | | | | | | | | | | | | |
| 78 or 51 | 5 | 0% | 0 | 23.08% | R03, R07 | 2 | 0% | 0 | 23.08% | R03, R07, R12, R15 | 0 | 0% | 0 | 16.67% | R03, R07, R12, R15 |
| 80 or 51 | | | | | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 82 or 51 & 55 | 0 | 0% | 0 | 0.00% | R07, R28 | 0 | 0% | 0 | 0.00% | R07, R28 | 0 | 0% | 0 | 0.00% | R07, R28 |
| 83 or 51 & 55 | 5 | 100% | 5.5 | 100.00% | R38, R30 | | | | | | | | | | |
| 88 | | | | | | 1 | 100% | 1 | 100.00% | | | | | | |
| 89 | 5 | 0% | 0 | 0.00% | R07, R21 | 5 | 20% | 5 | 20.00% | R07, R21 | 0 | 40% | 5 | 33.33% | R07, R21 |
| 90 or 61 | | | | | | | | | | | | | | | |
| 95 | 5 | 100% | 5 | 100.00% | | | | | | | | | | | |
| 96 | | | | | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 97 | | | | | | | | | | | | | | | |
| 100 or 66 | | | | | | | | | | | | | | | |
| 101 or 66 | 5 | 0% | 0 | 0.00% | R12, R15 | 5 | 0% | 0 | 0.00% | R12, R15 | 0 | 0% | 0 | 0.00% | R12, R15 |
| 102 or 66 | 5 | 0% | 0 | 0.00% | R12, R15 | 5 | 0% | 0 | 0.00% | R12, R15 | 5 | 0% | 0 | 0.00% | R12, R15 |
| 103 or 66 | | | | | | | | | | | | | | | |
| 104 or 67 | 5 | 0% | 0 | 0.00% | R07, R14, R15, R16, R21 | 5 | 0% | 0 | 0.00% | R07, R14, R15, R16, R21 | 5 | 0% | 0 | 0.00% | R07, R14, R15, R16, R21 |
| 109 | 1 | 100% | 1 | 100.00% | | | | | | | | | | | |
| 110 or 74 | 5 | 0% | 0 | 0.00% | R07, R12, R15, R21 | 5 | 0% | 0 | 0.00% | R07, R12, R15, R21 | 5 | 0% | 0 | 0.00% | R07, R12, R15, R21 |
| 115 | 0 | 0% | 0 | 0.00% | R06, R08, R20 & R18 | 0 | 0% | 0 | 0.00% | R06, R08, R20 & R18 | 0 | 0% | 0 | 0.00% | R06, R08, R20 & R18 |
| 116 | 5 | 45% | 4.5 | 45.00% | R07, R15, R16, R27, R30 | 5 | 55% | 4.75 | 55.00% | R07, R15, R16, R27, R30 | 5 | 65% | 5.75 | 65.00% | R07, R15, R16, R27, R30 |
| 118 | 5 | 0% | 0 | 0.00% | R06, R08, R20 & R18 | 0 | 0% | 0 | 0.00% | R06, R08, R20 & R18 | 0 | 0% | 0 | 0.00% | R06, R08, R20 & R18 |
| 119 | | | | | | 5 | 80% | 4 | 80.00% | R15, R20 | 5 | 80% | 4 | 80.00% | R15, R20 |
| 120 | | | | | | 5 | 80% | 4 | 80.00% | R15, R20 | 5 | 80% | 4 | 80.00% | R15, R20 |
| 121 | 5 | 0% | 0 | 0.00% | R07, R15 | 0 | 0% | 0 | 0.00% | R07, R15 | 0 | 0% | 0 | 0.00% | R07, R15 |
| 122 | | | | | | 5 | 100% | 5 | 100.00% | | 5 | 100% | 5 | 100.00% | |
| 124 | 0 | 0% | 0 | 0.00% | R06, R15, R21 | 0 | 0% | 0 | 0.00% | R06, R15, R21 | 0 | 0% | 0 | 0.00% | R06, R15, R21 |
| 125 | 0 | 0% | 0 | 10.00% | R06, R15, R21 | 0 | 0% | 0 | 5.56% | R06, R15, R21 | 0 | 0% | 0 | 4.35% | R06, R15, R21 |
| 126 | 5 | 40% | 2 | 40.00% | R07, R15 | 5 | 55% | 3.5 | 55.00% | R07, R15 | 5 | 70% | 5 | 70.00% | R07, R15 |
| | 87 | | 29.25 | | | 90 | | 46.5 | | | 70 | | 49 | | |

During wk 6 delays occurred due to the BA aircraft that crashed on the runway

| | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | Reason | Reason | Reason | Reason | Reason | Reason | Reason | Reason | Reason |
| 12 | R15 | R15 | R15 | | | | | | |
| 33 | R17, R23, R28 | R17, R23, R28 | R17, R23, R28 | | | | | | |
| 74 | | | R14, R21 | | | | | | |
| 5 | | | | R12 | | | | | |
| 9 | | | | R17 | | | | | |
| 10 | | | | | R28, R29 | | | | |
| 16 | | | | | R29 | | | | |
| 22 | | | | | | | R15, R16, R23 | R15, R16, R23 | R15, R16, R23 |
| 25 | | | | | R12, R16, R38 | R12, R16, R38 & R23 | R12, R16, R38 & R23 & R20 | R12, R16, R38 & R23 & R20 | R12, R16, R38 & R23 & R20 |
| 28 | | | | R16 | | | | | |
| 29 | | | | | R12, R28 | | | | |
| 30 | | | | | R18 | R18 | | | |
| 33 | | | | | R09, R18 | | | | |
| 36 | | | | | | R16 | R16 | | |
| 39 | | | | | R09, R16, R29 | | | | |
| 40 | | | | | R16 | | | | |
| 41 | | | | | | | R12, R30 | R12, R30 | R12, R30 |
| 48 | | | | R16, R29, R30, R32 | R14, R16, R29, R30, R32 | R14, R16, R29, R30, R32 | R14, R16, R29, R30, R32 | R14, R16, R29, R30, R32 | R14, R16, R29, R30, R32 |
| 56 | | | | R16, R17 | | | | | |
| 58 | | | | | R28, R32 | | | | |
| 60 | | | | R23 | R23 | R07, R23 | R07, R23 | R07, R23 | R07, R23 |
| 61 | | | | | | | | R07, R12, R15, R23 | R07, R12, R15, R23 |
| 62 | | | | | | | | | R07, R12, R15, R23 |
| 64 | | | | | | | | R07, R12, R15, R23 | R07, R12, R15, R23 |
| 66 | | | | | | | | R07, R12, R15, R23 | R07, R12, R15, R23 |
| 71 | | | | | R14, R15 | | | | |
| 72 | | | | | | | R12 | R12 | R12 |
| 74 | | | | | | R03, R07 | R03, R07, R29, R30 | R03, R07, R29, R30 | R03, R07, R29, R30 |
| 78 | | | | | | R03, R07 | R03, R07 | R03, R07, R12, R15 | R03, R07, R12, R15 |
| 82 | | | | R21 | R21 | R21 | | | |
| 83 | | | | R21 | R28 | R28 | R07, R28 | R07, R28 | R07, R28 |
| 88 | | | | | R39, R30 | R38, R30 | R38, R30 | | |
| 90 | | | | R07, R21 | R07, R21 | R07, R21 | R07, R21 | R07, R21 | R07, R21 |
| 102 | | | | | | | R12, R15 | R12, R15 | R12, R15 |
| 103 | | | | R15 | R15 | R15 | R12, R15 | R12, R15 | R12, R15 |
| 104 | | | | R07, R14, R21 | R07, R14, R21 | R07, R14, R16, R21 | R07, R14, R15, R16, R21 | R07, R14, R15, R16, R21 | R07, R14, R15, R16, R21 |
| 110 | | | | | | | R07, R12, R15, R21 | R07, R12, R15, R21 | R07, R12, R15, R21 |
| 115 | | | | | | R06, R08, R20 & R18 | R06, R08, R20 & R18 | R06, R08, R20 & R18 | R06, R08, R20 & R18 |
| 116 | | | | R15, R16, R27, R30 | R15, R16, R27, R30 | R15, R16, R27, R30 | R07, R15, R16, R27, R30 | R07, R15, R16, R27, R30 | R07, R15, R16, R27, R30 |
| 118 | | | | | | | R06, R08, R20 & R18 | R06, R08, R20 & R18 | R06, R08, R20 & R18 |
| 119 | | | | | | | | R15, R20 | R15, R20 |
| 120 | | | | | | | | R15, R20 | R15, R20 |
| 121 | | | | | | | R07, R15 | R07, R15 | R07, R15 |
| 124 | | | | | | R06, R15, R21 | R06, R15, R21 | R06, R15, R21 | R06, R15, R21 |
| 125 | | | | | | R06, R15, R21 | R06, R15, R21 | R06, R15, R21 | R06, R15, R21 |
| 126 | | | | | | | R07, R15 | R07, R15 | R07, R15 |

# Appendix D – Chapter 7 – Results

## Sampling information

Table AP.D-7.3. Total Contractors' Output Vs Contractors' Output in Sampled Area

| Region | Contractors' Output in GB (in £M) | Contractors' Output in Sampled Area (in £M) | % of Total |
|---|---|---|---|
| Scotland | £10,391 | | |
| North East | £4,125 | | |
| North West | £11,706 | | |
| Yorkshire | £9,343 | | |
| East Midlands | £8,323 | | |
| West Midlands | £9,570 | | |
| Wales | £4,474 | | |
| East of England | £11,393 | | |
| South West | £9,499 | | |
| South East | £16,447 | **£32,873** | **29.43** |
| London | £16,426 | | |
| **Total** | **£111,697** | | |

Table AP.D-7.4. Contractors' Employment in GB Vs Contractors' Employment in Sampled Area

| Region | Contractors' - Total Employment in GB (in 000s) | Total Employment in Sampled Area (in '000s) | % of Total |
|---|---|---|---|
| Scotland | 116.1 | | |
| North East | 49.0 | | |
| North West | 127.5 | | |
| Yorkshire | 113.7 | | |
| East Midlands | 86.0 | | |
| West Midlands | 104.7 | | |
| Wales | 47.0 | | |
| East of England | 130.1 | | |
| South West | 98.0 | | |
| South East | 194.2 | **343.3** | **12.27** |
| London | 149.1 | | |
| | **1,215.4** | | |

Table AP.D-7.6. Estimate of population of PMs, population of PMs and Directors and contractor percentage response for total contractor employment in sampled area

| | | Est. population of PMs | Estimated population of PMs & Directors |
|---|---|---|---|
| Total employment in sampled area (in '000s) | 343.3 | 15.45 | 27.12 |
| | | **Response %** | **Response %** |
| Contractor Responses received | 39 | **0.25** | **0.14** |

Table AP.D-7.7. Estimate of population of PMs, population of PMs and Directors and contractor percentage response for contractors' employment figures for staff only (less operatives) in sampled area

| | | Est. population of PMs | Estimated population of PMs & Directors |
|---|---|---|---|
| Staff, less operatives in ('000s) | 167.1 | 7.52 | 13.20 |
| | | **Response %** | **Response %** |
| Contractor Responses received | 39 | **0.52** | **0.30** |

Table AP.D-7.8. Estimate of population of PMs, population of PMs and Directors and contractor percentage response for contractors' employment for firms with over 300 staff in GB

| | | Est. population of PMs | Estimated population of PMs & Directors |
|---|---|---|---|
| Total employment for firms with over 300 staff (in '000s) | 293.4 | 13.20 | 23.18 |
| | | **Response %** | **Response %** |
| Contractor Responses received | 39 | **0.30** | **0.17** |

## Tables and graphs - Part 1 of Postal Questionnaire-Demographics

Table AP.D-7.14. Respondents' seniority

| | Total Frequency | Client Frequency | Contractor Frequency |
|---|---|---|---|
| Project Director | 6 | 2 | 4 |
| Senior Project Manager | 34 | 26 | 8 |
| Project Manager | 42 | 23 | 19 |
| Assistant Project Manager | 6 | 1 | 5 |
| Site Manager | 3 | -- | 3 |
| Total | 91 | 52 | 39 |

Table AP.D-7.15. Respondents' years of experience

| | Frequency | Percent |
|---|---|---|
| 5yrs or Less | 8 | 8.8 |
| 6 to 10 yrs | 17 | 18.7 |
| 11 to 15yrs | 10 | 11.0 |
| Over 15yrs | 55 | 60.4 |
| Total | 90 | 98.9 |
| Missing | 1 | 1.1 |
| Total | 91 | 100.0 |

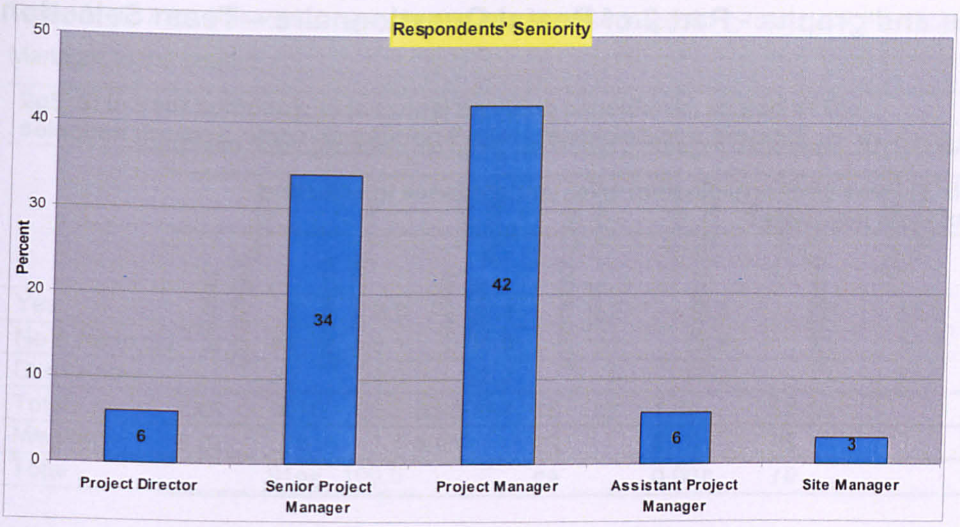



Figure AP.D-7.1. Respondents' Seniority

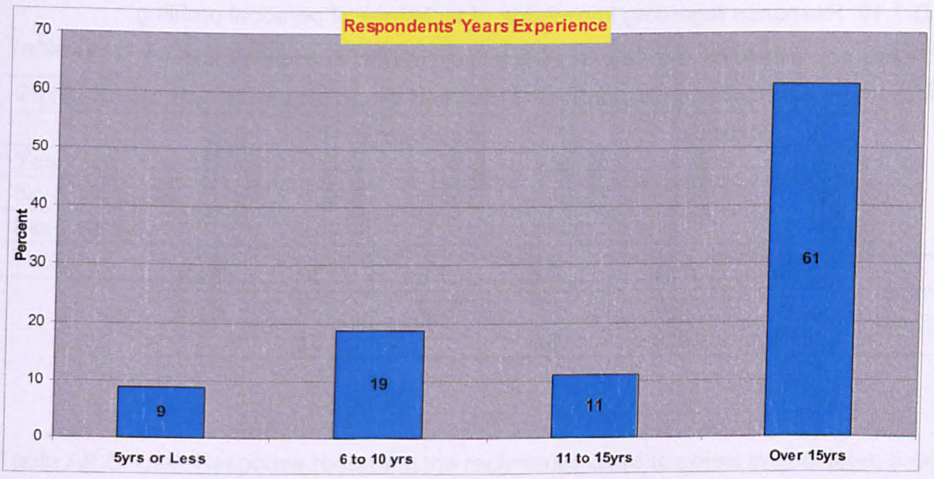



Figure AP.D-7.2. Graphical representation of respondents' years of experience

Table AP.D-7.16. Respondents' academic and professional qualifications

| Academic Qualifications | Frequency | Percent | Professional Qualifications | Frequency | Percent |
|---|---|---|---|---|---|
| Chartered | 22 | 24.2 | APMP | 3 | 3.3 |
| MAPM & MPMI | 4 | 4.4 | APM Practitioner | 1 | 1.1 |
| Member other Institutes | 20 | 22.0 | APM Certificated | 1 | 1.1 |
| None | 15 | 16.5 | None | 78 | 85.7 |
| Chartered & MAPM | 3 | 3.3 | NVQ L4 | 6 | 6.6 |
| Chartered & MPMI | 26 | 28.6 | PMP | 1 | 1.1 |
| Total | 90 | 98.9 | Total | 90 | 98.9 |
| Missing | 1 | 1.1 | | 1 | 1.1 |
| Total | 91 | 100.0 | | 91 | 100.0 |

## Tables and graphs - Part 2 of Postal Questionnaire – Team Selection

Table AP.D-7.18. Response regarding guidance given for selecting team members

**2q1a-b 1) Does your organisation offer you guidance in selecting project team members?**

| | Frequency | Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Yes | 62 | 68.1 | 31 | 59.6 | 31 | 79.5 |
| No | 29 | 31.9 | 21 | 40.4 | 8 | 20.5 |
| Total | 91 | 100.0 | **52** | | **39** | |

Table AP.D-7.19. Response regarding knowledge of technique of personal profiling

**2q2a-b 2) Are you aware of any known techniques/methods of personal profiling?**

| | Frequency | Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Yes | 65 | 71.4 | 35 | 67.3 | 30 | 76.9 |
| No | 26 | 28.6 | 17 | 32.7 | 9 | 23.1 |
| Total | 91 | 100.0 | **52** | | **39** | |

Table AP.D-7.20. Response regarding personal profiling of project team members

**2q4 4) Please indicate for which project team members personal profiling has been carried out, within your company.**

| | Frequency | Percent | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|---|
| All Levels | 23 | 25.3 | 27.1 | 8 | 16.7 | 15 | 40.5 |
| None / No | 62 | 68.1 | 72.9 | 40 | 83.3 | 22 | 59.5 |
| Total | 85 | 93.4 | 100.0 | **48** | | **37** | |
| Missing | 6 | 6.6 | | | | | |
| Total | 91 | 100.0 | | | | | |

Table AP.D-7.22. Response regarding the use of personal profiling to appoint the Project Manager to the project

| **2q5 5) In your company, is personal profiling considered, as part of the selection process, when appointing Project Managers to a project?** | Freq/cy | Percent | Valid Percent | Client Freq/cy | Client Percent | Contractor Freq/cy | Contractor Percent |
|---|---|---|---|---|---|---|---|
| Yes | 8 | 8.8 | 8.9 | 2 | 3.8 | 6 | 15.8 |
| No & No to Q2 | 62 | 68.1 | 68.9 | 41 | 78.8 | 21 | 55.3 |
| Don't Know | 20 | 22.0 | 22.2 | 9 | 17.3 | 11 | 28.9 |
| Total | 90 | 98.9 | 100.0 | 52 | | 38 | |
| Missing | 1 | 1.1 | | | | | |
| Total | 91 | 100.0 | | | | | |

Table AP.D-7.23. Response regarding supervisors' selection techniques

| **2q10 10) Do the site supervisors use any selection process techniques?** | Frequency | Percent |
|---|---|---|
| Yes | 13 | 14.3 |
| No & No to Q9 | 63 | 69.2 |
| Don't Know | 15 | 16.5 |
| Total | 91 | 100.0 |

Table AP.D-7.24. Response regarding the techniques used to select project team members

| **2q11 11) Indicate which of the following techniques/methods your supervisors use/consider for selecting team members** | Freq/cy | Percent | Valid Percent | Client Freq/cy | Client Percent | Contractor Freq/cy | Contractor Percent |
|---|---|---|---|---|---|---|---|
| Interview, Agency Interview, Recommendation | 18 | 19.8 | 19.8 | 6 | 11.5 | 12 | 30.8 |
| None / No (incl No to Q9 &.or Q10) | 71 | 78.0 | 78.0 | 44 | 84.6 | 27 | 69.2 |
| Profiling | 2 | 2.2 | 2.2 | 2 | 3.8 | 0 | 0 |
| Total | 91 | 100.0 | 100.0 | 52 | | 39 | |

Table AP.D-7.25. Response regarding the importance of criteria for selecting the project manager (in % of responses)

**Overall feedback for Part 2 Q 7: Criteria for Selection of Project Manager**

| Rating | Availability | Capability | Technical Skills | Management Skill | Leadership Skill | Experience | Previous Performance | Project Environment | Personal Development | Personal Profile |
|---|---|---|---|---|---|---|---|---|---|---|
| Very Little | 2.27 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 2.27 | 22.73 | **45.45** |
| Little | 7.95 | 2.27 | 12.50 | 2.30 | 9.09 | 3.41 | 13.64 | 28.41 | **42.05** | 30.68 |
| Important | 36.36 | 20.00 | **50.00** | 36.36 | 29.55 | **45.45** | **40.91** | **50.00** | 28.41 | 20.45 |
| Very Important | **36.36** | **53.41** | 32.95 | **52.27** | **43.18** | 32.95 | 35.23 | 15.91 | 6.82 | 3.41 |
| Critical | 17.05 | 22.73 | 3.41 | 7.95 | 17.05 | 17.05 | 9.09 | 3.41 | 0.00 | 0.00 |

Table AP.D-7.26. Response regarding the importance of criteria for selecting the project team members (in % of responses)

**Overall feedback for Part 2 Q 8: Criteria for Selection of Project Team Members**

| Rating | Availability | Capability | Technical Skills | Experience | Previous Performance | Project Environment | Personal Development | Personal Profile |
|---|---|---|---|---|---|---|---|---|
| Very Little | 2.2 | 2.2 | 2.2 | 2.2 | 4.4 | 10.0 | 26.7 | **53.3** |
| Little | 4.4 | 1.1 | 3.3 | 3.3 | 10.0 | 23.3 | **38.9** | 27.8 |
| Important | **40.0** | 20.0 | 34.4 | **48.9** | **45.6** | **47.8** | 30.0 | 17.8 |
| Very Important | 32.2 | **60.0** | **47.8** | 37.8 | 32.2 | 17.8 | 4.4 | 1.1 |
| Critical | 21.1 | 16.7 | 12.2 | 7.8 | 7.8 | 1.1 | 0.0 | 0.0 |

Table AP.D-7.28 Response regarding lowest level of selection of team members

**For your most recently completed project consider the questions below and indicate to what organisational level did you, or others on your behalf,**

**2q13a Carry out selection of team members?**

| | Freq/cy | Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor % |
|---|---|---|---|---|---|---|
| Discipline & Team Leaders | 47 | 51.6 | 25 | 48.08 | 22 | 56.41 |
| Supervisors & Team Members | 34 | 37.4 | 20 | 38.46 | 14 | 35.90 |
| None | 10 | 11.0 | 7 | 13.46 | 3 | 7.69 |
| Total | 91 | 100.0 | 52 | | 39 | |

Table AP.D-7.29. Response regarding carrying out personal profiling for selecting team members

**2q13b Carry out personal profiling?**

| | Freq/cy | Valid Percent | Client Freq/cy | Client Valid % | Contractor Frequency | Contractor Valid % |
|---|---|---|---|---|---|---|
| Discipline & Team Leaders | 15 | 17.2 | 8 | 16.33 | 7 | 18.42 |
| Supervisors & Team Members | 6 | 6.9 | 2 | 4.08 | 4 | 10.53 |
| None | 66 | 75.9 | 39 | 79.59 | 27 | 71.05 |
| Total | 87 | 100.0 | 49 | | 38 | |
| Missing | 4 | | 3 | | 1 | |
| Total | 91 | | 52 | | 39 | |

Table AP.D-7.30 Response regarding confirmation of following a selection process

**2q14a For your most recently completed project please answer the following? a) Did your subcontractors follow a team selection process?**

| | Freq/cy | Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor Valid % |
|---|---|---|---|---|---|---|
| Yes | 27 | 29.7 | 10 | 19.2 | 17 | 43.6 |
| No | 14 | 15.4 | 10 | 19.2 | 4 | 10.3 |
| Don't Know | 50 | 54.9 | 32 | 61.5 | 18 | 46.2 |
| Total | 91 | 100.0 | 52 | | 39 | |

Table AP.D-7.31 Response regarding confirmation of team forming techniques

**2q14 For your most recently completed project please answer the following? b) Were there any team forming techniques carried out?**

| | Freq/cy | Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor Valid % |
|---|---|---|---|---|---|---|
| Yes | 32 | 35.2 | 15 | 28.8 | 17 | 43.6 |
| No | 34 | 37.4 | 18 | 34.6 | 16 | 41.0 |
| Don't Know | 25 | 27.5 | 19 | 36.5 | 6 | 15.4 |
| Total | 91 | 100.0 | 52 | | 39 | |

Table AP.D-7.32 Response regarding confirmation of carrying out personal profiling

**2q14 For your most recently completed project please answer the following? c) Was any personal profiling carried as part of the above?**

| | Freq/cy | Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor Valid % |
|---|---|---|---|---|---|---|
| Yes | 3 | 3.3 | 1 | 1.9 | 2 | 5.3 |
| No | 49 | 54.4 | 21 | 40.4 | 28 | 73.7 |
| Don't Know | 38 | 42.2 | 30 | 57.7 | 8 | 21.1 |
| Total | 90 | 100.0 | 52 | | 38 | |
| Missing | 1 | | | | | |
| Total | 91 | | | | | |

## Tables and graphs - Part 3 of Postal Questionnaire-Structuring the Team

Table AP.D-7.34 Response regarding who defines the overall project structure

**3q1 Consider the questions in the table below and reply in terms of the norm in your company: a) Who defines the overall project structure?**

| | Freq/cy | Valid Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor Valid % |
|---|---|---|---|---|---|---|
| Proj.Director | 41 | 45.6 | 16 | 31.37 | 25 | 64.10 |
| Proj. Mngr | 44 | 48.9 | 33 | 64.71 | 11 | 28.21 |
| Team Leader | 2 | 2.2 | 1 | 1.96 | 1 | 2.56 |
| Don't Know | 3 | 3.3 | 1 | 1.96 | 2 | 5.13 |
| Total | 90 | 100.0 | 51 | | 39 | |
| Missing | 1 | | | | | |
| Total | 91 | | | | | |

Table AP.D-7.35 Response regarding who defines the design team structure

**3q1b Who defines the design team structure?**

| | Freq/cy | Valid Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor Valid % |
|---|---|---|---|---|---|---|
| Proj.Director | 11 | 12.2 | 5 | 9.80 | 6 | 15.38 |
| Proj. Mngr | 36 | 40.0 | 21 | 41.18 | 15 | 38.46 |
| Team Leader | 29 | 32.2 | 19 | 37.25 | 10 | 25.64 |
| Don't Know | 14 | 15.6 | 6 | 11.76 | 8 | 20.51 |
| Total | 90 | 100.0 | 51 | | 39 | |
| Missing | 1 | | | | | |
| Total | 91 | | | | | |

Table AP.D-7.36 Response regarding who defines the site team structure

**3q1c Who defines the Site team structure?**

| | Freq/cy | Valid Percent | Client Freq/cy | Client Valid % | Contractor Freq/cy | Contractor Valid % |
|---|---|---|---|---|---|---|
| Proj.Director | 7 | 8.0 | 3 | 6.12 | 4 | 10.26 |
| Proj. Mngr | 42 | 47.7 | 18 | 36.73 | 24 | 61.54 |
| Team Leader | 18 | 20.5 | 13 | 26.53 | 5 | 12.82 |
| Supervisor | 9 | 10.2 | 5 | 10.20 | 4 | 10.26 |
| Don't Know | 12 | 13.6 | 10 | 20.41 | 2 | 5.13 |
| Total | 88 | 100.0 | 49 | | 39 | |
| Missing | 3 | | | | | |
| Total | 91 | | | | | |

## Tables and graphs - Part 4 of Postal Questionnaire-Management of Team

Table AP.D-7.41.1 Client PM response of the Management Style adopted

| Statistical Analysis of responses to Management style adopted | | | Statistical Investigation of responses where two codes were selected | | |
|---|---|---|---|---|---|
| **Freq** | **%** | **Description** | **Freq** | **%** | **Description** |
| 5 | 9.6% | A-Egalitarian | 1 | 4.5% | A & G |
| 1 | 1.9% | B-Dictatorial | 1 | 4.5% | D & G |
| 0 | 0.0% | C-Manage Themselves | 7 | 31.8% | A & F |
| 3 | 5.8% | D-Standard Processes | 3 | 13.6% | A & C |
| 0 | 0.0% | E-Technocratic | 1 | 4.5% | D & J |
| 9 | 17.3% | F-Situational | 1 | 4.5% | D & E |
| 0 | 0.0% | G-Control Systems | 1 | 4.5% | D & F |
| 0 | 0.0% | H-People | 2 | 9.1% | F & G |
| 0 | 0.0% | J-Long term | 4 | 18.2% | A & D |
| 22 | 42.3% | Two codes have been selected | 1 | 4.5% | B & C |
| 7 | 13.5% | Three codes have been selected | | | |
| 5 | 9.6% | More than three codes | | | |

Table AP.D-7.41.2 Contractor PM response of the Management Style adopted

| Statistical Analysis of responses to Management style adopted | | | Statistical Investigation of responses where two codes were selected | | |
|---|---|---|---|---|---|
| **Freq** | **%** | **Description** | **Freq** | **%** | **Description** |
| 9 | 23.1% | A-Egalitarian | 1 | 9.1% | A & G |
| 0 | 0.0% | B-Dictatorial | 1 | 9.1% | D & G |
| 1 | 2.6% | C-Manage Themselves | 1 | 9.1% | A & F |
| 0 | 0.0% | D-Standard Processes | 3 | 27.3% | A & C |
| 0 | 0.0% | E-Technocratic | 1 | 9.1% | C & F |
| 7 | 17.9% | F-Situational | 1 | 9.1% | D & F |
| 0 | 0.0% | G-Control System | 1 | 9.1% | F & G |
| 0 | 0.0% | H-People | 1 | 9.1% | F & H |
| 0 | 0.0% | J-Long term objectives | 1 | 9.1% | A & D |
| 11 | 28.2% | Two codes have been selected | | | |
| 6 | 15.4% | Three codes have been selected | | | |
| 5 | 12.8% | More than three codes | | | |

Table AP.D-7.42.4.1 *Management style adopted at Discipline Leader level*

**4q4a_Discipline Leader level**

| | Freq/cy | Valid % | Client Freq/cy | Client % | Contractor Freq/cy | Contractor % |
|---|---|---|---|---|---|---|
| A-Egalitarian | 37 | **42.5** | 20.0 | **40.0** | 17.0 | **45.9** |
| B-Dictatorial | 2 | 2.3 | 1.0 | 2.0 | 1.0 | 2.7 |
| C-Manage Themselves | 3 | 3.4 | 2.0 | 4.0 | 1.0 | 2.7 |
| D-Standard Processes | 9 | 10.3 | 7.0 | 14.0 | 2.0 | 5.4 |
| F-Situational | 13 | 14.9 | 8.0 | 16.0 | 5.0 | 13.5 |
| G-Control System | 1 | 1.1 | 1.0 | 2.0 | 0.0 | 0.0 |
| J-Long term Objectives | 3 | 3.4 | 2.0 | 4.0 | 1.0 | 2.7 |
| A & G | 1 | 1.1 | 1.0 | 2.0 | 0.0 | 0.0 |
| A & F | 2 | 2.3 | 1.0 | 2.0 | 1.0 | 2.7 |
| F & G | 1 | 1.1 | 1.0 | 2.0 | 0.0 | 0.0 |
| A, C & F | 1 | 1.1 | 0.0 | 0.0 | 1.0 | 2.7 |
| A, D & F | 1 | 1.1 | 0.0 | 0.0 | 1.0 | 2.7 |
| Don't Know | 13 | 14.9 | 6.0 | 12.0 | 7.0 | 18.9 |
| Total | 87 | 100.0 | 50.0 | | 37.0 | |
| Missing | 4 | | | | | |
| Total | 91 | | | | | |

Table AP.D-7.42.4.2 Management style adopted at Team Leader level

**4q4b_Team Leader level**

| | Freq/cy | Valid % | Client Freq/cy | Client % | Contractor Freq/cy | Contractor % |
|---|---|---|---|---|---|---|
| A-Egalitarian | 31 | **35.6** | 19.0 | **38.0** | 12.0 | **32.4** |
| B-Dictatorial | 4 | 4.6 | 1.0 | 2.0 | 3.0 | 8.1 |
| C-Manage Themselves | 11 | 12.6 | 7.0 | 14.0 | 4.0 | 10.8 |
| D-Standard Processes | 10 | 11.5 | 9.0 | 18.0 | 1.0 | 2.7 |
| F-Situational | 16 | 18.4 | 6.0 | 12.0 | 10.0 | 27.0 |
| A & G | 2 | 2.3 | 1.0 | 2.0 | 1.0 | 2.7 |
| A & F | 2 | 2.3 | 1.0 | 2.0 | 1.0 | 2.7 |
| D & F | 1 | 1.1 | 0.0 | 0.0 | 1.0 | 2.7 |
| F & G | 1 | 1.1 | 1.0 | 2.0 | 0.0 | 0.0 |
| A, C & F | 1 | 1.1 | 0.0 | 0.0 | 1.0 | 2.7 |
| Don't Know | 8 | 9.2 | 5.0 | 10.0 | 3.0 | 8.1 |
| Total | 87 | 100.0 | 50.0 | | 37.0 | |
| Missing | 4 | | | | | |
| Total | 91 | | | | | |

Table AP.D-7.42.4.3 Management style adopted at Supervisor level

| **4q4c_Supervisor level** | Freq/cy | Valid % | Client Freq/cy | Client % | Contractor Freq/cy | Contractor % |
|---|---|---|---|---|---|---|
| A-Egalitarian | 17 | **19.8** | 14.0 | **28.0** | 3.0 | 8.3 |
| B-Dictatorial | 3 | 3.5 | 0.0 | 0.0 | 3.0 | 8.3 |
| C-Manage Themselves | 14 | 16.3 | 5.0 | 10.0 | 9.0 | **25.0** |
| D-Standard Processes | 14 | 16.3 | 9.0 | 18.0 | 5.0 | 13.9 |
| F-Situational | 9 | 10.5 | 6.0 | 12.0 | 3.0 | 8.3 |
| G-Control System | 10 | 11.6 | 5.0 | 10.0 | 5.0 | 13.9 |
| A & G | 1 | 1.2 | 1.0 | 2.0 | 0.0 | 0.0 |
| A & F | 1 | 1.2 | 1.0 | 2.0 | 0.0 | 0.0 |
| F & G | 2 | 2.3 | 1.0 | 2.0 | 1.0 | 2.8 |
| A, C & F | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.8 |
| A, D & G | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.8 |
| Don't Know | 13 | 15.1 | 8.0 | 16.0 | 5.0 | 13.9 |
| Total | 86 | 100.0 | 50.0 | | 36.0 | |
| Missing | 5 | | | | | |
| Total | 91 | | | | | |

Table AP.D-7.42.4.4 Management style adopted at Design Team Member level

| **4q4d_Design Team Member level** | Freq/cy | Valid % | Client Freq/cy | Client % | Contractor Freq/cy | Contractor % |
|---|---|---|---|---|---|---|
| A-Egalitarian | 25 | **29.4** | 14.0 | **28.0** | 11.0 | **31.4** |
| B-Dictatorial | 2 | 2.4 | 1.0 | 2.0 | 1.0 | 2.9 |
| C-Manage Themselves | 5 | 5.9 | 2.0 | 4.0 | 3.0 | 8.6 |
| D-Standard Processes | 16 | 18.8 | 14.0 | **28.0** | 2.0 | 5.7 |
| E-Technocrat | 1 | 1.2 | 1.0 | 2.0 | 0.0 | 0.0 |
| F-Situational | 9 | 10.6 | 6.0 | 12.0 | 3.0 | 8.6 |
| G-Control System | 5 | 5.9 | 2.0 | 4.0 | 3.0 | 8.6 |
| H-People | 2 | 2.4 | 2.0 | 4.0 | 0.0 | 0.0 |
| J-Long term Objectives | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.9 |
| A & G | 1 | 1.2 | 1.0 | 2.0 | 0.0 | 0.0 |
| A & F | 1 | 1.2 | 1.0 | 2.0 | 0.0 | 0.0 |
| F & G | 1 | 1.2 | 1.0 | 2.0 | 0.0 | 0.0 |
| A & D | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.9 |
| G & J | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.9 |
| A, C & F | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.9 |
| A, D & F | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.9 |
| A, B & C | 1 | 1.2 | 0.0 | 0.0 | 1.0 | 2.9 |
| Don't Know | 11 | 12.9 | 5.0 | 10.0 | 6.0 | 17.1 |
| Total | 85 | 100.0 | 50.0 | | 35.0 | |
| Missing | 6 | | | | | |
| Total | 91 | | | | | |

Table AP.D-7.42.4.5 Management style adopted at Site Team Member level

**4q4e_Site Team Member level**

| | Freq/cy | Valid % | Client Freq/cy | Client % | Contractor Freq/cy | Contractor % |
|---|---|---|---|---|---|---|
| A-Egalitarian | 16 | 18.6 | 11.0 | 22.0 | 5.0 | **10.0** |
| B-Dictatorial | 8 | 9.3 | 4.0 | 8.0 | 4.0 | **8.0** |
| C-Manage Themselves | 7 | 8.1 | 2.0 | 4.0 | 5.0 | **10.0** |
| D-Standard Processes | 17 | **19.8** | 13.0 | **26.0** | 4.0 | **8.0** |
| E-Technocrat | 1 | 1.2 | 0.0 | 0.0 | 1.0 | **2.0** |
| F-Situational | 3 | 3.5 | 2.0 | 4.0 | 1.0 | **2.0** |
| G-Control System | 11 | 12.8 | 5.0 | 10.0 | 6.0 | **12.0** |
| H-People | 3 | 3.5 | 3.0 | 6.0 | 0.0 | **0.0** |
| G & H | 1 | 1.2 | 0.0 | 0.0 | 1.0 | **2.0** |
| A & F | 1 | 1.2 | 1.0 | 2.0 | 0.0 | **0.0** |
| A & C | 1 | 1.2 | 0.0 | 0.0 | 1.0 | **2.0** |
| F & G | 1 | 1.2 | 1.0 | 2.0 | 0.0 | **0.0** |
| B & C | 1 | 1.2 | 0.0 | 0.0 | 1.0 | **2.0** |
| A, C & F | 1 | 1.2 | 0.0 | 0.0 | 1.0 | **2.0** |
| A, D & G | 1 | 1.2 | 0.0 | 0.0 | 1.0 | **2.0** |
| Don't Know | 13 | 15.1 | 8.0 | 16.0 | 5.0 | **10.0** |
| Total | 86 | 100.0 | 50.0 | | 36.0 | |
| Missing | 5 | | | | | |
| *Total* | 91 | | | | | |

The set of sub-tables below present the prevailing culture per project organisation level, as overall valid percent and by client or contractor respondents

Table AP.D-7.43.1 Prevailing culture at Discipline Leaders' level

| **Discipline Leaders** | **Overall Freq/cy** | **Valid %** | **Client Freq/cy** | **Client %** | **Contractor Freq/cy** | **Contractor %** |
|---|---|---|---|---|---|---|
| In Structured Places | 43 | 53.8 | 23 | 51.1 | 20 | **57.1** |
| Only Objectives Set | 22 | 27.5 | 14 | 31.1 | 8 | **22.9** |
| Distribute Work themselves | 3 | 3.8 | 2 | 4.4 | 1 | **2.9** |
| No clear pattern | 3 | 3.8 | 2 | 4.4 | 1 | **2.9** |
| Don't Know | 9 | 11.3 | 4 | 8.9 | 5 | **14.3** |
| **Total** | 80 | 100 | 45 | 100 | 35 | **100** |
| Rejected | 10 | | 6 | | 4 | |
| Missing | 1 | | 1 | | 0 | |

Table AP.D-7.43.2 Prevailing culture at Team Leaders' level

| **Team Leaders** | **Overall Freq/cy** | **Valid %** | **Client Freq/cy** | **Client %** | **Contractor Frequency** | **Contractor %** |
|---|---|---|---|---|---|---|
| In Structured Places | 31 | 42.5 | 16 | 39.0 | 15 | 46.9 |
| Only Objectives Set | 29 | 39.7 | 16 | 39.0 | 13 | 40.6 |
| Distribute Work themselves | 5 | 6.8 | 4 | 9.8 | 1 | 3.1 |
| No clear pattern | 3 | 4.1 | 3 | 7.3 | 0 | 0.0 |
| Don't Know | 5 | 6.8 | 2 | 4.9 | 3 | 9.4 |
| **Total** | 73 | 100 | 41 | 100 | 32 | 100 |
| Rejected | 17 | | 10 | | 7 | |
| Missing | 1 | | 1 | | 0 | |

Table AP.D-7.43.3 Prevailing culture at Supervisor level

| **Supervisors** | **Overall Freq/cy** | **Valid %** | **Client Freq/cy** | **Client %** | **Contractor Frequency** | **Contractor %** |
|---|---|---|---|---|---|---|
| In Structured Places | 34 | 43.0 | 19 | 43.2 | 15 | 42.9 |
| Only Objectives Set | 20 | 25.3 | 12 | 27.3 | 8 | 22.9 |
| Distribute Work themselves | 9 | 11.4 | 2 | 4.5 | 7 | 20.0 |
| No clear pattern | 4 | 5.1 | 4 | 9.1 | 0 | 0.0 |
| Don't Know | 12 | 15.2 | 7 | 15.9 | 5 | 14.3 |
| **Total** | 79 | 100 | 44 | 100 | 35 | 100 |
| Rejected | 11 | | 7 | | 4 | |
| Missing | 1 | | 1 | | 0 | |

Table AP.D-7.43.4 Prevailing culture at Design Team Members' level

| **Design Team Members** | **Overall Freq/cy** | **Valid %** | **Client Freq/cy** | **Client %** | **Contractor Frequency** | **Contractor %** |
|---|---|---|---|---|---|---|
| In Structured Places | 34 | 42.5 | 19 | 43.2 | 15 | 41.7 |
| Only Objectives Set | 14 | 17.5 | 7 | 15.9 | 7 | 19.4 |
| Distribute Work themselves | 15 | 18.8 | 8 | 18.2 | 7 | 19.4 |
| No clear pattern | 5 | 6.3 | 4 | 9.1 | 1 | 2.8 |
| Don't Know | 12 | 15.0 | 6 | 13.6 | 6 | 16.7 |
| **Total** | 80 | 100 | 44 | 100 | 36 | 100 |
| Rejected | 10 | | 7 | | 3 | |
| Missing | 1 | | 1 | | 0 | |

Table AP.D-7.43.5 Prevailing culture at Site Team Members' level

| Site Team Members | Overall Freq/cy | Valid % | Client Freq/cy | Client % | Contractor Frequency | Contractor % |
|---|---|---|---|---|---|---|
| In Structured Places | 37 | 46.3 | 19 | 41.3 | 18 | 52.9 |
| Only Objectives Set | 12 | 15.0 | 8 | 17.4 | 4 | 11.8 |
| Distribute Work themselves | 11 | 13.8 | 8 | 17.4 | 3 | 8.8 |
| No clear pattern | 7 | 8.8 | 4 | 8.7 | 3 | 8.8 |
| Don't Know | 13 | 16.3 | 7 | 15.2 | 6 | 17.6 |
| **Total** | 80 | 100 | 46 | 100 | 34 | 100 |
| Rejected | 10 | | 5 | | 5 | |
| Missing | 1 | | 1 | | 0 | |

## Tables and graphs - Part 5 of Postal Questionnaire-Outcome

Respondents' detailed ranking of project management sub-processes.

Table AP.D-7.44.1 Ranking of project management process – Team Selection

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 3 | 3.3 | 1 | 2.0 | 2 | 5.1 |
| 2 | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| 3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 4 | 3 | 3.3 | 1 | 2.0 | 2 | 5.1 |
| 5 | 3 | 3.3 | 1 | 2.0 | 2 | 5.1 |
| 6 | 6 | 6.7 | 5 | 9.8 | 1 | 2.6 |
| 7 | 13 | 14.4 | 9 | 17.6 | 4 | 10.3 |
| 8 | 25 | 27.8 | 17 | 33.3 | 8 | 20.5 |
| 9 | 15 | 16.7 | 5 | 9.8 | 10 | 25.6 |
| 10 | 20 | 22.2 | 11 | 21.6 | 9 | 23.1 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.44.2 Ranking of project management process – Structuring of the Project Team

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 1 | 1.1 | 0 | 0.0 | 1 | 2.6 |
| 2 | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| 3 | 1 | 1.1 | 0 | 0.0 | 1 | 2.6 |
| 4 | 4 | 4.4 | 4 | 7.8 | 0 | 0.0 |
| 5 | 5 | 5.6 | 2 | 3.9 | 3 | 7.7 |
| 6 | 8 | 8.9 | 4 | 7.8 | 4 | 10.3 |
| 7 | 22 | 24.4 | 14 | 27.5 | 8 | 20.5 |
| 8 | 27 | 30.0 | 19 | 37.3 | 8 | 20.5 |
| 9 | 17 | 18.9 | 5 | 9.8 | 12 | 30.8 |
| 10 | 3 | 3.3 | 2 | 3.9 | 1 | 2.6 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.44.3 Ranking of project management process – Management of the Team

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 2 | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| 3 | 1 | 1.1 | 0 | 0.0 | 1 | 2.6 |
| 4 | 2 | 2.2 | 0 | 0.0 | 2 | 5.1 |
| 5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 6 | 3 | 3.4 | 1 | 2.0 | 2 | 5.1 |
| 7 | 17 | 19.1 | 11 | 22.0 | 6 | 15.4 |
| 8 | 18 | 20.2 | 7 | 14.0 | 11 | 28.2 |
| 9 | 21 | 23.6 | 16 | 32.0 | 5 | 12.8 |
| 10 | 25 | 28.1 | 14 | 28.0 | 11 | 28.2 |
| Total | 89 | 100.0 | 50 | | 39 | |

Table AP.D-7.44.4 Ranking of project management process – Monitoring & Control

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 2 | 1 | 1.1 | 1 | 2.0 | 0 | 0.0 |
| 3 | 1 | 1.1 | 0 | 0.0 | 1 | 2.6 |
| 4 | 2 | 2.2 | 0 | 0.0 | 2 | 5.1 |
| 5 | 1 | 1.1 | 1 | 2.0 | 0 | 0.0 |
| 6 | 10 | 11.1 | 2 | 3.9 | 8 | 20.5 |
| 7 | 13 | 14.4 | 9 | 17.6 | 4 | 10.3 |
| 8 | 22 | 24.4 | 16 | 31.4 | 6 | 15.4 |
| 9 | 25 | 27.8 | 14 | 27.5 | 11 | 28.2 |
| 10 | 15 | 16.7 | 8 | 15.7 | 7 | 17.9 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.44.5 Ranking of project management process – Reporting

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 2 | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| 3 | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| 4 | 13 | 14.4 | 7 | 13.7 | 6 | 15.4 |
| 5 | 9 | 10.0 | 2 | 3.9 | 7 | 17.9 |
| 6 | 12 | 13.3 | 8 | 15.7 | 4 | 10.3 |
| 7 | 14 | 15.6 | 10 | 19.6 | 4 | 10.3 |
| 8 | 21 | 23.3 | 14 | 27.5 | 7 | 17.9 |
| 9 | 11 | 12.2 | 5 | 9.8 | 6 | 15.4 |
| 10 | 6 | 6.7 | 3 | 5.9 | 3 | 7.7 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.44.6 Ranking of project management process – Conflict resolution

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 3 | 3 | 3.3 | 2 | 3.9 | 1 | 2.6 |
| 4 | 4 | 4.4 | 2 | 3.9 | 2 | 5.1 |
| 5 | 9 | 10.0 | 5 | 9.8 | 4 | 10.3 |
| 6 | 9 | 10.0 | 7 | 13.7 | 2 | 5.1 |
| 7 | 13 | 14.4 | 7 | 13.7 | 6 | 15.4 |
| 8 | 21 | 23.3 | 12 | 23.5 | 9 | 23.1 |
| 9 | 15 | 16.7 | 7 | 13.7 | 8 | 20.5 |
| 10 | 16 | 17.8 | 9 | 17.6 | 7 | 17.9 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.44.7 Ranking of project management process – Efficient use of resources

| Ranking | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| 1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 3 | 3 | 3.4 | 2 | 4.0 | 1 | 2.6 |
| 4 | 6 | 6.8 | 1 | 2.0 | 5 | 13.2 |
| 5 | 11 | 12.5 | 6 | 12.0 | 5 | 13.2 |
| 6 | 4 | 4.5 | 4 | 8.0 | 0 | 0.0 |
| 7 | 21 | 23.9 | 12 | 24.0 | 9 | 23.7 |
| 8 | 14 | 15.9 | 10 | 20.0 | 4 | 10.5 |
| 9 | 16 | 18.2 | 9 | 18.0 | 7 | 18.4 |
| 10 | 13 | 14.8 | 6 | 12.0 | 7 | 18.4 |
| Total | 88 | 100.0 | 50 | | 38 | |

**Rate of success of project management sub-process within a successful project.**

Table AP.D-7.46.1. Rate of success of sub-process - Team Selection

| (5q2a) | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| Acceptable | 50 | 55.6 | 29 | 56.9 | 21 | 53.8 |
| Successful | 38 | 42.2 | 21 | 41.2 | 17 | 43.6 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.46.2. Rate of success of sub-process - Structuring of the Project Team

| (5q2b) | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 2 | 2.2 | 1 | 2.0 | 1 | 2.6 |
| Acceptable | 51 | 56.7 | 29 | 56.9 | 22 | 56.4 |
| Successful | 37 | 41.1 | 21 | 41.2 | 16 | 41.0 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.46.3 Rate of success of sub-process - Management of Team

| (5q2c) | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 1 | 1.1 | 1 | 2.0 | 0 | 0.0 |
| Acceptable | 41 | 45.6 | 21 | 41.2 | 20 | 51.3 |
| Successful | 48 | 53.3 | 29 | 56.9 | 19 | 48.7 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.46.4 Rate of success of sub-process - Monitoring & Control

| | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 6 | 6.7 | 2 | 3.9 | 4 | 10.3 |
| Acceptable | 66 | 73.3 | 42 | 82.4 | 24 | 61.5 |
| Successful | 18 | 20.0 | 7 | 13.7 | 11 | 28.2 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.46.5 Rate of success of sub-process - Reporting

| | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 7 | 7.8 | 2 | 3.9 | 5 | 12.8 |
| Acceptable | 61 | 67.8 | 37 | 72.5 | 24 | 61.5 |
| Successful | 22 | 24.4 | 12 | 23.5 | 10 | 25.6 |
| Total | 90 | 100.0 | 51 | | 39 | |

Table AP.D-7.46.6 Rate of success of sub-process - Conflict resolution

| | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 3 | 3.4 | 2 | 3.9 | 1 | 2.6 |
| Acceptable | 49 | 55.1 | 28 | 54.9 | 21 | 55.3 |
| Successful | 37 | 41.6 | 21 | 41.2 | 16 | 42.1 |
| Total | 89 | 100.0 | 51 | | 38 | |

Table AP.D-7.46.7 Rate of success of sub-process - Efficient use of Resources

| | Frequency | Valid Percent | Client Frequency | Client Percent | Contractor Frequency | Contractor Percent |
|---|---|---|---|---|---|---|
| Unsuccessful | 6 | 6.7 | 4 | 7.8 | 2 | 5.3 |
| Acceptable | 61 | 68.5 | 35 | 68.6 | 26 | 68.4 |
| Successful | 22 | 24.7 | 12 | 23.5 | 10 | 26.3 |
| Total | 89 | 100.0 | 51 | | 38 | |

Table AP.D-7.49 Detailed results regarding contribution of the project management sub-processes to the success of the quality of project management

| | | Combined | | Clients | | Contractors | |
|---|---|---|---|---|---|---|---|
| **Project Management sub-process** | **Scale** | **Freq/cy** | **%** | **Freq/cy** | **%** | **Freq/cy** | **%** |
| Team Selection | Very Little | 1 | 1.1% | 0 | 0.0% | 1 | 2.6% |
| | Little | 5 | 5.5% | 4 | 7.7% | 1 | 2.6% |
| | Important | 29 | 31.9% | 18 | 34.6% | 11 | 28.2% |
| | Substantial | 46 | 50.5% | 26 | 50.0% | 20 | 51.3% |
| | Excellent | 10 | 11.0% | 4 | 7.7% | 6 | 15.4% |
| Structure of the Team | Very Little | 1 | 1.1% | 0 | 0.0% | 1 | 2.6% |
| | Little | 6 | 6.6% | 6 | 11.5% | 0 | 0.0% |
| | Important | 41 | 45.1% | 26 | 50.0% | 15 | 38.5% |
| | Substantial | 36 | 39.6% | 17 | 32.7% | 19 | 48.7% |
| | Excellent | 7 | 7.7% | 3 | 5.8% | 4 | 10.3% |
| Management style | Very Little | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| | Little | 1 | 1.1% | 1 | 1.9% | 0 | 0.0% |
| | Important | 19 | 20.9% | 12 | 23.1% | 7 | 17.9% |
| | Substantial | 45 | 49.5% | 25 | 48.1% | 20 | 51.3% |
| | Excellent | 26 | 28.6% | 14 | 26.9% | 12 | 30.8% |
| Monitoring & Control | Very Little | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| | Little | 3 | 3.3% | 3 | 5.8% | 0 | 0.0% |
| | Important | 29 | 31.9% | 18 | 34.6% | 11 | 28.2% |
| | Substantial | 45 | 49.5% | 24 | 46.2% | 21 | 53.8% |
| | Excellent | 14 | 15.4% | 7 | 13.5% | 7 | 17.9% |
| Reporting | Very Little | 3 | 3.3% | 1 | 1.9% | 2 | 5.1% |
| | Little | 11 | 12.1% | 8 | 15.4% | 3 | 7.7% |
| | Important | 53 | 58.2% | 30 | 57.7% | 23 | 59.0% |
| | Substantial | 22 | 24.2% | 12 | 23.1% | 10 | 25.6% |
| | Excellent | 2 | 2.2% | 1 | 1.9% | 1 | 2.6% |
| Conflict Resolution | Very Little | 3 | 3.3% | 3 | 5.8% | 0 | 0.0% |
| | Little | 14 | 15.4% | 10 | 19.2% | 4 | 10.3% |
| | Important | 36 | 39.6% | 24 | 46.2% | 12 | 30.8% |
| | Substantial | 25 | 27.5% | 10 | 19.2% | 15 | 38.5% |
| | Excellent | 13 | 14.3% | 5 | 9.6% | 8 | 20.5% |
| Efficient usage of resources | Very Little | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| | Little | 5 | 5.6% | 5 | 9.6% | 0 | 0.0% |
| | Important | 40 | 44.4% | 28 | 53.8% | 12 | 31.6% |
| | Substantial | 36 | 40.0% | 17 | 32.7% | 19 | 50.0% |
| | Excellent | 9 | 10.0% | 2 | 3.8% | 7 | 18.4% |

# Tables and graphs from Interviews – General Complexity

Table AP.D-7.50 Tabular report of interview questionnaire response on general complexity

RM Phase 2

**Statistical Analysis**
**Interview Questionnaire on**
**General Complexity Points**

| | | I2C.1 | I2C3 | | | | | | | | | | | | | | | | I2C.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Question | | Does your organisation give definition for complexity? | How does your organisation identify complexity (the characteristics)? Project Size | Project Duration | Procurement method | Project Resource | Communications | Structure of project team | Structure of project | Clarity of Brief | Tasks involved | Social | Cultural | Number of parties | Management style | Client environment | Programme (schedule) | Interaction with Organisations / Project Type / Environment | Do you use any tool / technique to identify complexity? |
| Resp Code | | 1,0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 1,0 |
| 1 | G1.1.1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | G1.1.2 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 3 | G1.1.3 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 4 | G1.1.4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| 5 | G1.1.5 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | G1.1.6 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 7 | G1.1.7 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 8 | G1.2.1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9 | G1.3.1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10 | G1.3.2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 11 | G1.3.3 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 12 | G1.3.4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 13 | G1.3.5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 14 | G1.3.6 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | G2.1.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 16 | G2.1.2 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| 17 | G2.1.3 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 18 | G2.1.4 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 19 | G2.1.5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 20 | G2.1.6 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 21 | G2.1.7 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 22 | G2.1.8 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 23 | G2.1.9 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 24 | G2.2.1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 25 | G2.2.2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 26 | G2.2.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 27 | G2.2.4 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 28 | G2.2.5 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 29 | G2.2.6 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | G2.2.7 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 31 | G2.2.8 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Count # (1) | | 3 | 19 | 11 | 19 | 14 | 19 | 11 | 13 | 13 | 20 | 9 | 9 | 18 | 8 | 14 | 21 | 4 | 13 |
| Mode | | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |

| | | I2C7 | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Question | | What are the complexity factors/characteristics that originate from the proj. organisation/structure? Not experienced team members | Lack of Interaction | Lack of training | Individual's behaviour | Individual's career ambitions | Lack of Team environment | The right person in the right position | Fixity of task for individuals | Phase of project affects individuals | Teams do not self-organise | Team interfaces within and outside | Lack of communication | Clarity of goal / target | Headless chicken - style | No motivation | Lack of structure | Rigidity in the structure | People are in fixed places | Inappropriate Organisational Structure | Inappropriate Work Structure | Inappropriate Management style | Lack of Integration / Maintaining the team |
| Resp Code | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 1 | G1.1.1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 2 | G1.1.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 3 | G1.1.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 4 | G1.1.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | G1.1.5 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 6 | G1.1.6 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7 | G1.1.7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | G1.2.1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 9 | G1.3.1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10 | G1.3.2 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 11 | G1.3.3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 12 | G1.3.4 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 13 | G1.3.5 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 14 | G1.3.6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 15 | G2.1.1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 16 | G2.1.2 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| 17 | G2.1.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 18 | G2.1.4 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 19 | G2.1.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 20 | G2.1.6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | G2.1.7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 22 | G2.1.8 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 23 | G2.1.9 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| 24 | G2.2.1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 25 | G2.2.2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 26 | G2.2.3 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 27 | G2.2.4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 28 | G2.2.5 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 29 | G2.2.6 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 30 | G2.2.7 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 31 | G2.2.8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| Count # (1) | | 27 | 17 | 20 | 25 | 18 | 21 | 21 | 19 | 15 | 15 | 20 | 28 | 21 | 17 | 20 | 20 | 18 | 19 | 25 | 22 | 28 | 4 |
| Mode | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

| | | I2C8 | I2C.10 | I2C.11 | I2C.12 | I2C.14 | I2C.16 | I2C.17 | I2C.18 | I2C.20 | I2C.22 | I2C.23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Question | | How much do you agree with the following definition of complexity: "complexity is caused by the interactions of structures / systems and/or the objects that are interacting"? | Are any components of the project organisation, e.g. as investigated in this research – e.g. selection of team members, setting up of the team structure and management approach, used as means to minimise complexity? | Is complexity used as a criterion for selecting the project team members? | Does your organisation structure project team(s) specifically to tackle complexity? | Does your organisation use specific management techniques that depend on the level of complexity of the project? | In an increasingly complex environment, are you, in your view, following the appropriate organisational framework to deliver projects successfully? | How much do you agree with the following statement: "We do not Select the Teams, We do not Set up the Project Organisation and We do not Manage the Project Teams in a manner that will reduce complexity"? | Do you measure project team performance? | Do you set targets to the team? | Do you identify the reasons for increase or decrease of performance? | Do you record and analyse the reasons? |
| Resp Code | | 1,4 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | 1,4 | 1,0 | 1,0 | 1,0 | 1,0 |
| 1 | G1.1.1 | 1 | 1 | 0 | 1 | 0 | 1 | 4 | 0 | 0 | 0 | 0 |
| 2 | G1.1.2 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| 3 | G1.1.3 | 2 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 4 | G1.1.4 | 3 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 1 |
| 5 | G1.1.5 | 2 | 1 | 1 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 0 |
| 6 | G1.1.6 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 1 | 0 |
| 7 | G1.1.7 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 0 |
| 8 | G1.2.1 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| 9 | G1.3.1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 1 | 1 | 1 |
| 10 | G1.3.2 | 3 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 |
| 11 | G1.3.3 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| 12 | G1.3.4 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| 13 | G1.3.5 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| 14 | G1.3.6 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 |
| 15 | G2.1.1 | 1 | 1 | 1 | 1 | 0 | 1 | 3 | 1 | 1 | 1 | 1 |
| 16 | G2.1.2 | 3 | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 |
| 17 | G2.1.3 | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 1 |
| 18 | G2.1.4 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 1 |
| 19 | G2.1.5 | 2 | 1 | 1 | 1 | 1 | 0 | 4 | 1 | 1 | 1 | 1 |
| 20 | G2.1.6 | 2 | 1 | 1 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 0 |
| 21 | G2.1.7 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 22 | G2.1.8 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 1 |
| 23 | G2.1.9 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| 24 | G2.2.1 | 2 | 1 | 1 | 1 | 0 | 1 | 3 | 0 | 1 | 1 | 0 |
| 25 | G2.2.2 | 1 | 1 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 0 |
| 26 | G2.2.3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 27 | G2.2.4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 28 | G2.2.5 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 1 |
| 29 | G2.2.6 | 2 | 0 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| 30 | G2.2.7 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 31 | G2.2.8 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Count # (1) | | CI1 9 | 15 | 13 | 12 | 5 | 19 | CI1 5 | 13 | 20 | 17 | 12 |
| Mode | | CI2 18 | 0 | 0 | 0 | 0 | 1 | CI2 17 | 0 | 1 | 1 | 0 |
| | | CI3 4 | | | | | | CI3 7 | | | | |
| | | CI4 0 | | | | | | CI4 2 | | | | |

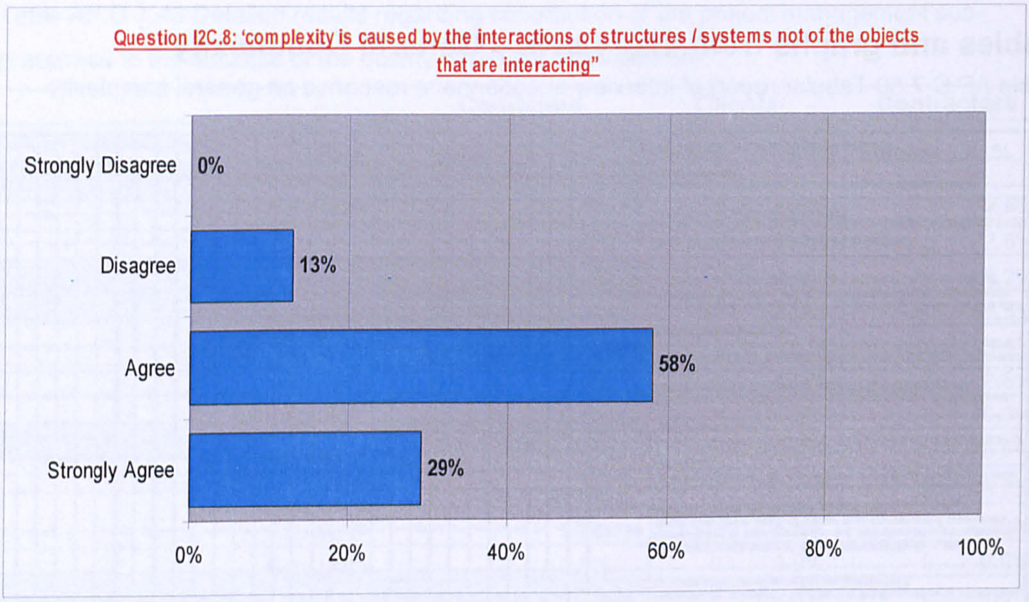



Figure AP.D-7.8 Response regarding interviewees' agreement to the definition of complexity used for this research

Table AP.D-7.52 Responses to interview open questions regarding tools / techniques used to identify complexity and measures taken to minimise complexity

| Interviewee | I2C.4. Do you use any tools / techniques to identify complexity? | I2C.5. What are these tools / techniques? | I2C.6. In your view, what are the measures required to be taken to minimise complexity? |
|---|---|---|---|
| G1.1.1 | Yes | Risk matrix | Clear goals, reduce constraints with others, reduce interfaces within project |
| G1.1.2 | No | -- | Control and understanding the situations |
| G1.1.3 | No | -- | Monitor, Control and Reporting |
| G1.1.4 | Yes | Stakeholder identification, development brief, scheduling, risk identification/ mitigation, issues log | Clear lines of communication, stakeholder engagement, transparency (bringing issue to the front as quickly as possible, clearly defined roles and responsibilities) |
| G1.1.5 | No | -- | Planning. Clear brief and fixity |
| G1.1.6 | No | -- | Definition of the project, communication, understanding between the parties |
| G1.1.7 | Yes | Grouping projects by their size and risks | Clarity of project definition; definition of scope |
| G1.2.1 | No | -- | Continuous review of conditions that prevail and making sure that actions can be taken to prevent disasters |
| G1.3.1 | Yes | Clasification of projects | Having the right people in the team. Experience - knowledge, serious third party issues which is dealt with experts dealing with these parties. |
| G1.3.2 | Yes | Key issues recorded in Db 'anything that can affect the delivery of the project', acts as a reminder to the PMs. Procedures are available to guide the PM on complex issues | There is no formal review of complexity |
| G1.3.3 | No | -- | Work in a collaborative manner. clear line of communicaitons |
| G1.3.4 | No | -- | No reply |
| G1.3.5 | No | -- | No reply |
| G1.3.6 | No | -- | If technical complexity then carry out VM |
| G2.1.1 | No | -- | Communication and explanation of what the project outputs are |
| G2.1.2 | Yes | Carrying out Risk managament activities / processes | Understand the brief, the scheme, the other parties involved, the geography of the project coontractual arrangements. |
| G2.1.3 | Yes | On each area systems are devised to deal / address areas of complexity | As per Q5 |
| G2.1.4 | Yes | Reviewing the risks and mitigating actions | Identify issues early,in terms of the teams and the other parties |
| G2.1.5 | Yes | A scoring matrix is used | Client brief is defined and constraints are known within budget |

| Interviewee | I2C.4. Do you use any tools / techniques to identify complexity? | I2C.5. What are these tools / techniques? | I2C.6. In your view, what are the measures required to be taken to minimise complexity? |
|---|---|---|---|
| | | | and time |
| G2.1.6 | Yes | The production of a risk register | To ensure plenty of time for planning |
| G2.1.7 | No | -- | Clear scope of works, agreed programme bought by all parties, clear roles of engagement |
| G2.1.8 | No | -- | Considering continuously the environment and what is happening within the project |
| G2.1.9 | Yes | Using and identifying the right method of carrying out actions and systems that the company has. | Structure of the team (what the project entails) |
| G2.2.1 | No | -- | Clear understanding of the scheme, what is the outturn scope, clear structure, minimising interfaces, realistic time frames |
| G2.2.2 | No | -- | Communication minimises complexity. simplify meetings and process |
| G2.2.3 | No | -- | Manage the organisations involved and the interfaces and drive the programme, with an approval process for the projects |
| G2.2.4 | Yes | The programme | Programme, interaction with other departments |
| G2.2.5 | Yes | Risk assessment tool | Talking to the risk owners |
| G2.2.6 | No | -- | 5 year Contract is well defined therefore there is no complexity arising - frequently it requires amendments |
| G2.2.7 | No | -- | Processes are used to study various areas |
| G2.2.8 | No | -- | Risk register, scheme control document; when in design we do a hazzards elimination |

Table AP.D-7.56 Interviewee response to the open question 9 - 'How would you go about managing / minimising complexity if it is as defined in this research'?

| Interviewee | Response |
|---|---|
| G1.1.1 | Very defined and simple team structure and communications system |
| G1.1.2 | Very careful consideration of factors that influence the interfaces |
| G1.1.3 | Very careful view and actions around factors that influence the interfaces |
| G1.1.4 | N/A |
| G1.1.5 | Planning, clear brief and fixity |
| G1.1.6 | No response |
| G1.1.7 | Control the parties involved, measure performance |
| G1.2.1 | Make sure that communication between the parties is clear; tasks of parties are clarified and sequenced - people know what they are doing and who is following on |
| G1.3.1 | Right people on the roles; make the most of what you get. Understand what the breakdown is, system complicated. Think of improving that interaction |
| G1.3.2 | Use of experienced trained and competent PMs. HR dept to carry out people development in the areas that are important to the business (easier to cary out soft training ) |
| G1.3.3 | Enable interfaces to work appropriately. Management of interconnecitons. Set up the teams appropriately and follow up. |
| G1.3.4 | Enable improved interactions between the different delivery teams (solutions & construction) |
| G1.3.5 | Talk to respective construction manager about issues raised, supporting him during consrtuction |
| G1.3.6 | Make sure that you have systems that are written by experts/ approp. people, also keeping the structures lean |
| G2.1.1 | Getting the individuals in the management structure to understand what is to be achieved and the output. |
| G2.1.2 | N/A |
| G2.1.3 | Management of the interfaces and allocating appropriate responsibilities |
| G2.1.4 | Make sure that interfaces have been identified and bringing the Client on board |
| G2.1.5 | Understanding the interfaces between perties |
| G2.1.6 | Planning |
| G2.1.7 | No response |
| G2.1.8 | Making sure that interfaces are identified and managed appropriately |
| G2.1.9 | Training team members, and management skills and systems that can be related to project(s) |
| G2.2.1 | Clear understanding of the scheme, what is the outturn scope, clear structure, minimising interfaces, realistic time frames and idenitfying a single individual to oversee / manage |
| G2.2.2 | Communication and people's experience involved in schemes |
| G2.2.3 | Manage the organisations involved and the interfaces and drive the programme, with an approval process for the projects and also have appropriate stakeholder management |
| G2.2.4 | Programme, interaction with other departments |
| G2.2.5 | Should have a direct input into the problem; there must be a command structure |
| G2.2.6 | Communication, managing the team, correct goal |
| G2.2.7 | Being aware of the potential of the interactions causing the problem and think in advance of how to manage them |
| G2.2.8 | Imposing solutions / answers and raising awareness to Senior Management |

Table AP.D-7.57. Analysis grid for content analysis of interview question 9.

| | Categories | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Int/wee | Interface | Team Structure | Communication | Individuals | Programme | Project / Brief / Scope | Interactions | System | Roles & Responsibilities | Unclassified |
| G1.1.1 | | ☑ | ☑ | | | | | | | |
| G1.1.2 | ☑ | | | | | | | | | |
| G1.1.3 | ☑ | | | | | | | | | |
| G1.1.4 | | | | | | | | | | |
| G1.1.5 | | | | | ☑ | ☑ | | | | |
| G1.1.6 | | | | | | | | | | |
| G1.1.7 | | | | | | | | | | ☑ |
| G1.2.1 | | | ☑ | ☑ | ☑ | | | | | |
| G1.3.1 | ☑ | | | | | | ☑ | ☑ | ☑ | |
| G1.3.2 | | | | ☑ | | | | | | |
| G1.3.3 | ☑ | ☑ | | | | | | | | |
| G1.3.4 | | | | | | | ☑ | | | |
| G1.3.5 | | | | | | | ☑ | | | |
| G1.3.6 | | ☑ | | | | | | ☑ | | |
| G2.1.1 | | ☑ | | ☑ | | | | | | |
| G2.1.2 | | | | | | | | | | |
| G2.1.3 | ☑ | | | | | | | | ☑ | |
| G2.1.4 | ☑ | | | | | | | | | ☑ |
| G2.1.5 | ☑ | | | | | | | | | |
| G2.1.6 | | | | | ☑ | | | | | |
| G2.1.7 | | | | | | | | | | |
| G2.1.8 | ☑ | | | | | | | | | |
| G2.1.9 | | | | ☑ | | | | ☑ | | ☑ |
| G2.2.1 | ☑ | ☑ | | | ☑ | ☑ | | | | |
| G2.2.2 | | | ☑ | ☑ | | | | | | |
| G2.2.3 | ☑ | | | | ☑ | | | | | ☑ |
| G2.2.4 | | | | | ☑ | | ☑ | | | |
| G2.2.5 | | | | | | | | | | ☑ |
| G2.2.6 | | | ☑ | | | ☑ | | | | |
| G2.2.7 | | | | | | | ☑ | | | |
| G2.2.8 | | | | | | | | | | |
| Total | 10 | 5 | 4 | 5 | 6 | 3 | 5 | 3 | 2 | 5 |

Table AP.D-7.58 Interviewee response to the open questions shown in the table below

| Interviewee | Response to question 12: Does your organisation structure project team(s) specifically to tackle complexity? | Response to question 13: If Yes, how do they do that? |
|---|---|---|
| G1.1.1 | Yes | Looking at roles, responsibilities, and accountabilities (RACI) |
| G1.1.2 | Yes | Project RACI |
| G1.1.3 | Yes | RACI |
| G1.1.4 | No | |
| G1.1.5 | No | |
| G1.1.6 | No | |
| G1.1.7 | No | |
| G1.2.1 | No | |
| G1.3.1 | Yes | Knowing how people work, also strengths and weaknesses; looking at their performance (are their jobs complex, or good at delivering) |
| G1.3.2 | No | |
| G1.3.3 | No | |
| G1.3.4 | No | |
| G1.3.5 | No | |
| G1.3.6 | No | |
| G2.1.1 | Yes | Looking at degrees of complexity at an early stage, i.e. tender, so that team are already identified |
| G2.1.2 | Yes | Knowledge of peoples' experience, teams that worked together before, proven track record of people in complex situations, people have an aptitude |
| G2.1.3 | Yes | Identifying risks and structuting the teams to tackle and mitigate these risks |
| G2.1.4 | No | |
| G2.1.5 | Yes | Thinking in terms of individuals' capabilities |
| G2.1.6 | Yes | By matching previous experiences of individuals' to projects |
| G2.1.7 | No | |
| G2.1.8 | No | |
| G2.1.9 | No | |
| G2.2.1 | Yes | Allocate resource (Design and Construction) based on difficulty within the design / construction - technical complexity of design, expertise based for construction |
| G2.2.2 | Yes | Selecting certain individuals; Informing stakeholders |
| G2.2.3 | No | |
| G2.2.4 | No | |
| G2.2.5 | No | |
| G2.2.6 | Yes | Specific VM strategy to prioritise schemes |
| G2.2.7 | No | |
| G2.2.8 | No | |

Table AP.D-7.61 Interviewee response to the open question15 shown in the table

| Interviewee | Response to question 14: Does your organisation use specific management techniques that depend on the level of complexity of the project? | Response to question 15: If Yes, what are these? |
|---|---|---|
| G1.1.1 | No | |
| G1.1.2 | No | |
| G1.1.3 | No | |
| G1.1.4 | No | |
| G1.1.5 | No | |
| G1.1.6 | No | |
| G1.1.7 | No | |
| G1.2.1 | No | |
| G1.3.1 | Yes | Depending on the programme of projects - managed by **specific people** who have the attributes to deliver the project. Driving the right solution throught people |
| G1.3.2 | No | |
| G1.3.3 | No | |
| G1.3.4 | No | |
| G1.3.5 | No | |
| G1.3.6 | Yes | It is taken care through selecting **the PM** that will lead the project. |
| G2.1.1 | No | |
| G2.1.2 | No | |
| G2.1.3 | No | |
| G2.1.4 | No | |
| G2.1.5 | Yes | Standard **process** defined / determined by the company |
| G2.1.6 | No | |
| G2.1.7 | No | |
| G2.1.8 | No | |
| G2.1.9 | Yes | Management system selection at the beginning of the project would accommodate that |
| G2.2.1 | No | |
| G2.2.2 | No | |
| G2.2.3 | No | |
| G2.2.4 | No | |
| G2.2.5 | No | |
| G2.2.6 | Yes | Our current schemes are straight forward do not require any particular management approach |
| G2.2.7 | No | |
| G2.2.8 | No | |

## Tables and graphs from Interviews – Complexity Characteristics

For quick referencing reasons table AP.D-7.61 below provides an overview of the information included in the following pages and which afford the detailed responses on Complexity Characteristics questions.

Table AP.D-7.61 Table of contents of interview information included in the following pages

Table AP.D-7.62.1 Tabular report for achieved management of complexity (in %) for Selecting Team members - Client PM Responses

| | | Group Client A | | | | | | | Group Clients B & C | | | | | | | **Client** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complexity Characteristics** | | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | **Aver** |
| Conditional | Autonomous agents | 5 | 5 | 5 | 5 | 8 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | **5** |
| | Instability | 50 | 70 | 30 | 70 | 70 | 70 | 70 | 50 | 70 | 50 | 50 | 30 | 30 | 50 | **54** |
| | Non-equilibrium | 50 | 70 | 10 | 50 | 30 | 30 | 10 | 30 | 50 | 30 | 50 | 30 | 50 | 50 | **39** |
| | Non-linear | 40 | 40 | 40 | 30 | 30 | 50 | 30 | 30 | 50 | 30 | 70 | 70 | 70 | 40 | **44** |
| | Attractors | 100 | 50 | 0 | 100 | 100 | 70 | 70 | 100 | 30 | 10 | 100 | 10 | 10 | 100 | **61** |
| Developmental | Co-evolution | 22 | 18 | 45 | 78 | 69 | 35 | 49 | 61 | 35 | 25 | 21 | 22 | 11 | 53 | **39** |
| | Self-modification | 30 | 30 | 70 | 10 | 30 | 10 | 10 | 100 | 0 | 10 | 100 | 10 | 100 | 10 | **37** |
| | Self-reproduction | 12 | 44 | 82 | 53 | 59 | 76 | 100 | 21 | 76 | 76 | 6 | 50 | 50 | 24 | **52** |
| | Downward Causation | 77 | 23 | 90 | 20 | 77 | 60 | 43 | 50 | 50 | 10 | 30 | 37 | 70 | 60 | **50** |
| | Mutability | 78 | 38 | 77 | 72 | 83 | 33 | 37 | 33 | 28 | 9 | 9 | 19 | 53 | 74 | **46** |
| | Non-uniform | 50 | 50 | 70 | 100 | 100 | 30 | 30 | 100 | 70 | 30 | 10 | 30 | 100 | 100 | **62** |
| | Emergence | 65 | 55 | 75 | 70 | 35 | 70 | 70 | 55 | 55 | 25 | 25 | 20 | 20 | 25 | **48** |
| | Phase changes | 0 | 0 | 40 | 40 | 40 | 0 | 40 | 100 | 0 | 0 | 0 | 0 | 60 | 0 | **23** |
| Behavioural | Unpredictability | 75 | 60 | 70 | 80 | 50 | 75 | 75 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | **62** |
| | Non-standard | 64 | 32 | 12 | 28 | 33 | 45 | 64 | 12 | 46 | 25 | 22 | 22 | 22 | 26 | **32** |
| | Undefined values | 35 | 16 | 15 | 5 | 15 | 25 | 15 | 15 | 15 | 25 | 25 | 5 | 15 | 5 | **16** |

Table AP.D-7.62.2 Tabular report for achieved management of complexity (in %) for Selecting Team members - Contractor PM Responses

| | | Group Contractor A | | | | | | | | | Group Contractor B | | | | | | | | Cntr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complexity** | **Characteristics** | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | **Aver** |
| Conditional | Autonomous agents | 15 | 65 | 40 | 40 | 35 | 40 | 40 | 35 | 40 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | **24** |
| | Instability | 70 | 100 | 70 | 100 | 70 | 30 | 70 | 70 | 50 | 100 | 100 | 30 | 50 | 50 | 30 | 70 | 50 | **68** |
| | Non-equilibrium | 30 | 100 | 50 | 30 | 50 | 100 | 30 | 30 | 50 | 70 | 100 | 30 | 100 | 30 | 50 | 50 | 100 | **59** |
| | Non-linear | 70 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | **61** |
| | Attractors | 30 | 10 | 50 | 100 | 100 | 70 | 100 | 100 | 70 | 70 | 100 | 70 | 100 | 30 | 30 | 100 | 100 | **72** |
| Developmental | Co-evolution | 100 | 35 | 72 | 71 | 45 | 71 | 35 | 60 | 61 | 15 | 15 | 25 | 15 | 5 | 5 | 35 | 5 | **39** |
| | Self-modification | 30 | 100 | 100 | 30 | 100 | 100 | 50 | 50 | 70 | 10 | 10 | 30 | 10 | 10 | 30 | 10 | 10 | **44** |
| | Self-reproduction | 100 | 77 | 76 | 76 | 76 | 76 | 76 | 59 | 76 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **41** |
| | Downward Causation | 20 | 73 | 97 | 27 | 77 | 80 | 70 | 83 | 67 | 50 | 40 | 40 | 7 | 3 | 7 | 7 | 70 | **48** |
| | Mutability | 70 | 33 | 53 | 73 | 58 | 57 | 82 | 78 | 69 | 15 | 15 | 5 | 5 | 5 | 15 | 5 | 5 | **38** |
| | Non-uniform | 100 | 70 | 30 | 70 | 50 | 30 | 100 | 100 | 50 | 10 | 10 | 10 | 30 | 10 | 10 | 30 | 30 | **44** |
| | Emergence | 70 | 65 | 65 | 75 | 75 | 50 | 85 | 85 | 85 | 5 | 5 | 15 | 5 | 5 | 5 | 5 | 5 | **41** |
| | Phase changes | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **51** |
| Behavioural | Unpredictability | 100 | 90 | 90 | 100 | 100 | 80 | 80 | 80 | 80 | 30 | 30 | 75 | 30 | 30 | 25 | 30 | 30 | **64** |
| | Non-standard | 65 | 25 | 60 | 25 | 56 | 35 | 35 | 61 | 25 | 15 | 15 | 5 | 5 | 15 | 5 | 5 | 25 | **28** |
| | Undefined values | 35 | 25 | 86 | 61 | 38 | 15 | 15 | 25 | 44 | 15 | 15 | 5 | 5 | 51 | 50 | 35 | 5 | **31** |

Table AP.D-7.62.3. Overall achieved management of complexity (in %) for Selecting Team members.

| | Characteristics | Description Relevant to Construction | Overall Aver/ge Achieved Mngt (in %) |
|---|---|---|---|
| Conditional | Autonomous agents | Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | **16** |
| | Instability | Stepped evolution(s) or catastrophes do occur in projects. Attractors (see definition) appear (currently unintentionally) and become system parameters and which will attract and avoid chaotic behaviour of the project system | **60** |
| | Non-equilibrium | The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | **50** |
| | Non-linear | Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behaviour. | **53** |
| | Attractors | Simple systems (individuals) come together and many times self-organise to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. So we have individuals, that could easily not be the line managers, who because of their capabilities, abilities, behavioural attributes are assigned to be 'attractors' is a certain situation arises. | **67** |
| Developmental | Co-evolution | The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment, which is self-evident in the Project Management world | **39** |
| | Self-modification | Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle | **41** |
| | Self-reproduction | The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different teams may require different organisational structure. Similarly the Mngt style is copied / imposed throughout. | **46** |
| | Downward Causation | The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. | **49** |
| | Mutability | It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | **41** |
| | Non-uniform | The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped. | **52** |

| | Characteristics | Description Relevant to Construction | Overall Aver/ge Achieved Mngt (in %) |
|---|---|---|---|
| Developmental | Emergence | This again is the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project | **44** |
| | Phase changes | As far as the individual is concerned this characteristic highlights the importance of feedback processes for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' 'properties' attributes. These could either be the standard phase changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property. | **38** |
| Behavioural | Unpredictability | This represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on the projects (*see also pathogens and incubation period, IJPM ref. needed here*). | **63** |
| | Non-standard | Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | **30** |
| | Undefined values | Identifying the system's/project's interfaces with the environment as the external stakeholders (re. W. Hughes 11 external factors see CME paper & my further thoughts on this subject) this characteristic identifies the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project | **24** |

Table AP.D-7.63.1 Tabular report for achieved management of complexity (in %) for Structuring the Team - Client PM Responses

| | | Group Client A | | | | | | | Group Clients B & C | | | | | | | Client |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complexity Characteristics** | | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | **Aver** |
| Conditional | Autonomous agents | 40 | 60 | 40 | 50 | 30 | 50 | 30 | 50 | 50 | 70 | 70 | 70 | 70 | 40 | 51 |
| | Instability | 50 | 70 | 30 | 70 | 30 | 30 | 50 | 10 | 10 | 10 | 50 | 10 | 10 | 50 | 34 |
| | Non-equilibrium | 70 | 65 | 5 | 40 | 40 | 40 | 30 | 20 | 50 | 50 | 40 | 50 | 40 | 45 | 42 |
| | Non-linear | 40 | 40 | 40 | 30 | 30 | 50 | 30 | 30 | 50 | 30 | 70 | 70 | 70 | 40 | 44 |
| | Attractors | 65 | 55 | 35 | 65 | 50 | 40 | 40 | 5 | 30 | 60 | 50 | 40 | 25 | 45 | 43 |
| Developmental | Co-evolution | 65 | 55 | 75 | 75 | 65 | 70 | 80 | 70 | 45 | 40 | 55 | 50 | 55 | 85 | 63 |
| | Self-modification | 64 | 12 | 45 | 18 | 13 | 10 | 63 | 60 | 60 | 60 | 57 | 57 | 57 | 78 | 47 |
| | Self-reproduction | 70 | 30 | 100 | 100 | 70 | 30 | 50 | 50 | 50 | 30 | 10 | 10 | 100 | 70 | 55 |
| | Downward Causation | 50 | 40 | 50 | 50 | 40 | 40 | 40 | 40 | 40 | 40 | 95 | 40 | 50 | 100 | 51 |
| | Mutability | 75 | 28 | 48 | 75 | 53 | 28 | 38 | 28 | 38 | 18 | 38 | 15 | 5 | 30 | 37 |
| | Non-uniform | 30 | 30 | 50 | 100 | 100 | 10 | 30 | 70 | 70 | 10 | 10 | 10 | 100 | 50 | 48 |
| | Emergence | 50 | 100 | 70 | 100 | 70 | 70 | 70 | 70 | 70 | 50 | 10 | 10 | 70 | 70 | 63 |
| | Phase changes | 70 | 10 | 70 | 100 | 10 | 70 | 50 | 100 | 50 | 10 | 30 | 10 | 100 | 100 | 56 |
| Behavioural | Unpredictability | 50 | 50 | 30 | 50 | 100 | 50 | 70 | 50 | 70 | 10 | 50 | 30 | 10 | 30 | 46 |
| | Non-standard | 100 | 70 | 50 | 70 | 70 | 100 | 100 | 30 | 50 | 30 | 30 | 30 | 10 | 50 | 56 |
| | Undefined values | 100 | 40 | 40 | 30 | 10 | 50 | 30 | 50 | 50 | 70 | 70 | 40 | 70 | 40 | 49 |

Table AP.D-7.63.2 Tabular report for achieved management of complexity (in %) for Structuring the Team - Contractor PM Responses

| | | Group Contractor A | | | | | | | | | Group Contractor B | | | | | | | | Cntr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complexity** | **Characteristics** | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | **Aver** |
| Conditional | Autonomous agents | 70 | 100 | 80 | 80 | 80 | 80 | 100 | 80 | 80 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | **63** |
| | Instability | 70 | 100 | 50 | 50 | 50 | 30 | 50 | 30 | 30 | 30 | 100 | 10 | 50 | 50 | 30 | 70 | 100 | **53** |
| | Non-equilibrium | 60 | 65 | 55 | 45 | 45 | 65 | 45 | 55 | 45 | 55 | 70 | 35 | 70 | 45 | 35 | 45 | 70 | **53** |
| | Non-linear | 70 | 80 | 80 | 80 | 80 | 80 | 80 | 8 | 80 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | **56** |
| | Attractors | 50 | 5 | 55 | 75 | 65 | 55 | 65 | 65 | 55 | 70 | 70 | 35 | 80 | 35 | 45 | 55 | 80 | **56** |
| Developmental | Co-evolution | 80 | 50 | 60 | 75 | 60 | 65 | 45 | 60 | 35 | 30 | 25 | 35 | 30 | 25 | 30 | 25 | 25 | **44** |
| | Self-modification | 100 | 60 | 71 | 71 | 71 | 76 | 60 | 75 | 76 | 50 | 0 | 50 | 50 | 35 | 50 | 50 | 50 | **58** |
| | Self-reproduction | 100 | 30 | 10 | 50 | 50 | 100 | 50 | 100 | 70 | 100 | 10 | 100 | 70 | 10 | 50 | 50 | 30 | **58** |
| | Downward Causation | 50 | 80 | 70 | 80 | 70 | 70 | 80 | 50 | 95 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | **57** |
| | Mutability | 88 | 28 | 48 | 5 | 48 | 48 | 15 | 88 | 50 | 28 | 18 | 28 | 28 | 18 | 38 | 28 | 28 | **37** |
| | Non-uniform | 50 | 30 | 50 | 70 | 50 | 30 | 30 | 100 | 30 | 30 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | **32** |
| | Emergence | 70 | 50 | 100 | 50 | 70 | 50 | 50 | 100 | 100 | 10 | 50 | 30 | 30 | 10 | 10 | 50 | 30 | **51** |
| | Phase changes | 100 | 70 | 50 | 30 | 50 | 70 | 30 | 100 | 100 | 10 | 30 | 30 | 10 | 10 | 10 | 10 | 30 | **44** |
| Behavioural | Unpredictability | 50 | 50 | 100 | 30 | 100 | 50 | 30 | 100 | 50 | 10 | 30 | 70 | 10 | 100 | 70 | 50 | 50 | **56** |
| | Non-standard | 100 | 50 | 100 | 70 | 100 | 70 | 50 | 100 | 50 | 30 | 10 | 100 | 30 | 100 | 100 | 100 | 50 | **71** |
| | Undefined values | 80 | 100 | 80 | 80 | 60 | 60 | 100 | 80 | 80 | 40 | 20 | 40 | 40 | 0 | 0 | 60 | 20 | **55** |

Table AP.D-7.63.3. Overall achieved management of complexity (in %) for Structuring the Project Team.

| | Characteristics | Description Relevant to Construction | Overall Aver/ge Achieved Mngt (in %) |
|---|---|---|---|
| Conditional | Autonomous agents | Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | **58** |
| | Instability | Stepped evolution(s) or catastrophes do occur in projects. Attractors (see definition) appear (currently unintentionally) and become system parameters and which will attract and avoid chaotic behaviour of the project system | **45** |
| | Non-equilibrium | The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | **48** |
| | Non-linear | Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behaviour. | **51** |
| | Attractors | Simple systems (individuals) come together and many times self-organise to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. So we have individuals, that could easily not be the line managers, who because of their capabilities, abilities, behavioural attributes are assigned to be 'attractors' is a certain situation arises. | **50** |
| Developmental | Co-evolution | The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment, which is self-evident in the Project Management world | **53** |
| | Self-modification | Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle | **53** |
| | Self-reproduction | The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different teams may require different organisational structure. Similarly the Mngt style is copied / imposed throughout. | **56** |
| | Downward Causation | The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. | **54** |
| | Mutability | It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | **37** |
| | Non-uniform | The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped. | **39** |

| | Characteristics | Description Relevant to Construction | Overall Aver/ge Achieved Mngt (in %) |
|---|---|---|---|
| Developmental | Emergence | This again is the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project | **56** |
| | Phase changes | As far as the individual is concerned this characteristic highlights the importance of feedback processes for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' 'properties' attributes. These could either be the standard phase changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property. | **49** |
| Behavioural | Unpredictability | This represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on the projects (*see also pathogens and incubation period, IJPM ref. needed here*). | **52** |
| | Non-standard | Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | **65** |
| | Undefined values | Identifying the system's/project's interfaces with the environment as the external stakeholders (re. W. Hughes 11 external factors see CME paper & my further thoughts on this subject) this characteristic identifies the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project | **53** |

Table AP.D-7.64.1 Tabular report for achieved management of complexity (in %) for Management Style followed (within Management of Team) - Client PM Responses

| | | Group Client A | | | | | | | Group Clients B & C | | | | | | | Client |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complexity Characteristics** | | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | **Aver** |
| Conditional | Autonomous agents | 60 | 70 | 60 | 65 | 85 | 40 | 60 | 40 | 40 | 60 | 40 | 20 | 30 | 60 | **52** |
| | Instability | 50 | 50 | 50 | 100 | 70 | 30 | 70 | 100 | 50 | 50 | 30 | 50 | 50 | 70 | **59** |
| | Non-equilibrium | 70 | 70 | 10 | 70 | 50 | 70 | 50 | 50 | 50 | 50 | 70 | 50 | 30 | 70 | **54** |
| | Non-linear | 60 | 70 | 60 | 55 | 70 | 30 | 70 | 30 | 40 | 40 | 50 | 30 | 30 | 60 | **50** |
| | Attractors | 70 | 70 | 30 | 100 | 100 | 70 | 70 | 50 | 50 | 30 | 30 | 30 | 50 | 70 | **59** |
| Developmental | Co-evolution | 60 | 30 | 85 | 65 | 75 | 30 | 70 | 65 | 50 | 50 | 75 | 30 | 65 | 70 | **59** |
| | Self-modification | 50 | 60 | 75 | 65 | 70 | 20 | 60 | 65 | 30 | 50 | 60 | 30 | 55 | 70 | **54** |
| | Self-reproduction | 100 | 70 | 100 | 30 | 70 | 10 | 10 | 50 | 30 | 10 | 10 | 10 | 100 | 100 | **50** |
| | Downward Causation | 70 | 70 | 70 | 10 | 70 | 10 | 70 | 30 | 50 | 70 | 70 | 30 | 10 | 70 | **50** |
| | Mutability | 70 | 10 | 90 | 70 | 10 | 10 | 10 | 30 | 30 | 10 | 50 | 0 | 70 | 90 | **39** |
| | Non-uniform | 50 | 70 | 60 | 65 | 85 | 50 | 60 | 65 | 50 | 50 | 30 | 40 | 65 | 70 | **58** |
| | Emergence | 85 | 70 | 85 | 65 | 85 | 50 | 85 | 65 | 60 | 60 | 85 | 40 | 40 | 85 | **69** |
| | Phase changes | 60 | 60 | 85 | 65 | 85 | 50 | 85 | 65 | 60 | 40 | 40 | 30 | 40 | 85 | **61** |
| Behavioural | Unpredictability | 70 | 54 | 46 | 42 | 58 | 18 | 58 | 50 | 50 | 42 | 38 | 46 | 46 | 58 | **48** |
| | Non-standard | 70 | 70 | 70 | 100 | 70 | 100 | 100 | 30 | 70 | 50 | 50 | 30 | 30 | 50 | **64** |
| | Undefined values | 70 | 70 | 50 | 70 | 70 | 70 | 70 | 50 | 70 | 30 | 50 | 30 | 50 | 50 | **57** |

Table AP.D-7.64.2 Tabular report for achieved management of complexity (in %) for Management Style followed (within Management of Team) - Contractor PM Responses

| | | Group Contractor A | | | | | | | | | Group Contractor B | | | | | | | | Cntr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complexity** | **Characteristics** | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | **Aver** |
| Conditional | Autonomous agents | 50 | 70 | 60 | 60 | 60 | 70 | 60 | 70 | 50 | 60 | 40 | 50 | 40 | 50 | 50 | 40 | 85 | **57** |
| | Instability | 30 | 100 | 100 | 70 | 50 | 30 | 50 | 70 | 50 | 70 | 100 | 50 | 50 | 50 | 50 | 70 | 100 | **64** |
| | Non-equilibrium | 50 | 70 | 50 | 50 | 50 | 70 | 30 | 50 | 50 | 100 | 100 | 50 | 100 | 50 | 50 | 70 | 100 | **64** |
| | Non-linear | 60 | 70 | 70 | 75 | 85 | 30 | 40 | 85 | 70 | 60 | 75 | 60 | 65 | 60 | 85 | 55 | 85 | **66** |
| | Attractors | 50 | 70 | 50 | 100 | 70 | 70 | 50 | 70 | 50 | 70 | 100 | 30 | 100 | 50 | 50 | 100 | 100 | **69** |
| Developmental | Co-evolution | 75 | 60 | 85 | 75 | 70 | 55 | 85 | 85 | 60 | 50 | 50 | 50 | 30 | 40 | 50 | 30 | 60 | **59** |
| | Self-modification | 60 | 60 | 70 | 75 | 70 | 55 | 85 | 85 | 60 | 40 | 40 | 50 | 20 | 50 | 50 | 30 | 50 | **56** |
| | Self-reproduction | 70 | 30 | 50 | 10 | 50 | 50 | 70 | 10 | 30 | 30 | 70 | 100 | 10 | 10 | 0 | 70 | 50 | **42** |
| | Downward Causation | 50 | 70 | 70 | 50 | 50 | 70 | 70 | 70 | 70 | 50 | 50 | 70 | 30 | 70 | 70 | 10 | 70 | **58** |
| | Mutability | 90 | 50 | 90 | 90 | 90 | 70 | 70 | 90 | 50 | 10 | 0 | 10 | 10 | 10 | 10 | 10 | 0 | **44** |
| | Non-uniform | 75 | 50 | 60 | 75 | 75 | 60 | 50 | 85 | 60 | 40 | 50 | 60 | 30 | 40 | 50 | 30 | 60 | **56** |
| | Emergence | 60 | 70 | 85 | 75 | 70 | 60 | 70 | 85 | 75 | 50 | 40 | 60 | 40 | 40 | 40 | 30 | 50 | **59** |
| | Phase changes | 60 | 70 | 60 | 60 | 50 | 40 | 40 | 85 | 50 | 40 | 40 | 50 | 30 | 40 | 60 | 30 | 50 | **50** |
| Behavioural | Unpredictability | 46 | 46 | 42 | 46 | 60 | 46 | 54 | 38 | 54 | 30 | 50 | 45 | 30 | 42 | 30 | 46 | 70 | **46** |
| | Non-standard | 70 | 50 | 100 | 50 | 100 | 70 | 50 | 100 | 70 | 50 | 50 | 100 | 50 | 100 | 100 | 100 | 50 | **74** |
| | Undefined values | 100 | 50 | 100 | 100 | 70 | 50 | 70 | 50 | 50 | 50 | 30 | 100 | 50 | 50 | 0 | 100 | 50 | **63** |

Table AP.D-7.64.3. Overall achieved management of complexity (in %) for Management Style followed (within Management of Team).

| | Characteristics | Description Relevant to Construction | Overall Aver/ge Achieved Mngt (in %) |
|---|---|---|---|
| Conditional | Autonomous agents | Each and every individual contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system. | 55 |
| | Instability | Stepped evolution(s) or catastrophes do occur in projects. Attractors (see definition) appear (currently unintentionally) and become system parameters and which will attract and avoid chaotic behaviour of the project system | 62 |
| | Non-equilibrium | The various 'pulls' (contractual, behavioural, stakeholder influences, company politics, and management pressures, to mention but a few) that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment | 60 |
| | Non-linear | Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behaviour. | 59 |
| | Attractors | Simple systems (individuals) come together and many times self-organise to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. So we have individuals, that could easily not be the line managers, who because of their capabilities, abilities, behavioural attributes are assigned to be 'attractors' is a certain situation arises. | 65 |
| Developmental | Co-evolution | The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment, which is self-evident in the Project Management world | 59 |
| | Self-modification | Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle | 55 |
| | Self-reproduction | The structure is set up to be the same throughout the project - cloned/copied, despite the fact that different teams may require different organisational structure. Similarly the Mngt style is copied / imposed throughout. | 45 |
| | Downward Causation | The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. | 55 |
| | Mutability | It is typical of random mutations to occur in Projects. Project Management has to identify and manage them | 42 |
| | Non-uniform | The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped. | 57 |

| | Characteristics | Description Relevant to Construction | Overall Aver/ge Achieved Mngt (in %) |
|---|---|---|---|
| Developmental | Emergence | This again is the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project | **63** |
| | Phase changes | As far as the individual is concerned this characteristic highlights the importance of feedback processes for their career development. These phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' 'properties' attributes. These could either be the standard phase changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property. | **55** |
| Behavioural | Unpredictability | This represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on the projects (*see also pathogens and incubation period, IJPM ref. needed here*). | **47** |
| | Non-standard | Each system that comes to the project will self-organise dynamically with the other project systems and change from its initial homogeneous status. | **69** |
| | Undefined values | Identifying the system's/project's interfaces with the environment as the external stakeholders (re. W. Hughes 11 external factors see CME paper & my further thoughts on this subject) this characteristic identifies the need for the evolution of the interfaces as the project progress. The complexity characteristic confirms the need for specifying the interfaces and the evolution of appropriate strategies. It represents the effect of the Undefined values on the system/project | **60** |

For quick referencing reasons table AP.D-7.66 below provides an overview of the graphs included in the following pages and which afford the detailed responses on Complexity Characteristics questions listed in tabular reports above.

Table AP.D-7.66 Table of contents of the graphs created from the interview information and included in the following pages

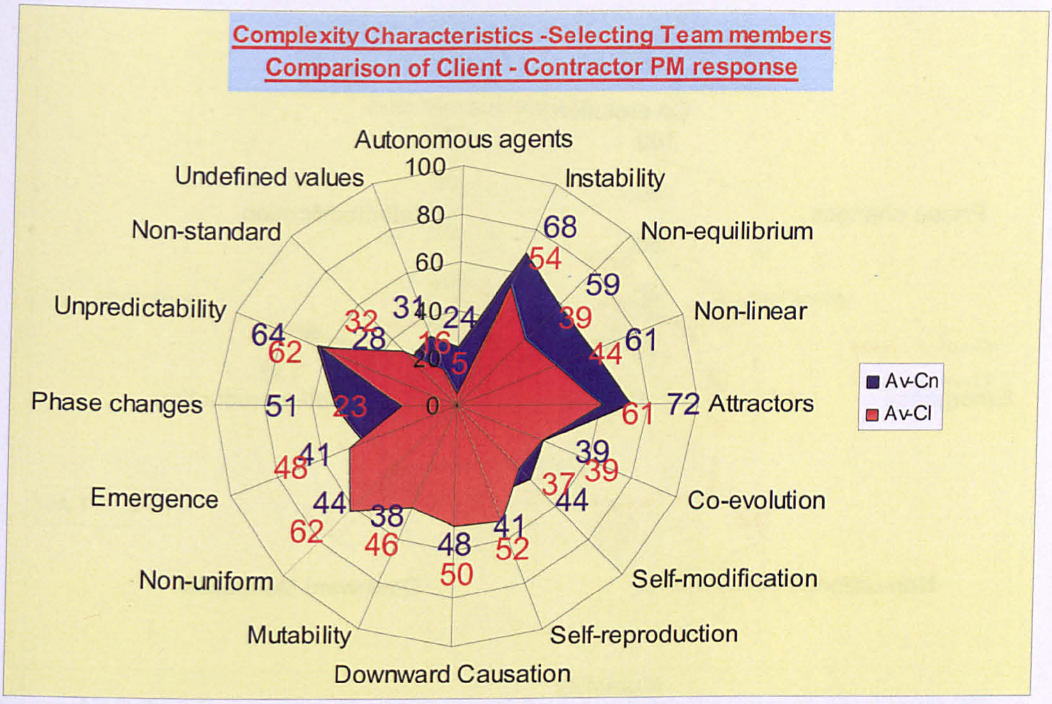



Figure AP.D-7.12 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of complexity characteristics when Selecting Team members (see data in tables AP.D-7.62.1 and AP.D-7.62.2)

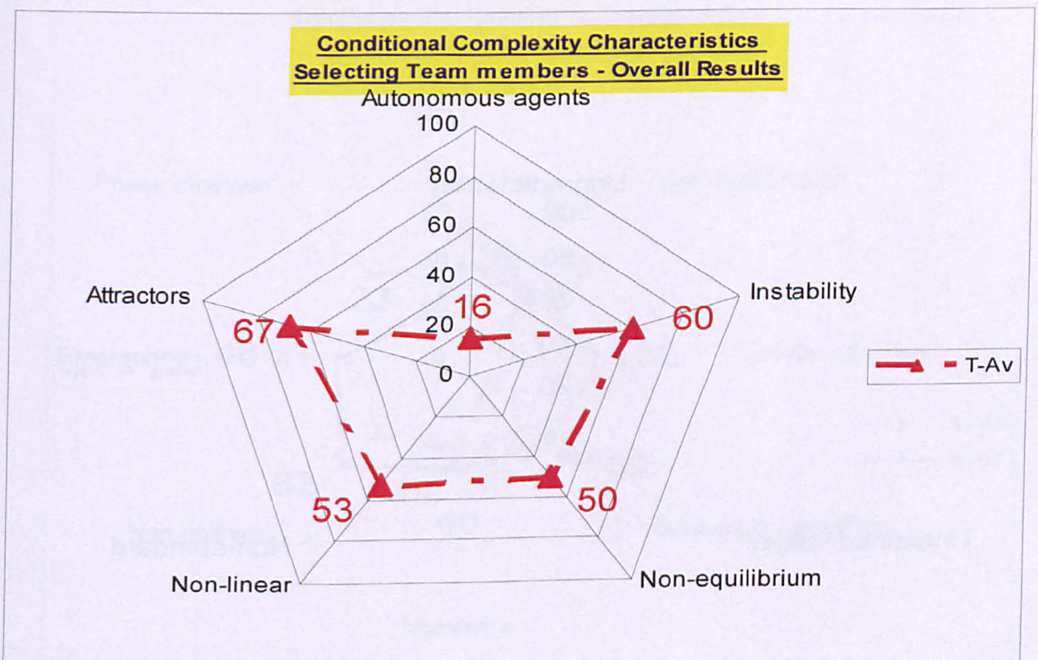



Figure AP.D-7.13 Overall results for current level of PM actions for managing the effect of conditional complexity characteristics when Selecting Team members (see data in table AP.D-7.62.3)

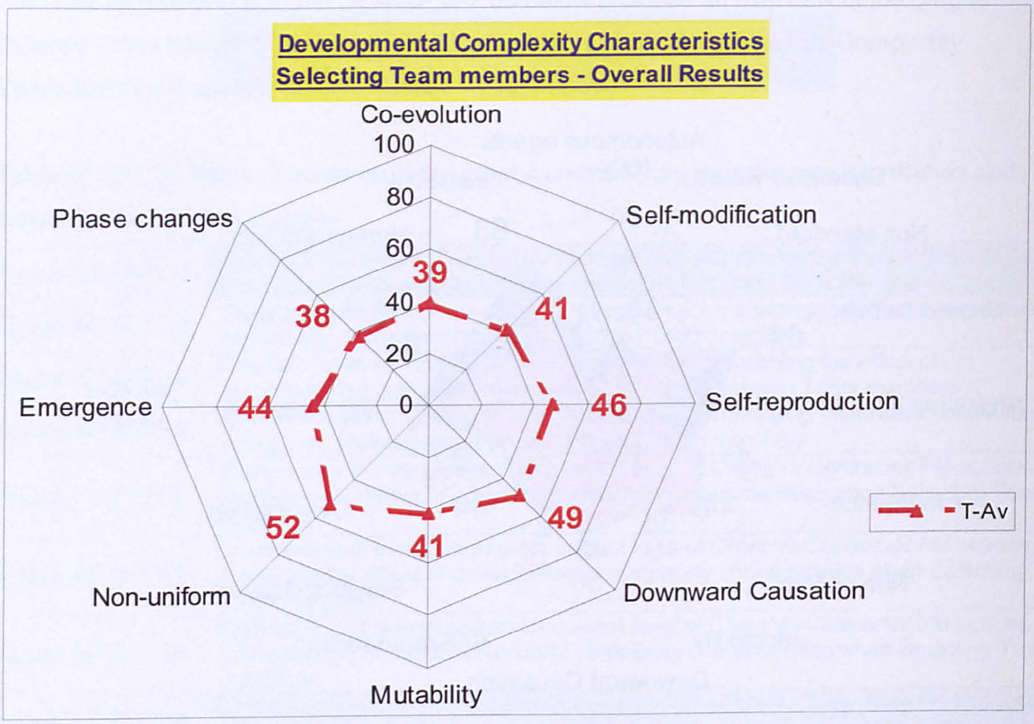



Figure AP.D-7.14 Overall results for current level of PM actions for managing the effect of developmental complexity characteristics when Selecting Team members (see data in table AP.D-7.62.3)

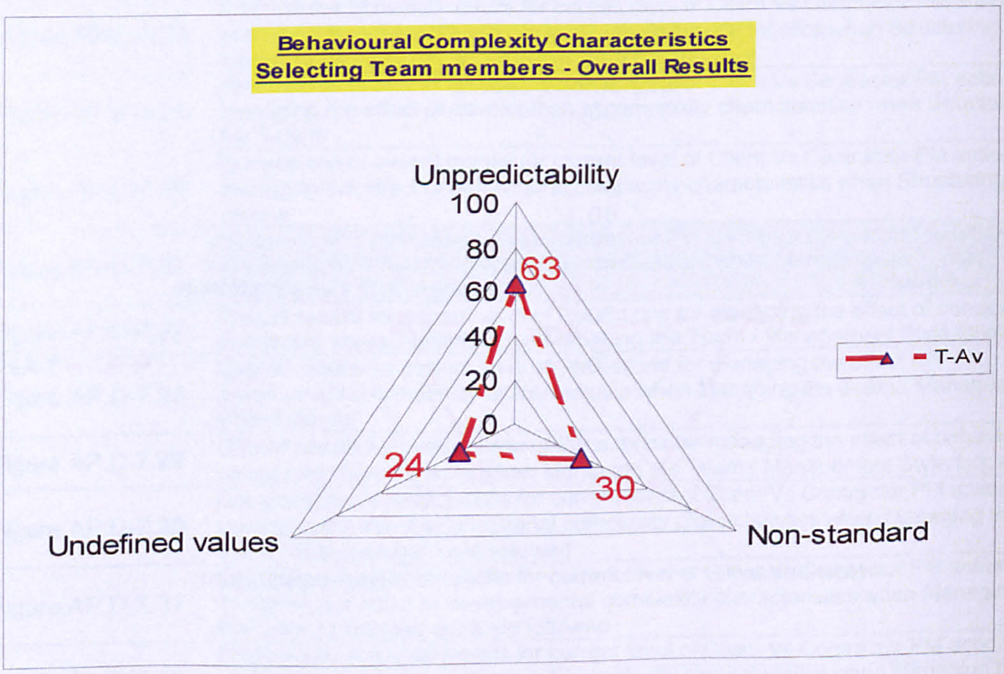



Figure AP.D-7.15 Overall results for current level of PM actions for managing the effect of behavioural complexity characteristics when Selecting Team members (see data in table AP.D-7.62.3)

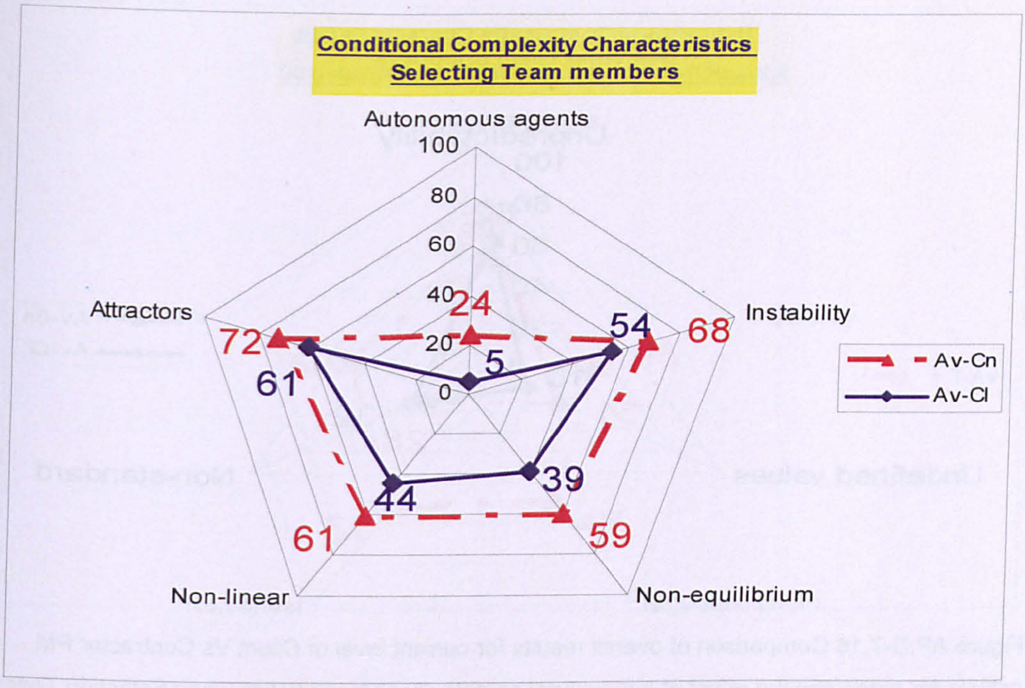



Figure AP.D-7.16 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of conditional complexity characteristics when Selecting Team members (see data in tables AP.D-7.62.1 and AP.D-7.62.2)

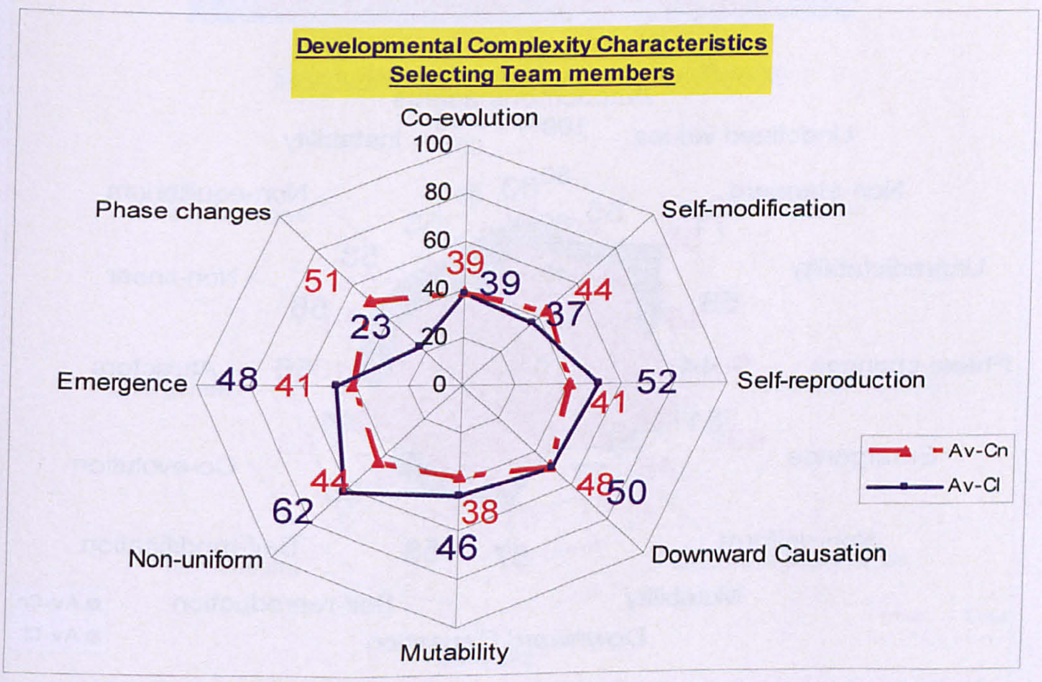



Figure AP.D-7.17 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of developmental complexity characteristics when Selecting Team members (see data in tables AP.D-7.62.1 and AP.D-7.62.2)

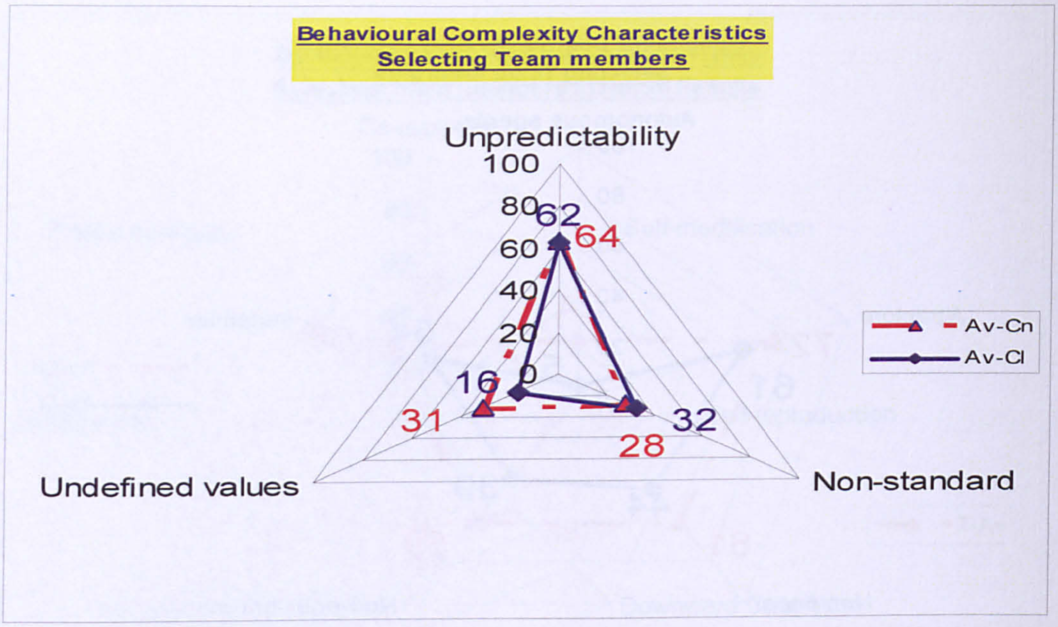



Figure AP.D-7.18 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of behavioural complexity characteristics when Selecting Team members (see data in tables AP.D-7.62.1 and AP.D-7.62.2)

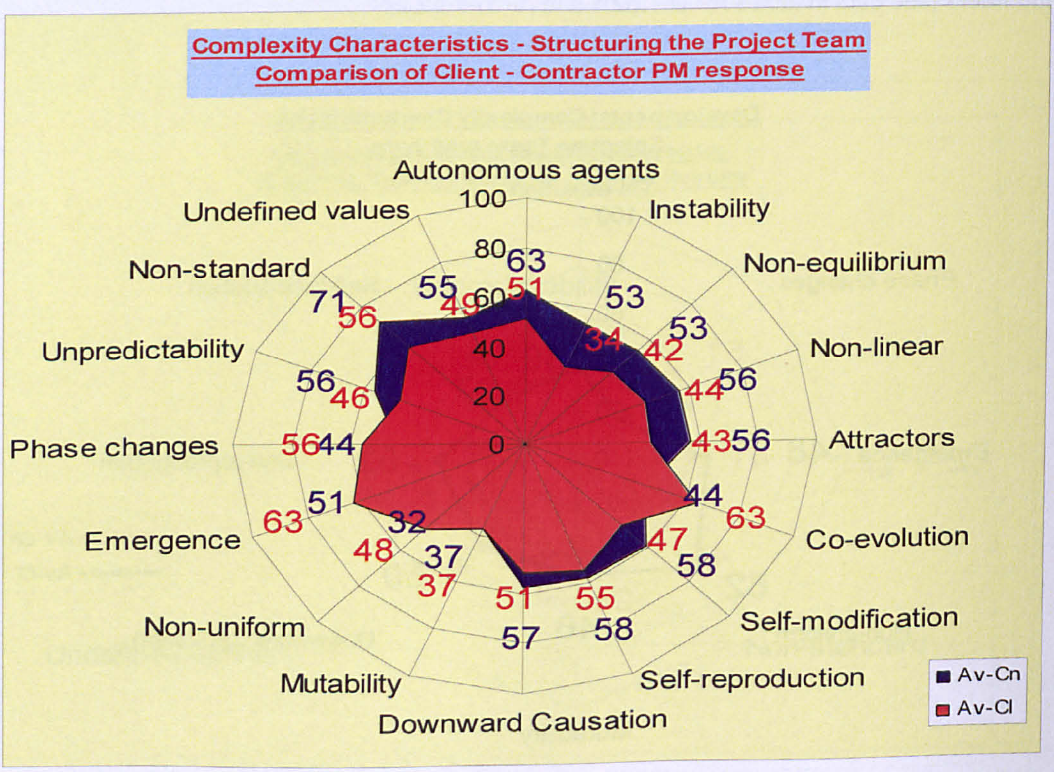



Figure AP.D-7.19 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of complexity characteristics when Structuring the Teams (see data in tables AP.D-7.63.1 and AP.D-7.63.2)

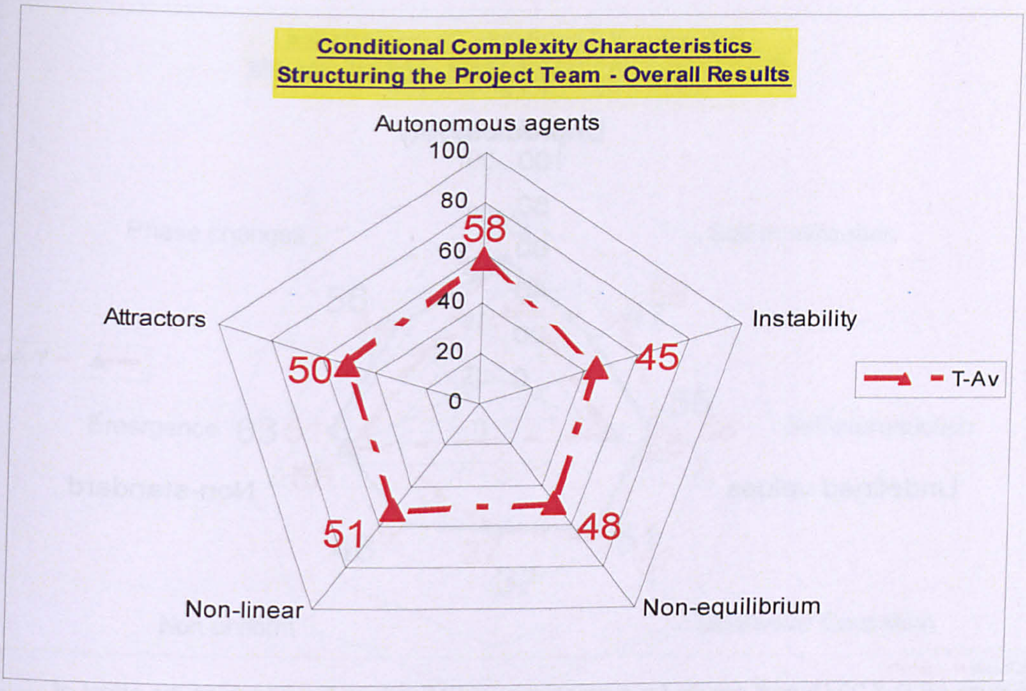



Figure AP.D-7.20 Overall results for current level of PM actions for managing the effect of conditional complexity characteristics when Structuring the Teams (see data in table AP.D-7.63.3)

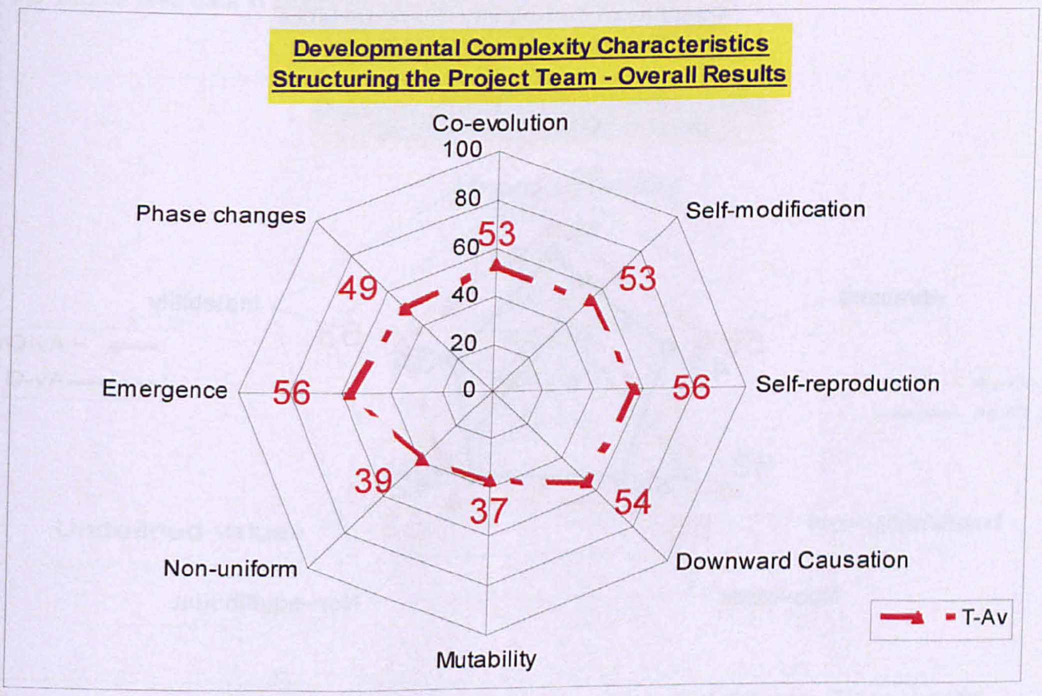



Figure AP.D-7.21 Overall results for current level of PM actions for managing the effect of developmental complexity characteristics when Structuring the Teams (see data in table AP.D-7.63.3)

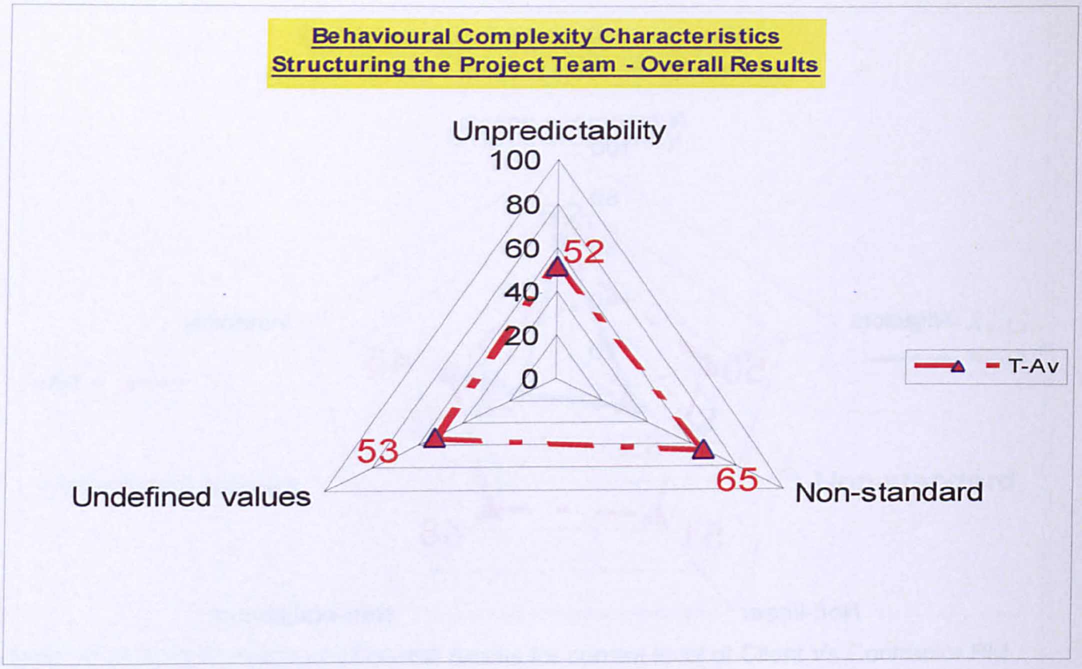



Figure AP.D-7.22 Overall results for current level of PM actions for managing the effect of behavioural complexity characteristics when Structuring the Teams (see data in table AP.D-7.63.3)

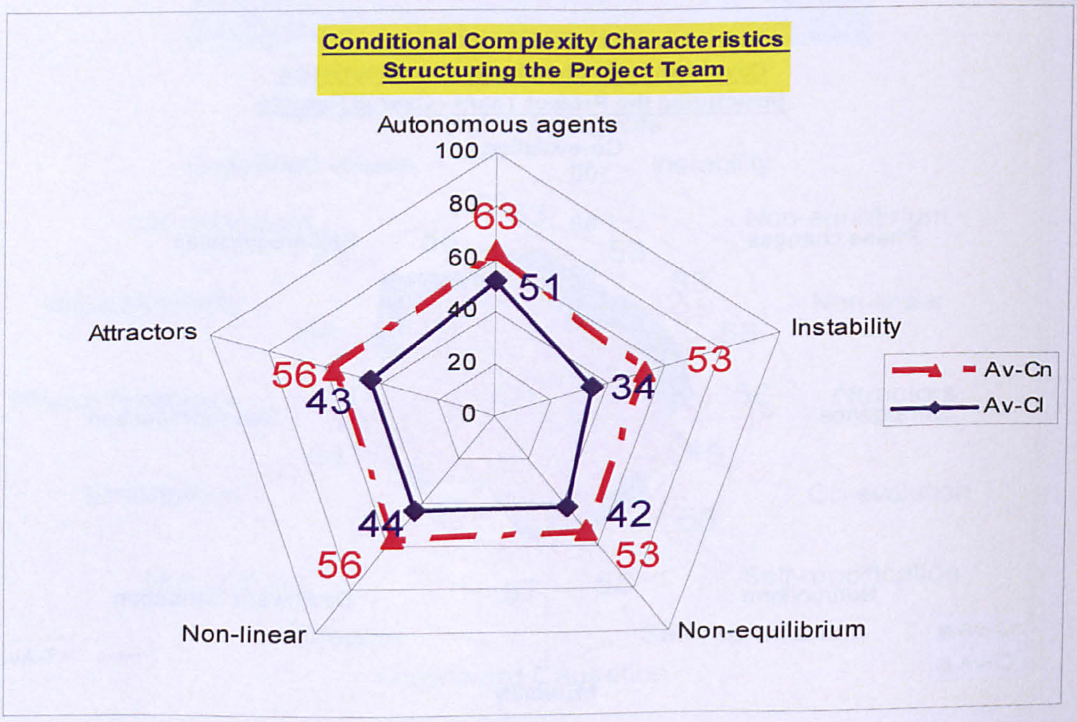



Figure AP.D-7.23 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of conditional complexity characteristics when Structuring the Teams (see data in tables AP.D-7.63.1 and AP.D-7.63.2)

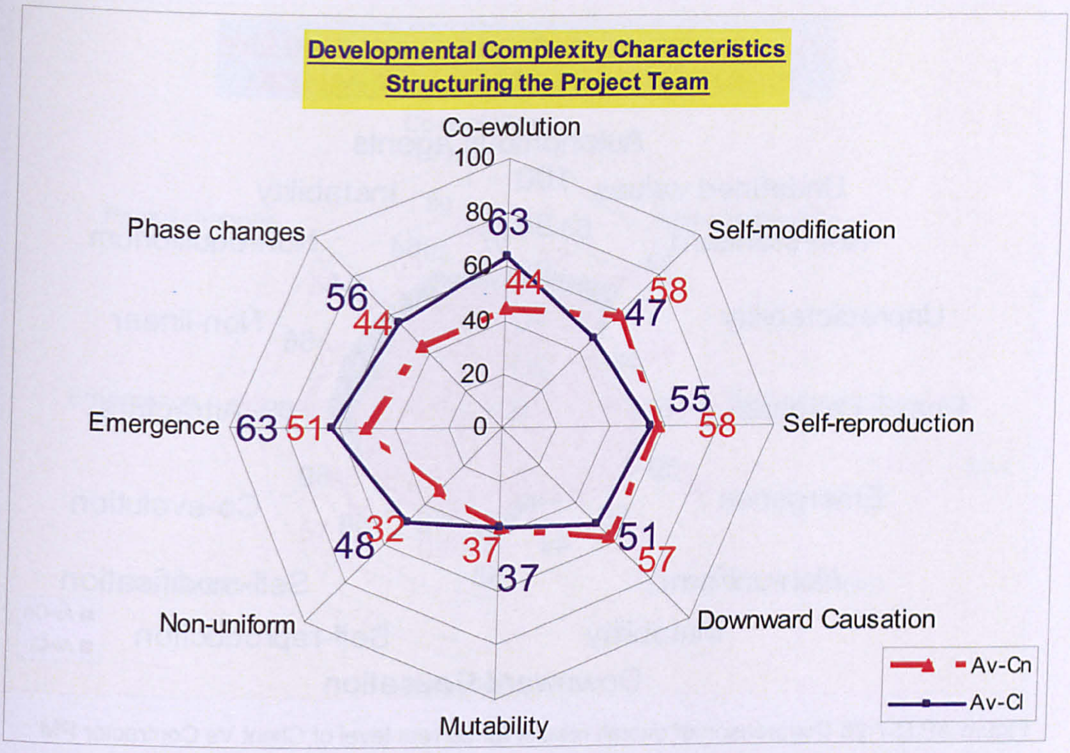



Figure AP.D-7.24 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of developmental complexity characteristics when Structuring the Teams (see data in tables AP.D-7.63.1 and AP.D-7.63.2)

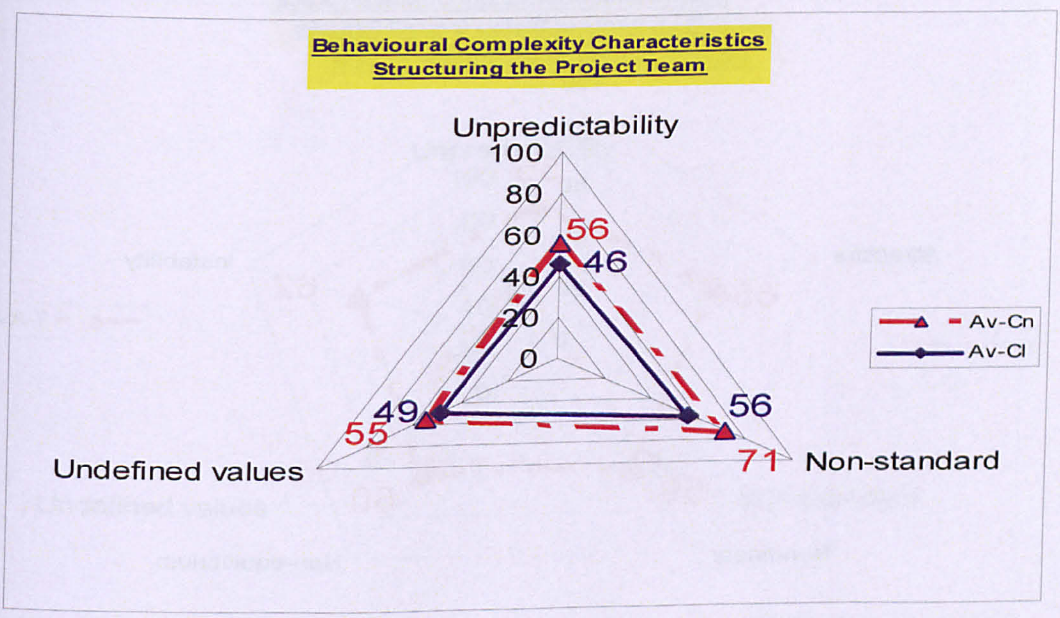



Figure AP.D-7.25 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of behavioural complexity characteristics when Structuring the Teams (see data in tables AP.D-7.63.1 and AP.D-7.63.2)

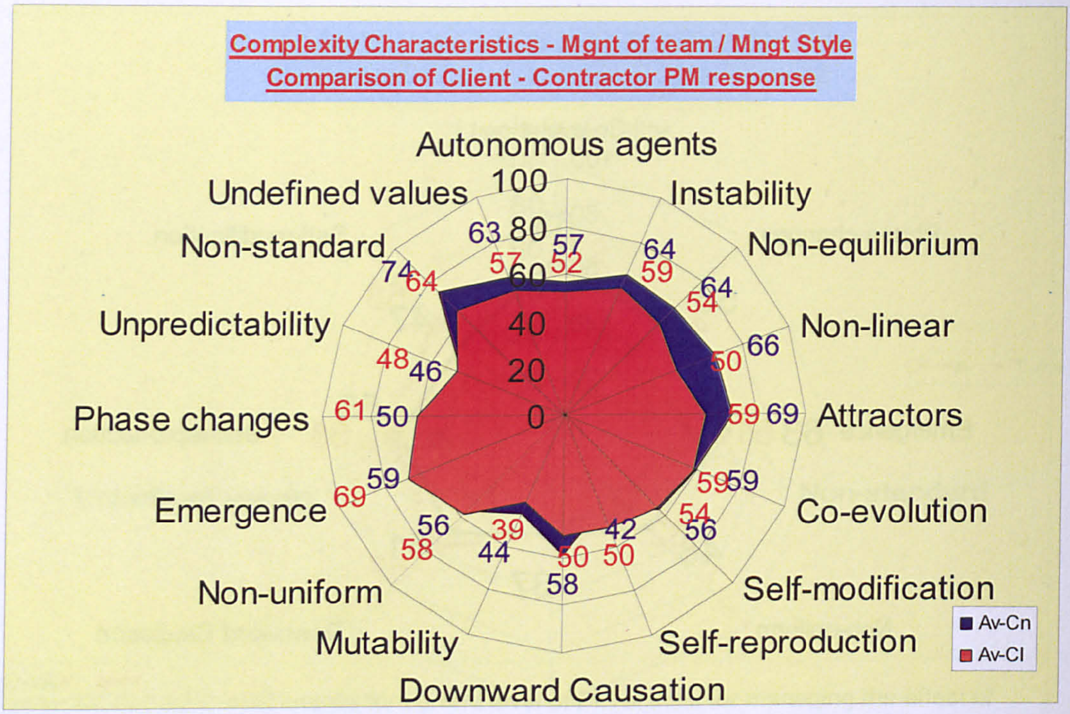



Figure AP.D-7.26 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of complexity characteristics when Managing the Team / Management Style followed (see data in tables AP.D-7.64.1 and AP.D-7.64.2)

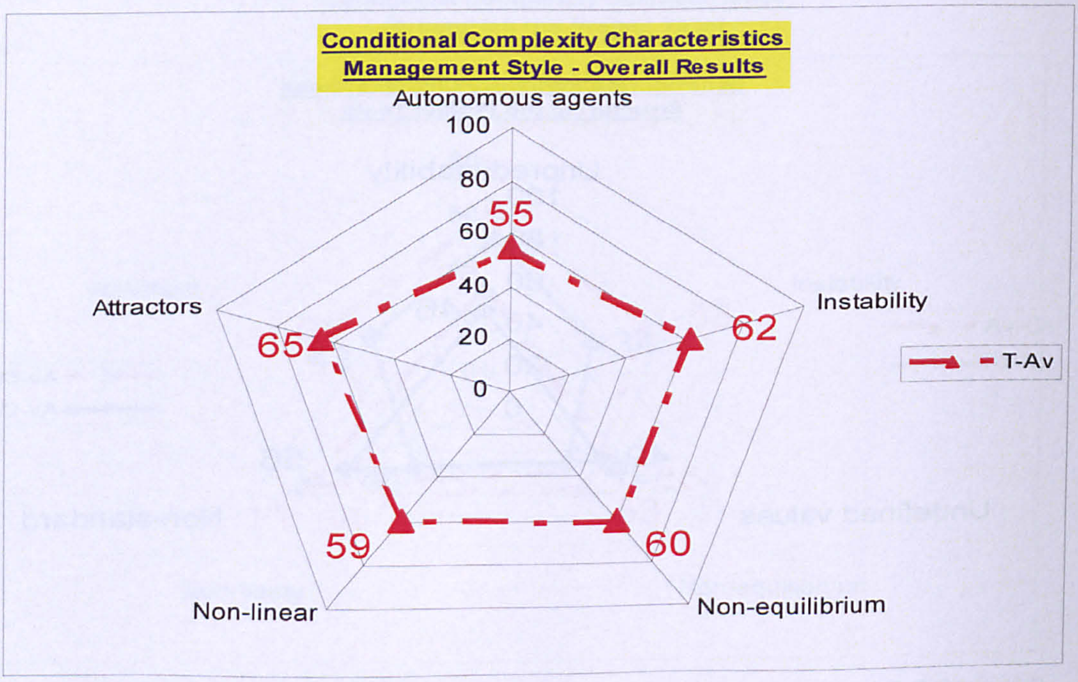



Figure AP.D-7.27 Overall results for current level of PM actions for managing the effect of conditional complexity characteristics when Managing the Team / Management Style followed (see data in table AP.D-7.64.3)

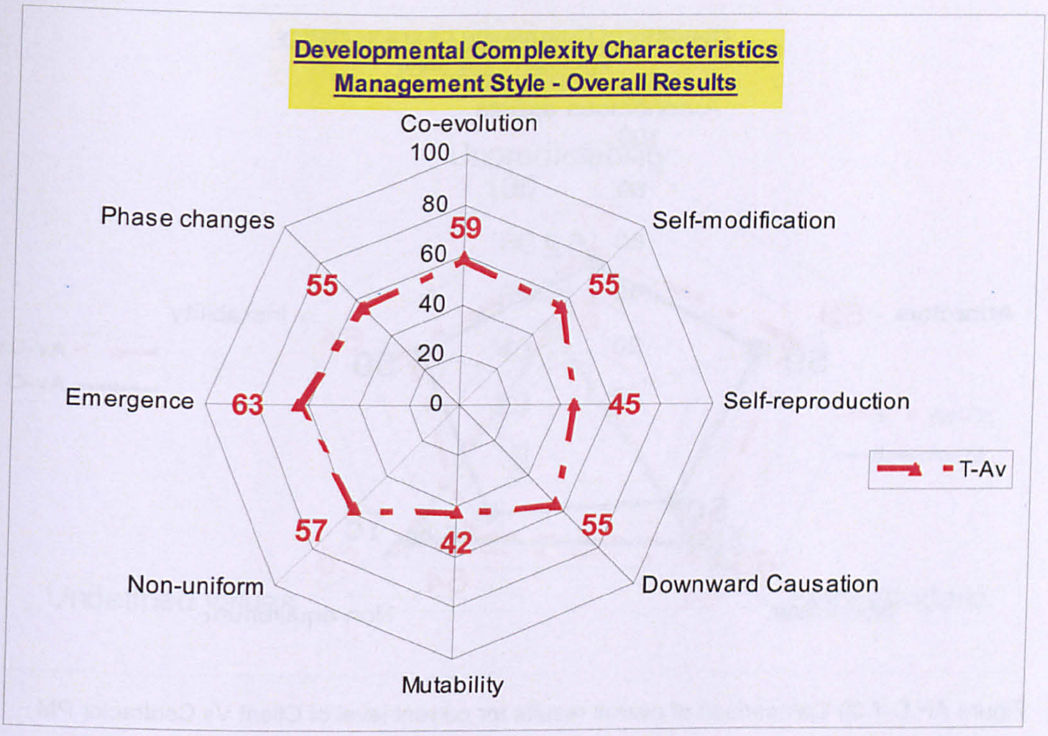



Figure AP.D-7.28 Overall results for current level of PM actions for managing the effect of developmental complexity characteristics when Managing the Team / Management Style followed (see data in table AP.D-7.64.3)

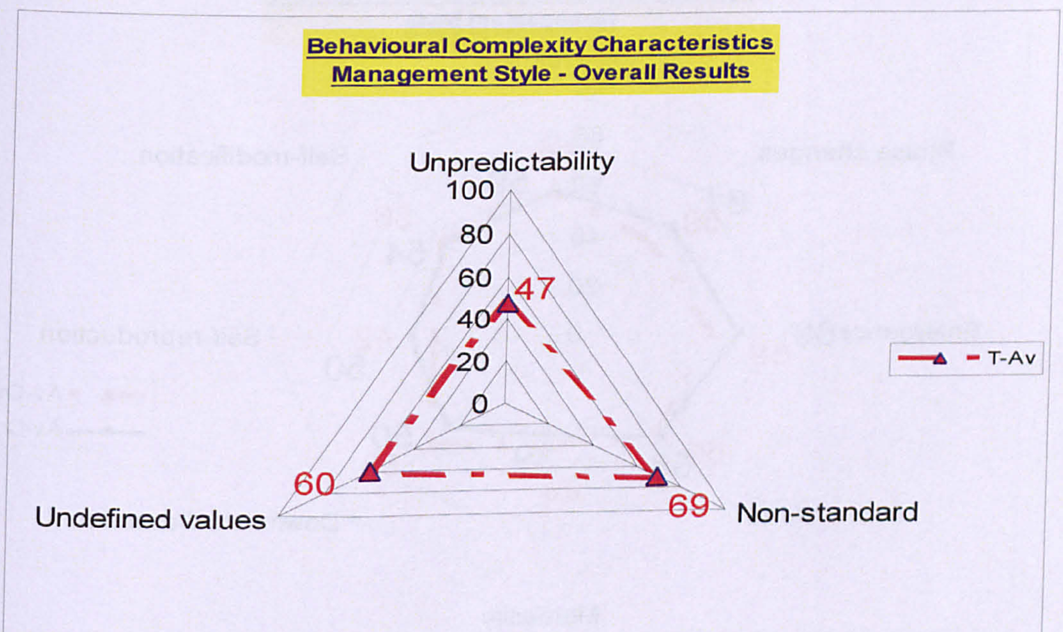



Figure AP.D-7.29 Overall results for current level of PM actions for managing the effect of behavioural complexity characteristics when Managing the Team / Management Style followed (see data in table AP.D-7.64.3)

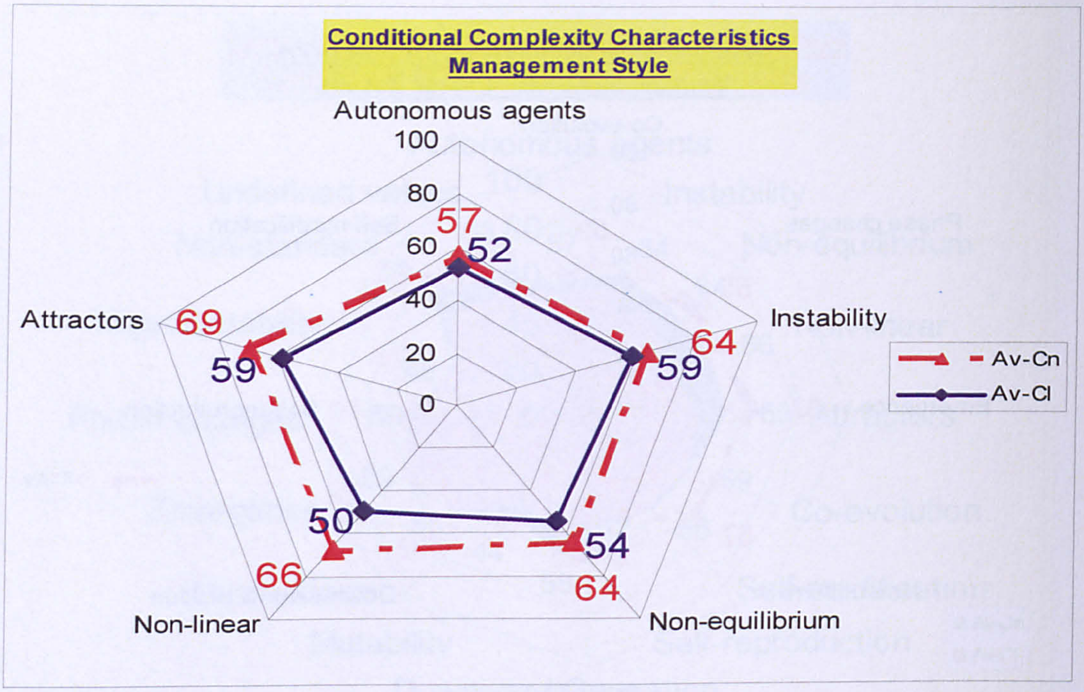



Figure AP.D-7.30 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of conditional complexity characteristics when Managing the Team / Management Style followed (see data in tables AP.D-7.64.1 and AP.D-7.64.2)

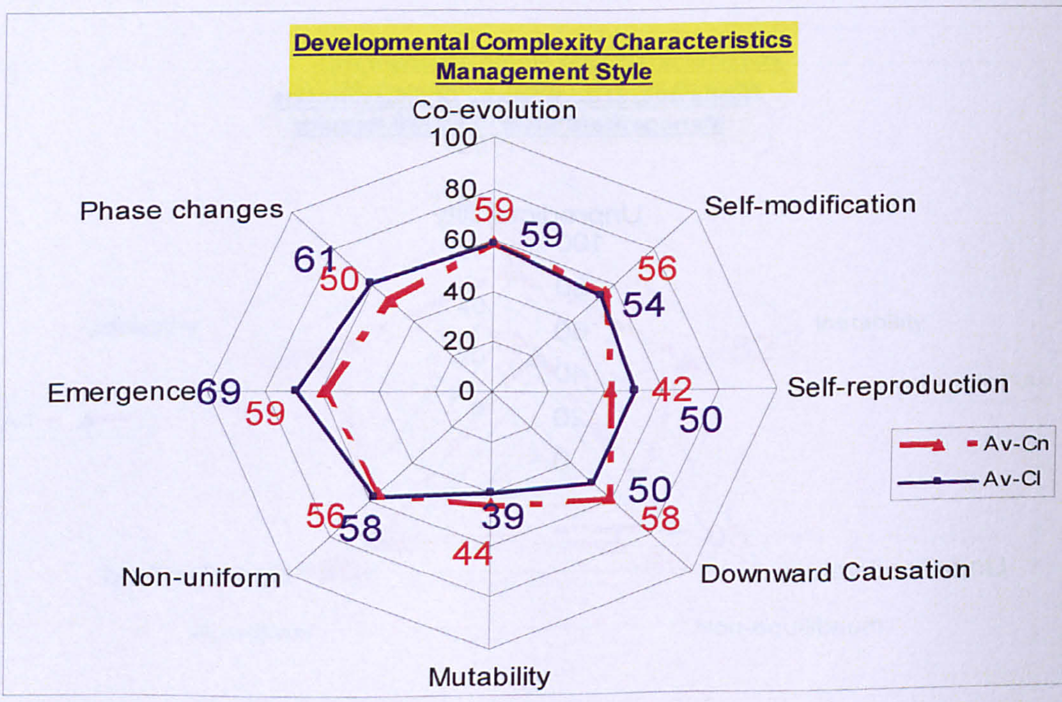



Figure AP.D-7.31Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of developmental complexity characteristics when Managing the Team / Management Style followed (see data in tables AP.D-7.64.1 and AP.D-7.64.2)

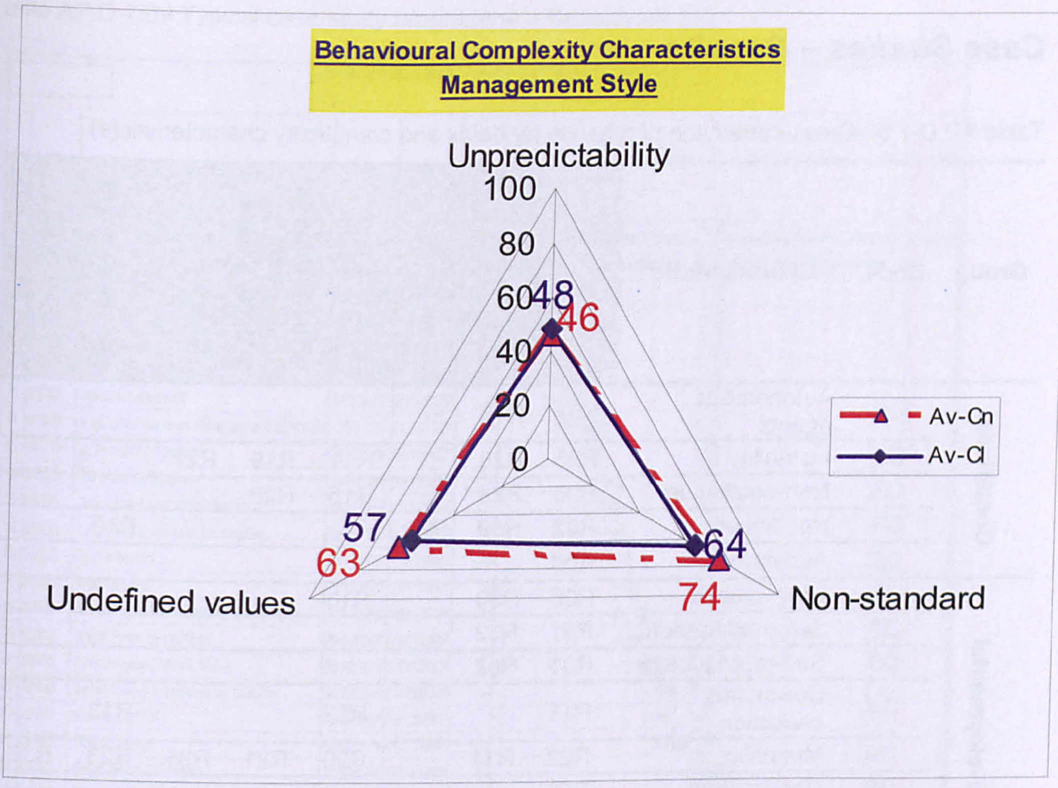



Figure AP.D-7.32 Comparison of overall results for current level of Client Vs Contractor PM actions for managing the effect of behavioural complexity characteristics when Managing the Team / Management Style followed (see data in tables AP.D-7.64.1 and AP.D-7.64.2)

Table AP.D-7.68 Cross-correlation of reasons for delay and complexity characteristic(s)

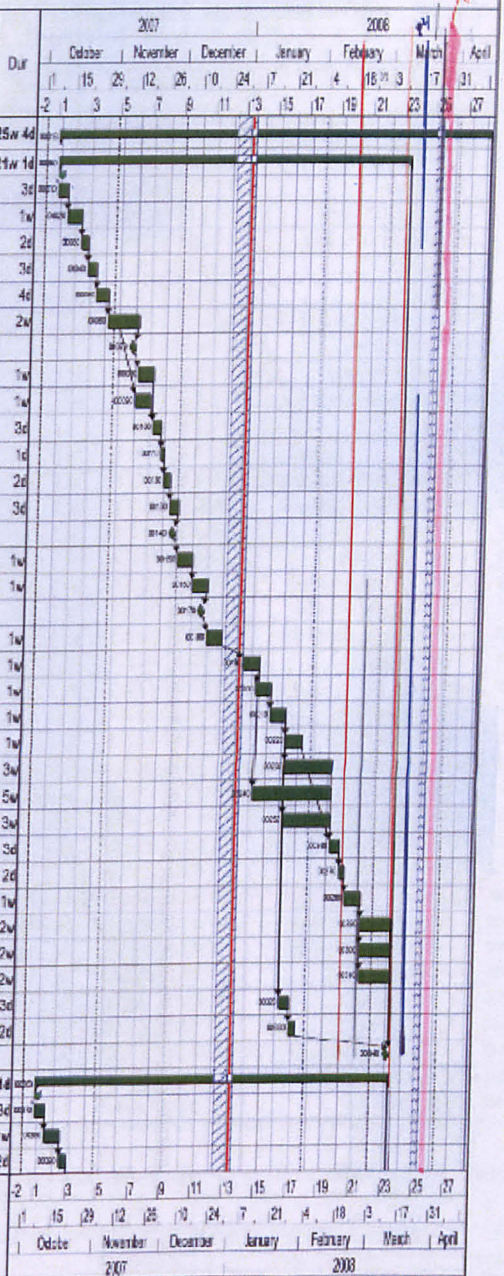
| Group | Code | Characteristic | Selecting the Team Delay Codes | | | Structuring the Team Delay Codes | | | Management of Team Delay Codes | |
|---|---|---|---|---|---|---|---|---|---|---|
| Conditional | C1 | Autonomous agents | R07 | R18 | | | | | | |
| | C2 | Instability | R25 | R26 | | R17 | R19 | R27 | | |
| | C3 | Non-equilibrium | R08 | R28 | | R18 | R28 | | | |
| | C4 | Non-linear | R02 | R09 | R29 | | | | R10 | |
| | C5 | Attractors | R08 | | | | | | | |
| Developmental | D1 | Co-evolution | R06 | R30 | | R16 | | | | |
| | D2 | Self-modification | R31 | R32 | | | | | | |
| | D3 | Self-reproduction | R01 | R02 | | | | | | |
| | D4 | Downward causation | R11 | | | R12 | | | R13 | |
| | D5 | Mutability | R22 | R34 | | R20 | R21 | R35 | R23 | R33 |
| | D6 | Non-uniform | R36 | | | | | | | |
| | D7 | Emergence | R03 | | | | | | | |
| | D8 | Phase changes | R24 | R37 | | R38 | | | R38 | R39 |
| Behavioural | B1 | Unpredictability | R14 | R15 | | | | | | |
| | B2 | Non-standard | R40 | | | R41 | | | R42 | |
| | B3 | Undefined values | R04 | | | R05 | | | | |

Descriptions of reasons for delay can be seen in Appendix C-3.5.

Table AP.D-7.69 Typical case study programme – Case Study G2.1

60 Brompton Road Apartment Target Programme

| Line | Act Num | Activity | Start | End | Dur |
|---|---|---|---|---|---|
| 1 | 00013 | **Apartment Fit Out Sequence** | 05/10/2007 | 14/04/2008 | 25w 4d |
| 2 | 00360 | **Apartment 2.1** | 05/10/2007 | 10/03/2008 | 21w 1d |
| 3 | 00010 | Install Acoustic Ceiling Metalwork | 06/10/2007 | 09/10/2007 | 3d |
| 4 | 00020 | Install High Level Acoustic Ceiling | 10/10/2007 | 16/10/2007 | 1w |
| 5 | 00030 | Mark Out BWIC / Chases | 17/10/2007 | 18/10/2007 | 2d |
| 6 | 00040 | Chase Walls inc BWIC | 19/10/2007 | 23/10/2007 | 3d |
| 7 | 00050 | Install Containment | 24/10/2007 | 29/10/2007 | 4d |
| 8 | 00060 | High Level Services - Mechanical & Electrical | 30/10/2007 | 12/11/2007 | 2w |
| 9 | 00070 | LDR / RPP Inspection | 09/11/2007 | 09/11/2007 | |
| 10 | 00080 | De Snag HL Services | 13/11/2007 | 19/11/2007 | 1w |
| 11 | 00090 | Install Low Level HDPE Wastes | 12/11/2007 | 16/11/2007 | 1w |
| 12 | 00100 | Low Level Services in U/F Heating | 20/11/2007 | 22/11/2007 | 3d |
| 13 | 00110 | Test Pipework | 23/11/2007 | 23/11/2007 | 1d |
| 14 | 00120 | Floor Screed | 26/11/2007 | 27/11/2007 | 2d |
| 15 | 00130 | Floor tiling to Bathrooms, Kitchen & Halls | 28/11/2007 | 30/11/2007 | 3d |
| 16 | 00140 | Install Protection to Floor | 29/11/2007 | 29/11/2007 | |
| 17 | 00150 | Fire Stopping / MG HL Holes | 03/12/2007 | 07/12/2007 | 1w |
| 18 | 00160 | Install Ceiling Framework inc Cornice | 10/12/2007 | 14/12/2007 | 1w |
| 19 | 00170 | Ceiling Sign Off | 13/12/2007 | 13/12/2007 | |
| 20 | 00180 | Board Ceilings | 17/12/2007 | 21/12/2007 | 1w |
| 21 | 00190 | Skim Ceiling & Columns | 02/01/2008 | 08/01/2008 | 1w |
| 22 | 00200 | Internal Walls Making Good | 08/01/2008 | 14/01/2008 | 1w |
| 23 | 00210 | Raised flooring | 15/01/2008 | 21/01/2008 | 1w |
| 24 | 00220 | Perimeter Skirting Heating | 22/01/2008 | 28/01/2008 | 1w |
| 25 | 00230 | AHU / HWC / Manifold Connections | 22/01/2008 | 11/02/2008 | 3w |
| 26 | 00240 | Bathroom Finishes and Fitting Out | 08/01/2008 | 11/02/2008 | 5w |
| 27 | 00250 | Joinery Works inc Wardrobes & Doors | 22/01/2008 | 11/02/2008 | 3w |
| 28 | 00260 | Pre-Final paint snag | 12/02/2008 | 14/02/2008 | 3d |
| 29 | 00270 | Builders clean | 15/02/2008 | 18/02/2008 | 2d |
| 30 | 00280 | Final Paint & Decorations | 19/02/2008 | 25/02/2008 | 1w |
| 31 | 00290 | Final Fix Electrical & Grilles | 26/02/2008 | 10/03/2008 | 2w |
| 32 | 00300 | Final snag | 26/02/2008 | 10/03/2008 | 2w |
| 33 | 00310 | Testing & Commissioning | 26/02/2008 | 10/03/2008 | 2w |
| 34 | 00320 | Kitchen Installation - Visit 1 | 22/01/2008 | 24/01/2008 | 3d |
| 35 | 00330 | Kitchen Installation - Visit 2 (Final Visit) | 25/01/2008 | 28/01/2008 | 2d |
| 36 | 00340 | Apartment Locked up | 10/03/2008 | 10/03/2008 | |
| 37 | 00360 | **Apartment 2.2** | 05/10/2007 | 10/03/2008 | 21w 1d |
| 38 | 00370 | Install Acoustic Ceiling Metalwork | 05/10/2007 | 09/10/2007 | 3d |
| 39 | 00380 | Install High Level Acoustic Ceiling | 10/10/2007 | 16/10/2007 | 1w |
| 40 | 00390 | Mark Out BWIC / Chases | 17/10/2007 | 18/10/2007 | 2d |




PROJECT TITLE: 60 Brompton Road Apartment Target Programme
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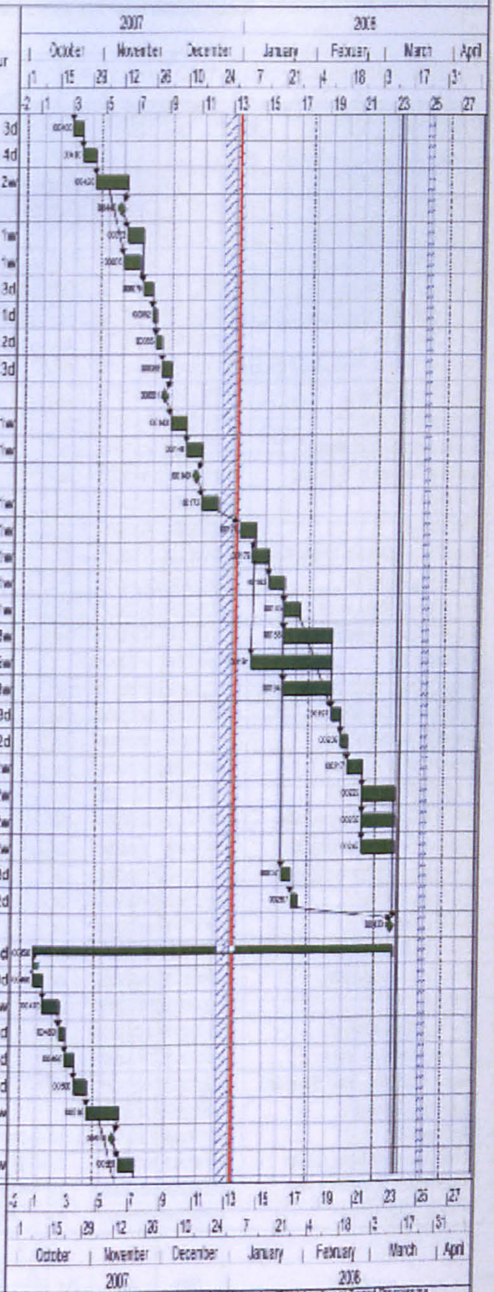
60 Brompton Road Apartment Target Programme

| Line | Act Num | Activity | Start | End | Dur |
|---|---|---|---|---|---|
| 41 | 00400 | Chase Walls inc BWIC | 19/10/2007 | 23/10/2007 | 3d |
| 42 | 00410 | Install Containment | 24/10/2007 | 29/10/2007 | 4d |
| 43 | 00420 | High Level Services - Mechanical & Electrical | 30/10/2007 | 12/11/2007 | 2w |
| 44 | 00440 | LOR / RPP Inspection | 09/11/2007 | 09/11/2007 | |
| 45 | 00073 | De Snag HL Services | 13/11/2007 | 19/11/2007 | 1w |
| 46 | 00076 | Install Low Level HDPE Wastes | 12/11/2007 | 16/11/2007 | 1w |
| 47 | 00079 | Low Level Services in U/F Heating | 20/11/2007 | 22/11/2007 | 3d |
| 48 | 00082 | Test Pipework | 23/11/2007 | 23/11/2007 | 1d |
| 49 | 00085 | Floor Screed | 26/11/2007 | 27/11/2007 | 2d |
| 50 | 00088 | Floor tiling to Bathrooms, Kitchen & Halls | 26/11/2007 | 30/11/2007 | 3d |
| 51 | 00091 | Install Protection to Floor | 29/11/2007 | 29/11/2007 | |
| 52 | 00143 | Fire Stopping / M/G HL Holes | 03/12/2007 | 07/12/2007 | 1w |
| 53 | 00146 | Install Ceiling Framework inc Cornice | 10/12/2007 | 14/12/2007 | 1w |
| 54 | 00149 | Ceiling Sign Off | 13/12/2007 | 13/12/2007 | |
| 55 | 00173 | Board Ceilings | 17/12/2007 | 21/12/2007 | 1w |
| 56 | 00176 | Skim Ceiling & Columns | 02/01/2008 | 08/01/2008 | 1w |
| 57 | 00179 | Internal Walls Making Good | 08/01/2008 | 14/01/2008 | 1w |
| 58 | 00182 | Raised flooring | 15/01/2008 | 21/01/2008 | 1w |
| 59 | 00185 | Perimeter Skirting Heating | 22/01/2008 | 28/01/2008 | 1w |
| 60 | 00188 | AHU / HWC / Manifold Connections | 22/01/2008 | 11/02/2008 | 3w |
| 61 | 00191 | Bathroom Finishes and Fitting Out | 08/01/2008 | 11/02/2008 | 5w |
| 62 | 00194 | Joinery Works inc Wardrobes & Doors | 22/01/2008 | 11/02/2008 | 3w |
| 63 | 00197 | Pre-Final paint snag | 12/02/2008 | 14/02/2008 | 3d |
| 64 | 00207 | Builders clean | 15/02/2008 | 18/02/2008 | 2d |
| 65 | 00217 | Final Paint & Decorations | 19/02/2008 | 25/02/2008 | 1w |
| 66 | 00227 | Final Fix Electrical & Grilles | 26/02/2008 | 10/03/2008 | 2w |
| 67 | 00237 | Final snag | 26/02/2008 | 10/03/2008 | 2w |
| 68 | 00247 | Testing & Commissioning | 26/02/2008 | 10/03/2008 | 2w |
| 69 | 00257 | Kitchen Installation - Visit 1 | 22/01/2008 | 24/01/2008 | 3d |
| 70 | 00267 | Kitchen Installation - Visit 2 (Final Visit) | 25/01/2008 | 28/01/2008 | 2d |
| 71 | 00430 | Apartment Locked up | 10/03/2008 | 10/03/2008 | |
| 72 | 00450 | **Apartment 3.1** | **05/10/2007** | **10/03/2008** | **21w 1d** |
| 73 | 00460 | Install Acoustic Ceiling Metalwork | 05/10/2007 | 09/10/2007 | 3d |
| 74 | 00470 | Install High Level Acoustic Ceiling | 10/10/2007 | 16/10/2007 | 1w |
| 75 | 00480 | Mark Out BWIC / Chases | 17/10/2007 | 18/10/2007 | 2d |
| 76 | 00490 | Chase Walls inc BWIC | 19/10/2007 | 23/10/2007 | 3d |
| 77 | 00500 | Install Containment | 24/10/2007 | 29/10/2007 | 4d |
| 78 | 00510 | High Level Services - Mechanical & Electrical | 30/10/2007 | 12/11/2007 | 2w |
| 79 | 00513 | LOR / RPP Inspection | 09/11/2007 | 09/11/2007 | |
| 80 | 00520 | De Snag HL Services | 13/11/2007 | 19/11/2007 | 1w |

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|---|---|---|---|
| PROJECT TITLE | 60 Brompton Road Apartment Target Programme | | |
| PROGRAMME TITLE | | | |
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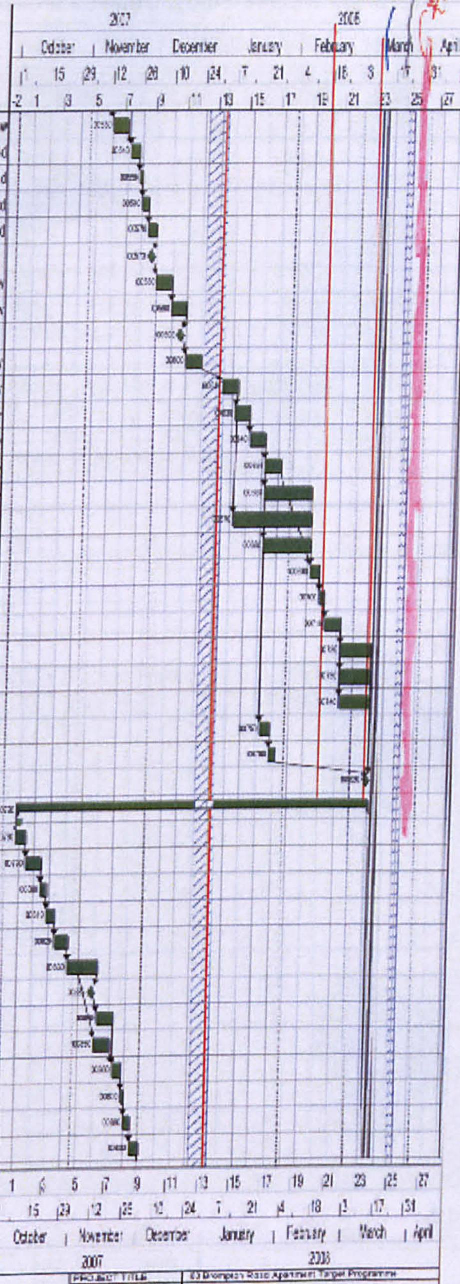
60 Brompton Road Apartment Target Programme

| Line | Act Num | Activity | Start | End | Dur |
|---|---|---|---|---|---|
| 81 | 00530 | Install Low Level HDPE Wastes | 12/11/2007 | 16/11/2007 | 1w |
| 82 | 00540 | Low Level Services in U/F Heating | 20/11/2007 | 22/11/2007 | 3d |
| 83 | 00550 | Test Pipework | 23/11/2007 | 23/11/2007 | 1d |
| 84 | 00560 | Floor Screed | 26/11/2007 | 27/11/2007 | 2d |
| 85 | 00570 | Floor tiling to Bathrooms, Kitchen & Halls | 28/11/2007 | 30/11/2007 | 3d |
| 86 | 00573 | Install Protection to Floor | 29/11/2007 | 29/11/2007 | |
| 87 | 00580 | Fire Stopping / MG HL Holes | 03/12/2007 | 07/12/2007 | 1w |
| 88 | 00590 | Install Ceiling Framework inc Cornice | 10/12/2007 | 14/12/2007 | 1w |
| 89 | 00593 | Ceiling Sign Off | 13/12/2007 | 13/12/2007 | |
| 90 | 00600 | Board Ceilings | 17/12/2007 | 21/12/2007 | 1w |
| 91 | 00610 | Skim Ceiling & Columns | 03/01/2008 | 08/01/2008 | 1w |
| 92 | 00630 | Internal Walls Making Good | 08/01/2008 | 14/01/2008 | 1w |
| 93 | 00640 | Raised flooring | 15/01/2008 | 21/01/2008 | 1w |
| 94 | 00650 | Perimeter Skirting Heating | 22/01/2008 | 25/01/2008 | 1w |
| 95 | 00660 | AHU / HWC / Manifold Connections | 22/01/2008 | 11/02/2008 | 3w |
| 96 | 00670 | Bathroom Finishes and Fitting Out | 08/01/2008 | 11/02/2008 | 5w |
| 97 | 00680 | Joinery Works inc Wardrobes & Doors | 22/01/2008 | 11/02/2008 | 3w |
| 98 | 00690 | Pre-Final paint snag | 12/02/2008 | 14/02/2008 | 3d |
| 99 | 00700 | Builders clean | 15/02/2008 | 18/02/2008 | 2d |
| 100 | 00710 | Final Paint & Decorations | 19/02/2008 | 25/02/2008 | 1w |
| 101 | 00720 | Final Fix Electrical & Grilles | 26/02/2008 | 10/03/2008 | 2w |
| 102 | 00730 | Final snag | 26/02/2008 | 10/03/2008 | 2w |
| 103 | 00740 | Testing & Commissioning | 26/02/2008 | 10/03/2008 | 2w |
| 104 | 00750 | Kitchen Installation - Visit 1 | 22/01/2008 | 24/01/2008 | 3d |
| 105 | 00760 | Kitchen Installation - Visit 2 (Final Visit) | 25/01/2008 | 28/01/2008 | 2d |
| 106 | 00620 | Apartment Locked up | 10/03/2008 | 10/03/2008 | |
| 107 | **00770** | **Apartment 3.2** | **05/10/2007** | **10/03/2008** | **21w 1d** |
| 108 | 00780 | Install Acoustic Ceiling Metalwork | 05/10/2007 | 09/10/2007 | 3d |
| 109 | 00790 | Install High Level Acoustic Ceiling | 10/10/2007 | 16/10/2007 | 1w |
| 110 | 00800 | Mark Out BWIC / Chases | 17/10/2007 | 18/10/2007 | 2d |
| 111 | 00610 | Chase Walls inc BWIC | 19/10/2007 | 23/10/2007 | 3d |
| 112 | 00620 | Install Containment | 24/10/2007 | 29/10/2007 | 4d |
| 113 | 00630 | High Level Services - Mechanical & Electrical | 30/10/2007 | 12/11/2007 | 2w |
| 114 | 00633 | LDR / RPP Inspection | 09/11/2007 | 09/11/2007 | |
| 115 | 00840 | De Snag HL Services | 13/11/2007 | 19/11/2007 | 1w |
| 116 | 00850 | Install Low Level HDPE Wastes | 12/11/2007 | 16/11/2007 | 1w |
| 117 | 00860 | Low Level Services in U/F Heating | 20/11/2007 | 22/11/2007 | 3d |
| 118 | 00870 | Test Pipework | 23/11/2007 | 23/11/2007 | 1d |
| 119 | 00880 | Floor Screed | 26/11/2007 | 27/11/2007 | 2d |
| 120 | 00890 | Floor tiling to Bathrooms, Kitchen & Halls | 28/11/2007 | 30/11/2007 | 3d |




PROJECT TITLE: 60 Brompton Road Apartment Target Programme

PROGRAMME TITLE

PROGRAMME No

REVISION COMMENT

REV

DATE

## Case Study – G1.3

Table AP.D-7.72. G1.3 Case Study. Detailed breakdown of the coded reasons for delay by week and activity

| Activ. | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Coded Reasons for Delay | | | | |
| SW13290 | | R03, R04, R16 | R03, R04, R16 | R03, R04, R16 | R03, R04, R16 | R03, R04, R16 | R03, R04, R16 | R03, R04, R16 | |
| SW13220 | | | | | R04, R06, R11, R16, R18 | R04, R06, R11, R16, R18 | R04, R06, R11, R16, R18 | R04, R06, R11, R16, R18 | |
| SW13240 | | | | | | R04, R16 | R04, R16 | R04, R16 | |
| SW13300 | | | | | | | | | |
| SW13380 | | | | | | | | | |
| SW13430 | | R29, R30 | R29, R30 | R29, R30 | R29, R30 | R29, R30 | | | |
| SW13440 | | | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | |
| SW241030 | | | | | | | | | |
| SW241040 | | | | | | | | | |
| SW241050 | | R04 | | | | | | | |
| SW241060 | | | | | | | | | |
| SW241070 | | | | | | | | | |
| SW241080 | | | | | | | | | |
| SW241090 | | R29, R30 | R04, R29, R30 | R29, R30 | R29, R30 | R29, R30 | | | |
| SW241100 | | | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | R26, R28, R29, R30 | | |
| SW14330 | | | | | | | | | |
| SW14340 | | | | | | | | | |
| SW13270 | | | | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 |
| SW13370 | | | | | | | R04, R16, R26 | R04, R16, R26 | R04, R16, R26 |
| SW13360 | | | | | | | | R04, R16, R26 | R04, R16, R26 |
| SW13390 | | | | | | | | | R04, R27 |
| SW13190 | | | | | | | | | |
| SW13135 | | | | | | | | R04, R16, R26 | R04, R16, R26 |
| SW13165 | | | | | | | | R04, R16, R26 | R04, R16, R26 |
| SW241010 | | | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | | | |
| SW241020 | | | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | R04, R26, R28, R29, R30 | | | |
| SW240970 | | | | | | | | | |

Table AP.D-7.73. Weekly count and frequency of occurrence of coded reasons for delay (as identified by Case Study PM and team)

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| Weekly occurrence of Coded Reasons for Delay | | R03 | R03 | R03 | R03 | R03 | R03 | R03 | | **7** |
| | | R04 | R04 | R04 | R04 | R04 | R04 | R04 | R04 | **8** |
| | | | | | R06 | R06 | R06 | R06 | | **4** |
| | | | | | R11 | R11 | R11 | R11 | | **4** |
| | | R16 | R16 | R16 | R16 | R16 | R16 | R16 | R16 | **8** |
| | | | | | R18 | R18 | R18 | R18 | | **4** |
| | | | R26 | R26 | R26 | R26 | R26 | R26 | R26 | **7** |
| | | | | | | | | | R27 | **1** |
| | | | R28 | R28 | R28 | R28 | R28 | R28 | R28 | **7** |
| | | R29 | R29 | R29 | R29 | R29 | R29 | R29 | R29 | **8** |
| | | R30 | R30 | R30 | R30 | R30 | R30 | R30 | R30 | **8** |
| **Total / week** | **0** | **5** | **7** | **7** | **10** | **10** | **10** | **10** | **7** | **66** |

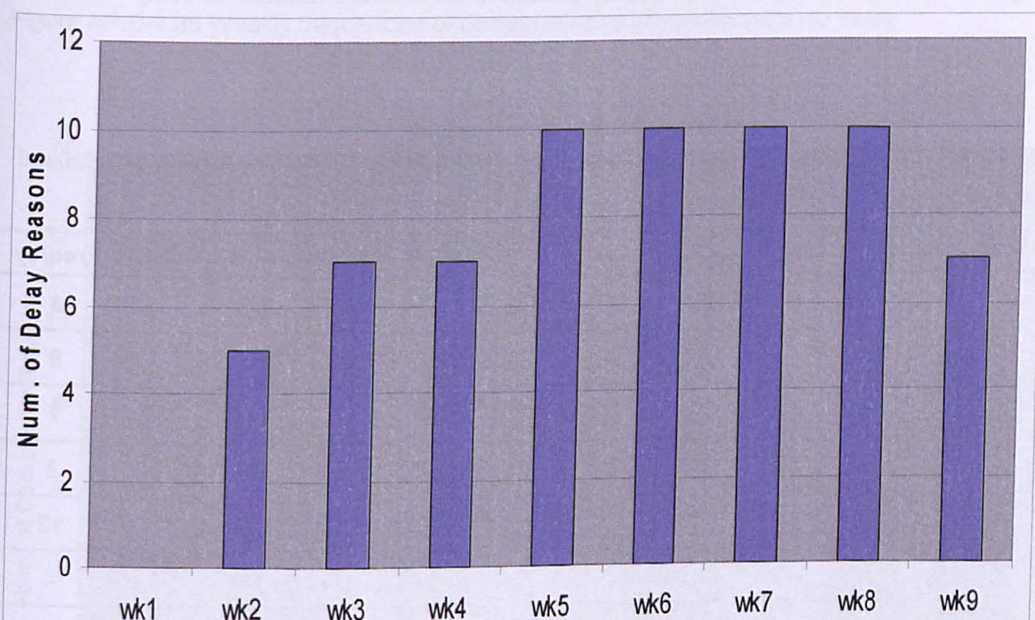



Figure AP.D-7.34. Histogram of weekly frequencies of coded reasons for delay

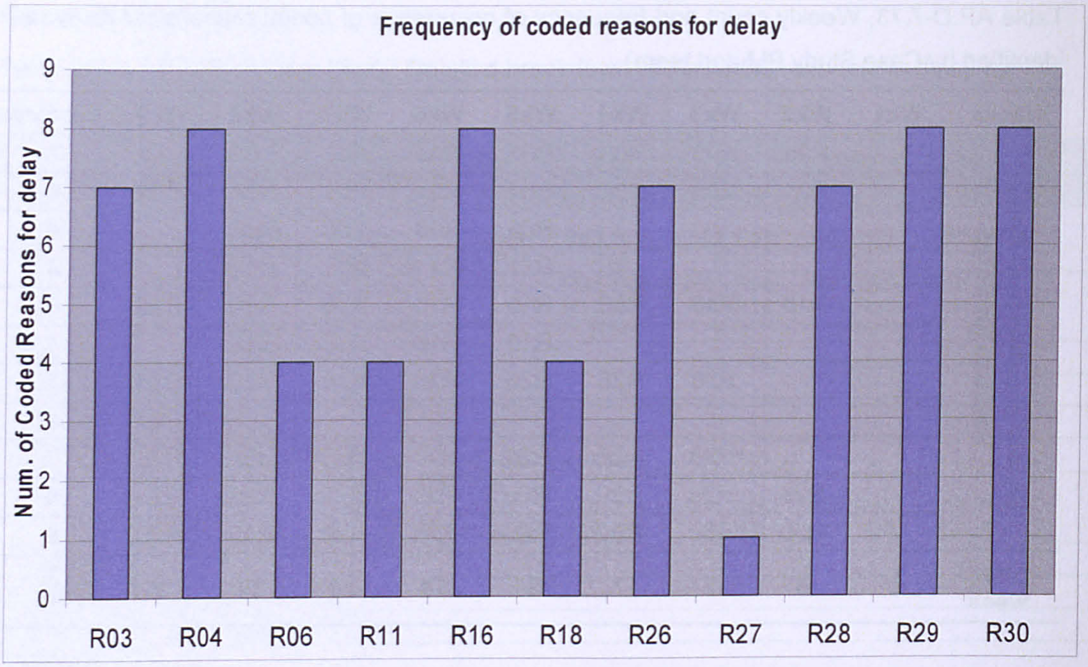



Figure AP.D-7.35. Histogram of frequency of occurrence of coded reasons for delay

Table AP.D-7.74. Weekly count and frequency of complexity characteristic(s) which caused delay

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Complexity characteristics which caused delay** | | B3 | B3 | B3 | B3 | B3 | B3 | B3 | B3 | **8** |
| | | | C2 | C2 | C2 | C2 | C2 | C2 | 2*C2 | **8** |
| | | | C3 | C3 | C3 | C3 | C3 | C3 | C3 | **7** |
| | | C4 | C4 | C4 | C4 | C4 | C4 | C4 | C4 | **8** |
| | | D1 | D1 | D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | D1 | **12** |
| | | | | | D4 | D4 | D4 | D4 | | **4** |
| | | D7 | D7 | D7 | D7 | D7 | D7 | D7 | | **7** |
| **Total / week** | | **4** | **6** | **6** | **8** | **8** | **8** | **8** | **6** | **54** |

(Note: Numbers against the code indicate that more than one of the processes investigated are affected by the characteristic, e.g. Selecting Team members and Structuring the Team.)

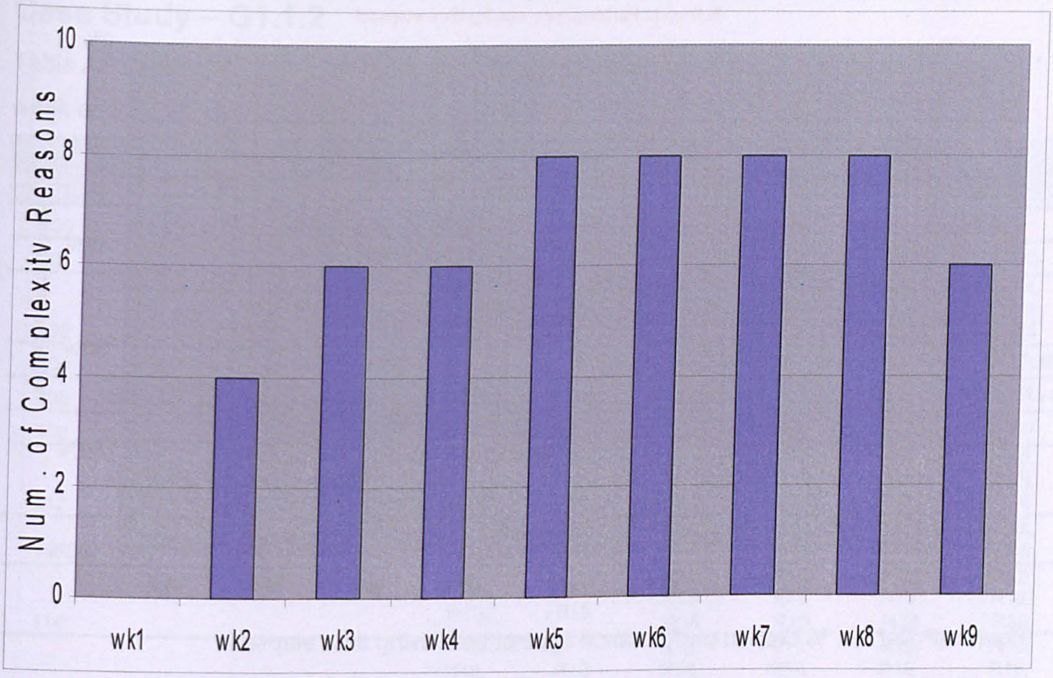



Figure AP.D-7.36 Weekly frequencies of complexity *characteristics* causing delay

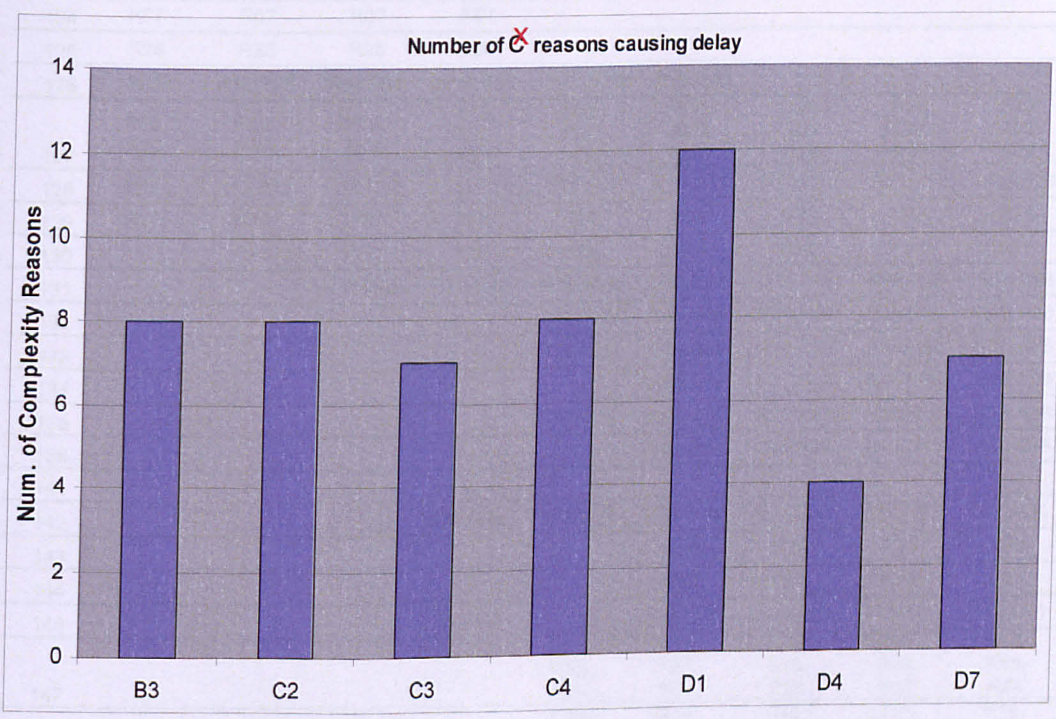



Figure AP.D-7.37. Frequency of complexity *characteristics* causing delay

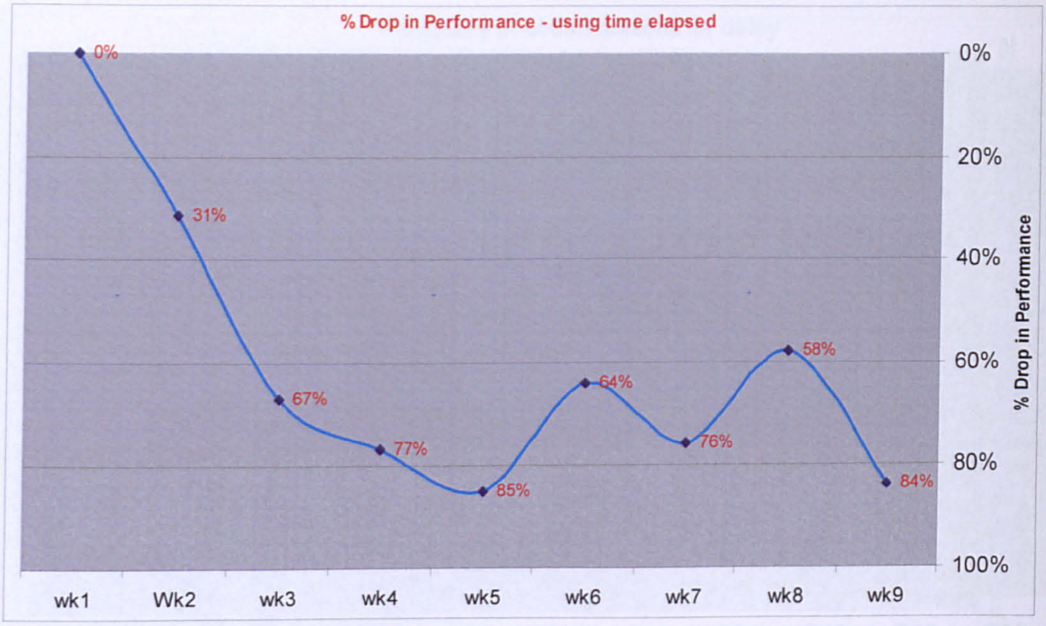



Figure AP.D-7.39. % drop in performance against time using time elapsed

## Case Study – G1.1.2

Table AP.D-7.78. G1.1.2 Case Study. Detailed breakdown of the coded reasons for delay by week and activity

| Activ. | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | Coded Reasons of Delay | | | | | | | | |
| 100 | | | R23,R14 | R23,R14 | | | | | |
| 101 | | | | | R23 | R23 | R23 | R23 | R23 |
| 102 | | R14, R23 | R14, R23 | R14, R15, R23 | R14, R15, R23 | R14, R15, R23 | R14, R15, R23 | R14, R15, R23 | R14, R15, R23 |
| 104 | | | | | | R16,R38 | R16,R38 | R16,R38 | R16,R38 |
| 106 | R07,R14 | R07,R14 | R07,R14 | R07,R14 | R07,R14 | R07,R14 | R07,R14 | R07,R14 | R07,R14 |
| 109 | -- | --- | R29 | R29 | R29 | R29 | R29 | R29 | R29 |
| 112 | R15, R16 | R13, R15, R16 | R13, R15, R16 | R13, R15, R16 | R13, R15, R16 | R13, R15, R16 | R13, R15, R16 | R13, R15, R16 | R13, R15, R16 |
| 113 | R12, R15 | R12, R15 | R12, R15 | R12, R15 | R12, R15 | R12, R15 | R12, R15 | R12, R15 | R12, R15 |
| 114 | | | | R12, R13 | R12, R13 | R12, R13, R38 | R12, R13, R38 | R12, R13, R38 | R12, R13, R38 |
| 115 | | | | R12 | R12 | R12, R16, R38 | R12, R16, R38 | R12, R16, R38 | R12, R16, R38 |
| 122 | | R16,R17 | | | | | | | |
| 123 | R14,R15 | R14,R15 | R14,R15 | R14,R15 | | | | | |
| 124 | R07 | R07 | R07 | R07 | | | | | |
| 125 | R28 | R28 | R28 | R28 | | | | | |
| 126 | R12 | R12,R28 | R12,R28 | R12,R28 | R12,R28 | R12,R28 | | | |
| 127 | R15, R20 | R15, R20 | R15, R20 | R15, R20, R28 | R15, R20, R28 | R15, R20, R28 | R15, R20, R28 | R15, R20, R28 | R15, R20, R28 |
| 128 | R14 | R14,R15 | R14,R15 | R14,R15 | R14,R15 | R14,R15 | R14,R15 | R14,R15 | R14,R15 |
| 129 | R28 | R28 | R28 | R28 | R28 | R28 | R28 | R28 | R28 |
| 130 | | R28 | R28 | R28 | R28 | R28 | R28 | R28 | R28 |
| 131 | | | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 |
| 132 | | | | | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 |
| 133 | | | | | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 |
| 134 | | | | | | R16,R38 | R16,R38 | R16,R38 | R16,R38 |
| 135 | | | | | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 |
| 136 | | | | | | R16,R38 | R16,R38 | R16,R38 | R16,R38 |
| 141 | | R29 | R29 | | | | | | |
| 142 | | | | R28,R30 | R28,R30 | R28,R30 | R28,R30 | R28,R30 | R28,R30 |
| 143 | | | | | | R28 | R28 | R28 | R28 |
| 144 | | | | | | R28 | R28 | R28 | R28 |
| 146 | | | | R12,R15 | R12,R15 | R12,R15 | R12,R15 | R12,R15 | R12,R15 |
| 147 | | | | | R15, R16, R24 | R15, R16, R24 | R15, R16, R24 | R15, R16, R24 | R15, R16, R24 |
| 148 | | | | | R15, R16, R24 | R15, R16, R24 | R15, R16, R24 | R15, R16, R24 | R15, R16, R24 |
| 153 | | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 154 | | | | | | | | R12, R14, R15 | R12, R14, R15 |

| | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| 155 | | | | | | | | R12, R14, R15 | R12, R14, R15 |
| 163 | | R16, R17, R28 | R16, R17, R28 | | | | | | |
| 164 | R15,R16 | R15,R16 | R15,R16 | R15,R16 | R15,R16 | | | | |
| 165 | | | | R14, R15 | R14, R15 | R14, R15, R28 | R14, R15, R28 | R14, R15, R28 | R14, R15, R28 |
| 166 | | | | | | R16, R38 | R16, R38 | R16, R38 | R16, R38 |
| 172 | R14 | R14 | R14 | R14 | R14 | R14 | R14 | R14 | R14 |
| 173 | | | R14 | R14 | R14 | R14 | R14 | R14 | R14 |
| 175 | | | R16 R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 |
| 176 | | | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 | R16,R28 |
| 177 | | | R14, R30 | R14, R30 | R14, R28, R30 | R14, R28, R30 | R14, R28, R30 | R14, R28, R30 | R14, R28, R30 |
| 178 | | | R14 | R14 | R14,R15 | R14,R15 | R14,R15 | R14,R15 | R14,R15 |
| 179 | | | | R14 | R14,R28 | R14,R28 | R14,R28 | R14,R28 | R14,R28 |
| 180 | | | R14,R28 | R14,R28 | R14,R28 | R14,R28 | R14,R28 | R14,R28 | R14,R28 |
| 182 | | | | | R14,R28 | R14,R28 | R14,R28 | R14,R28 | R14,R28 |
| 183 | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 184 | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 185 | | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 187 | | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 188 | | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 189 | | | | | | | R12, R14, R15 | R12, R14, R15 | R12, R14, R15 |
| 190 | | | | | | | | R12, R14, R15 | R12, R14, R15 |
| 191 | | | | | | | | R12, R14, R15 | R12, R14, R15 |
| 193 | | | | | | | | | R12 |
| 194 | | | | | | | | | R12 |
| 195 | | | | | | | | | R12 |
| 222 | | | | | | | R14, R21, R27 | R14, R21, R27 | R14, R21, R27 |
| 223 | | | | | | | R14, R21, R27 | R14, R21, R27 | R14, R21, R27 |
| 224 | | | | | | | R14, R21, R27 | R14, R21, R27 | R14, R21, R27 |

Table AP.D-7.79. Weekly count and frequency of occurrence of coded reasons for delay (as identified by Case Study PM and team)

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Coded Reasons for Delay** | R07 | R07 | R07 | R07 | R07 | R07 | R07 | R07 | R07 | **9** |
| | R12 | R12 | R12 | R12 | R12 | R12 | R12 | R12 | R12 | **9** |
| | | R13 | R13 | R13 | R13 | R13 | R13 | R13 | R13 | **8** |
| | R14 | R14 | R14 | R14 | R14 | R14 | R14 | R14 | R14 | **9** |
| | R15 | R15 | R15 | R15 | R15 | R15 | R15 | R15 | R15 | **9** |
| | R16 | R16 | R16 | R16 | R16 | R16 | R16 | R16 | R16 | **9** |
| | | R17 | R17 | | | | | | | **2** |
| | R20 | R20 | R20 | R20 | R20 | R20 | R20 | R20 | R20 | **9** |
| | | | | | | | R21 | R21 | R21 | **3** |
| | | R23 | R23 | R23 | R23 | R23 | R23 | R23 | R23 | **8** |
| | | | | | R24 | R24 | R24 | R24 | R24 | **5** |
| | | | | | | | R27 | R27 | R27 | **3** |
| | R28 | R28 | R28 | R28 | R28 | R28 | R28 | R28 | R28 | **9** |
| | | R29 | R29 | R29 | R29 | R29 | R29 | R29 | R29 | **8** |
| | | | R30 | R30 | R30 | R30 | R30 | R30 | R30 | **7** |
| | | | | | | R38 | R38 | R38 | R38 | **4** |
| **Total / week** | **7** | **11** | **12** | **11** | **12** | **13** | **15** | **15** | **15** | **111** |

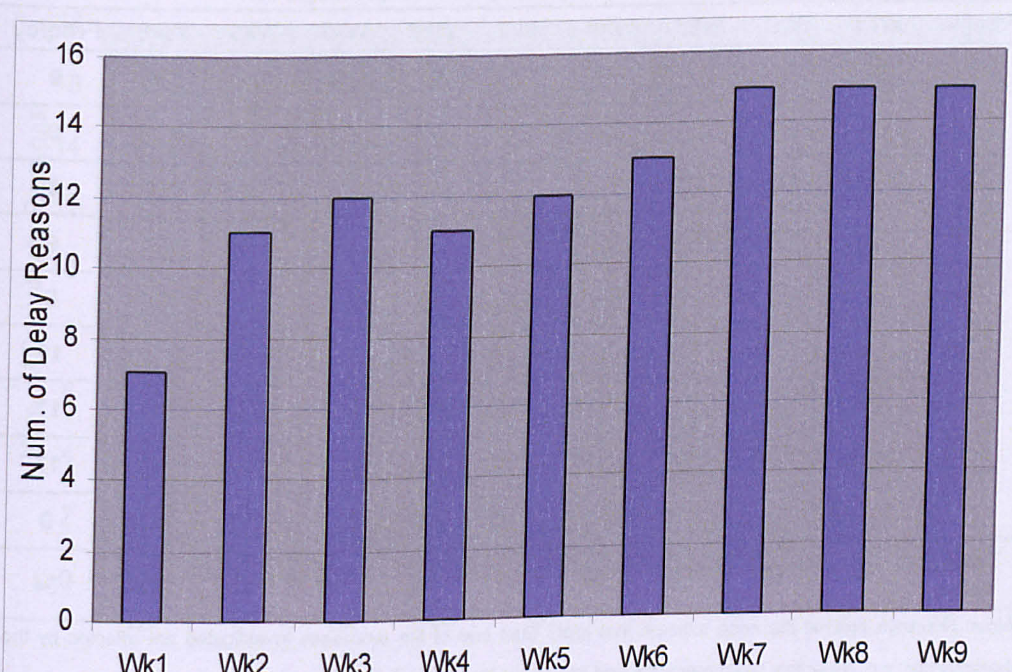



Figure AP.D-7.42. Histogram of weekly frequencies of coded reasons for delay

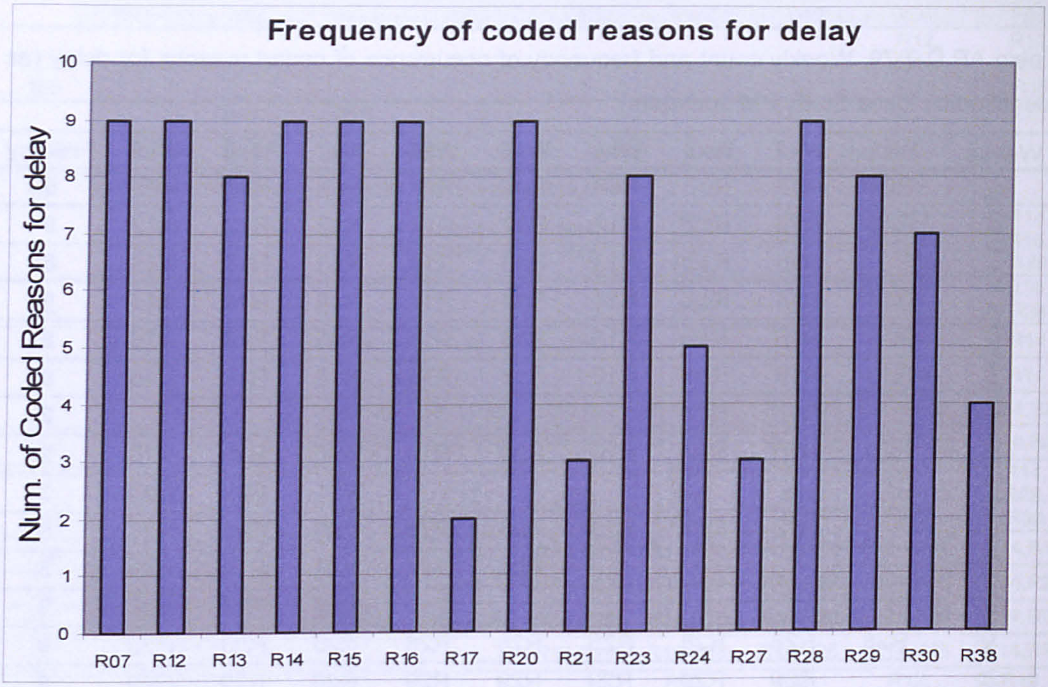



Figure AP.D-7.43. Histogram of frequency of occurrence of coded reasons for delay

Table AP.D-7.80. Weekly count and frequency of complexity characteristic(s) which caused delay

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Complexity characteristics which caused delay** | B1 | B1 | B1 | B1 | B1 | B1 | B1 | B1 | B1 | **9** |
| | C1 | C1 | C1 | C1 | C1 | C1 | C1 | C1 | C1 | **9** |
| | | C2 | C2 | | | | C2 | C2 | C2 | **5** |
| | C3 | C3 | C3 | C3 | C3 | C3 | C3 | C3 | C3 | **9** |
| | | C4 | C4 | C4 | C4 | C4 | C4 | C4 | C4 | **8** |
| | D1 | D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | **16** |
| | D4 | 2*D4 | 2*D4 | 2*D4 | 2*D4 | 2*D4 | 2*D4 | 2*D4 | 2*D4 | **17** |
| | D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | **17** |
| | | | | | D8 | 2*D8 | 2*D8 | 2*D8 | 2*D8 | **9** |
| **Total / week** | **6** | **10** | **11** | **10** | **11** | **12** | **13** | **13** | **13** | **54** |

(Note: Numbers against the code indicate that more than one of the processes investigated are affected by the characteristic, e.g. Selecting Team members and Structuring the Team.)

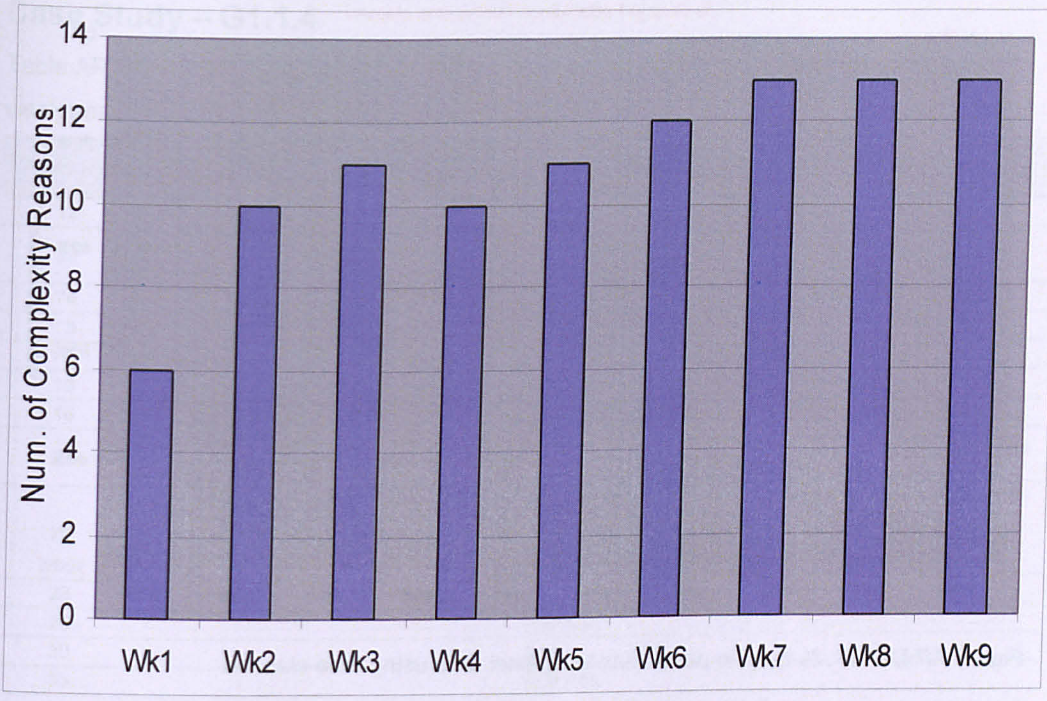



Figure AP.D-7.44. Weekly frequencies of complexity characteristics causing delay

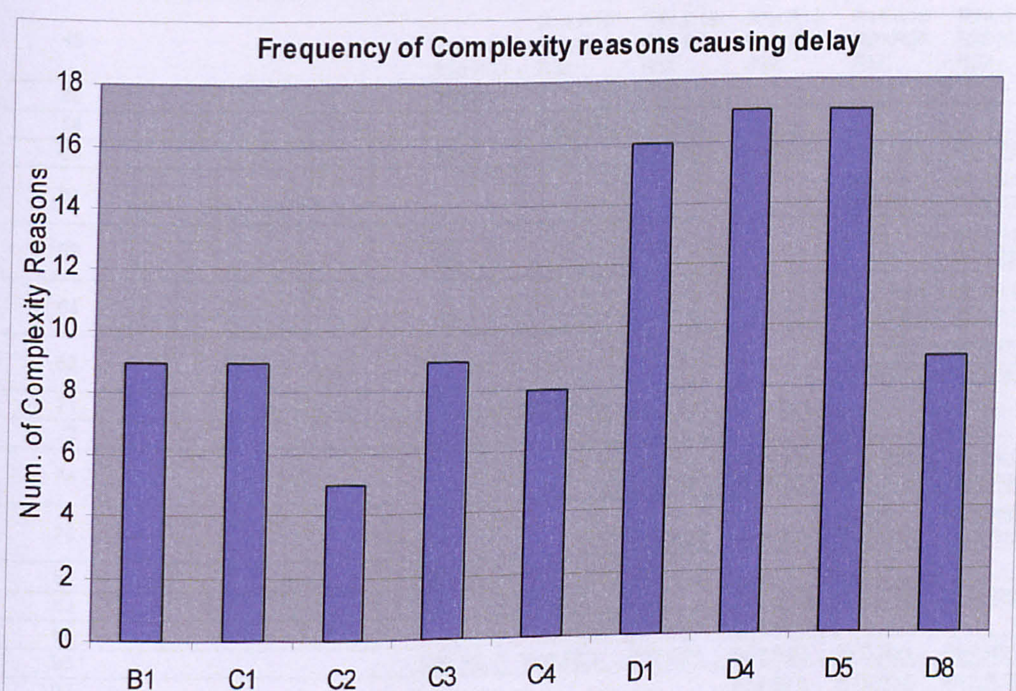



Figure AP.D-7.45. Frequency of complexity characteristics causing delay

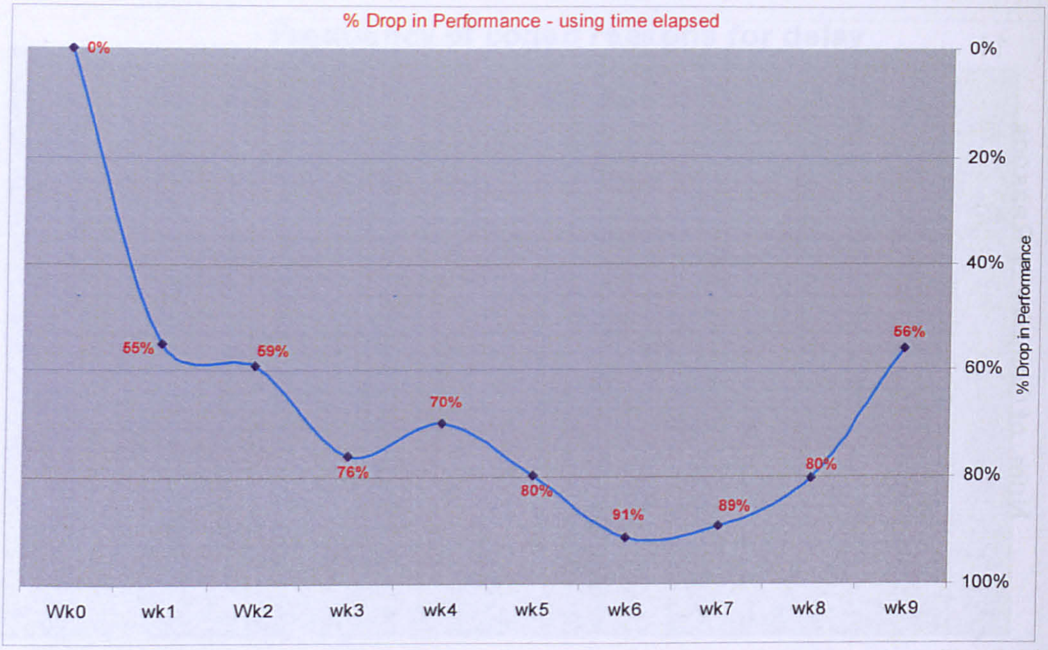



Figure AP.D-7.47. % drop in performance against time using time elapsed

## Case Study – G1.1.4

Table AP.D-7.84. G1.1.4 Case Study. Detailed breakdown of the coded reasons for delay by week and activity

| Activ. | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | Coded Reasons of Delay | | | | | | | | |
| 12 | R15 | R15 | R15 | | | | | | |
| 33 | R17,R23 R28 | R17,R23 R28 | R17,R23 R28 | | | | | | |
| 74 | | | R14,R21 | | | | | | |
| 5 | | | | R12 | | | | | |
| 9 | | | | R17 | | | | | |
| 10 | | | | | R28,R29 | | | | |
| 16 | | | | | R29 | | | | |
| 22 | | | | | | | R15,R16 R23 | R15,R16 R23 | R15,R16 R23 |
| 25 | | | | | R12,R16 R38 | R12,R16 R38 & R23 | R12,R16 R38 & R23 & R20 | R12,R16 R38 & R23 & R20 | R12,R16 R38& R23& R20 |
| 28 | | | | R16 | | | | | |
| 29 | | | | | R12,R28 | | | | |
| 30 | | | | | R18 | R18 | | | |
| 33 | | | | | R09,R18 | | | | |
| 36 | | | | | | R16 | R16 | | |
| 39 | | | | | R09,R16 R29 | | | | |
| 40 | | | | | R16 | | | | |
| 41 | | | | | | | R12,R30 | R12,R30 | R12,R30 |
| 48 | | | | R16,R29 R30,R32 | R14,R16 R29,R30 R32 | R14,R16 R29,R30 R32 | R14,R16 R29,R30 R32 | R14,R16 R29,R30 R32 | R14,R16 R29,R30 R32 |
| 56 | | | | R16,R17 | | | | | |
| 58 | | | | | R28,R32 | | | | |
| 60 | | | | R23 | R23 | R07,R23 | R07,R23 | R07,R23 | R07,R23 |
| 61 | | | | | | | | R07,R12 R15,R23 | R07,R12 R15,R23 |
| 62 | | | | | | | | | R07,R12 R15,R23 |
| 64 | | | | | | | | R07,R12 R15,R23 | R07,R12 R15,R23 |
| 66 | | | | | | | | R07,R12 R15,R23 | R07,R12 R15,R23 |
| 71 | | | | | R14,R15 | | | | |
| 72 | | | | | | | R12 | R12 | R12 |
| 74 | | | | | | R03,R07 | R03,R07 R29,R30 | R03,R07 R29,R30 | R03,R07 R29,R30 |
| 78 | | | | | | R03,R07 | R03,R07 | R03,R07 R12,R15 | R03,R07 R12,R15 |
| 82 | | | | R21 | R21 | R21 | | | |
| 83 | | | | R21 | R28 | R28 | R07,R28 | R07,R28 | R07,R28 |
| 88 | | | | | R38,R30 | R38,R30 | R38,R30 | | |
| 90 | | | | R07,R21 | R07,R21 | R07,R21 | R07,R21 | R07,R21 | R07,R21 |
| 102 | | | | | | | R12,R15 | R12,R15 | R12,R15 |
| 103 | | | | R15 | R15 | R15 | R12,R15 | R12,R15 | R12,R15 |
| 104 | | | | R07,R14 R21 | R07,R14 R21 | R07,R14 R16,R21 | R07,R14 R15,R16 R21 | R07,R14 R15,R16 R21 | R07,R14 R15,R16 R21 |

| Activ. | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | Coded Reasons of Delay | | | | | | | | |
| 110 | | | | | | | R07,R12 R15,R21 | R07,R12 R15,R21 | R07,R12 R15,R21 |
| 115 | | | | | | R06,R08 R20 & R18 | R06,R08 R20 & R18 | R06,R08 R20 & R18 | R06,R08 R20 & R18 |
| 116 | | | | R15,R16 R27,R30 | R15,R16 R27,R30 | R15,R16 R27,R30 | R07,R15 R16,R27 R30 | R07,R15 R16,R27 R30 | R07,R15 R16,R27 R30 |
| 118 | | | | | | | R06,R08 R20 & R18 | R06,R08 R20 & R18 | R06,R08 R20 & R18 |
| 119 | | | | | | | | R15,R20 | R15,R20 |
| 120 | | | | | | | | R15,R20 | R15,R20 |
| 121 | | | | | | | R07,R15 | R07,R15 | R07,R15 |
| 124 | | | | | | R06,R15 R21 | R06,R15 R21 | R06,R15 R21 | R06,R15 R21 |
| 125 | | | | | | R06,R15 R21 | R06,R15 R21 | R06,R15 R21 | R06,R15 R21 |
| 126 | | | | | | | R07,R15 | R07,R15 | R07,R15 |

Table AP.D-7.85. Weekly count and frequency of occurrence of coded reasons for delay (as identified by Case Study PM and the Site Manager)

| Weeks | **Wk1** | **Wk2** | **Wk3** | **Wk4** | **Wk5** | **Wk6** | **Wk7** | **Wk8** | **Wk9** | **Freq/cy** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Coded Reasons for Delay** | | | | | | R03 | R03 | R03 | R03 | **4** |
| | | | | | | R06 | R06 | R06 | R06 | **4** |
| | | | | R07 | R07 | R07 | R07 | R07 | R07 | **6** |
| | | | | | | R08 | R08 | R08 | R08 | **4** |
| | | | | | R09 | | | | | **1** |
| | | | | R12 | R12 | R12 | R12 | R12 | R12 | **6** |
| | | | R14 | R14 | R14 | R14 | R14 | R14 | R14 | **7** |
| | R15 | R15 | R15 | R15 | R15 | R15 | R15 | R15 | R15 | **9** |
| | | | | R16 | R16 | R16 | R16 | R16 | R16 | **6** |
| | R17 | R17 | R17 | R17 | | | | | | **4** |
| | | | | | R18 | R18 | R18 | R18 | R18 | **5** |
| | | | | | | R20 | R20 | R20 | R20 | **4** |
| | | | R21 | R21 | R21 | R21 | R21 | R21 | R21 | **7** |
| | R23 | R23 | R23 | R23 | R23 | R23 | R23 | R23 | R23 | **9** |
| | | | | R27 | R27 | R27 | R27 | R27 | R27 | **6** |
| | R28 | R28 | R28 | | R28 | R28 | R28 | R28 | R28 | **8** |
| | | | | R29 | R29 | R29 | R29 | R29 | R29 | **6** |
| | | | | R30 | R30 | R30 | R30 | R30 | R30 | **6** |
| | | | | R32 | R32 | R32 | R32 | R32 | R32 | **6** |
| | | | | | R38 | R38 | R38 | R38 | R38 | **5** |
| **Total / week** | **4** | **4** | **6** | **12** | **15** | **17** | **17** | **17** | **17** | **109** |

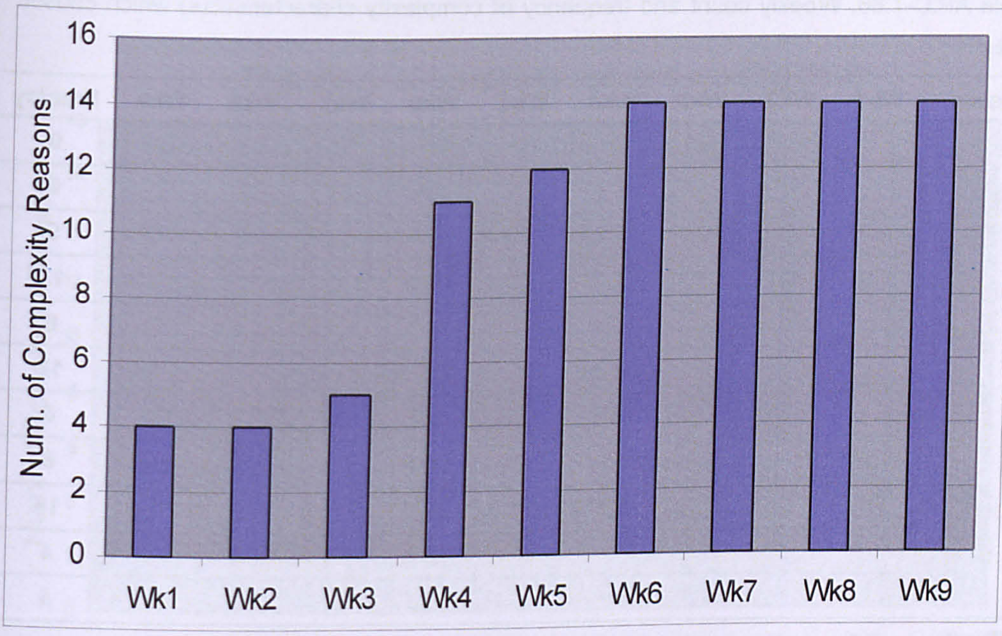



Figure AP.D-7.50. Histogram of weekly frequencies of coded reasons for delay

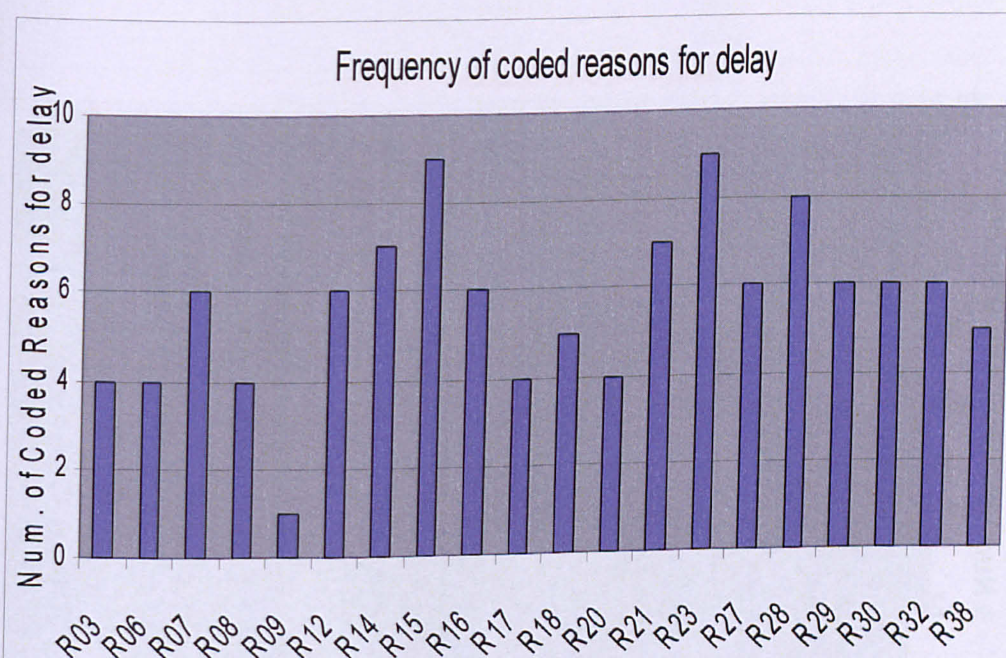



Figure AP.D-7.51. Histogram of frequency of occurrence of coded reasons for delay

Table AP.D-7.86. Weekly count and frequency of complexity characteristic(s) which caused delay

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Complexity characteristics which caused delay** | B1 | B1 | B1 | B1 | B1 | B1 | B1 | B1 | B1 | **9** |
| | | | | C1 | C1 | C1 | C1 | C1 | C1 | **6** |
| | C2 | C2 | C2 | C2 | C2 | C2 | C2 | C2 | C2 | **9** |
| | C3 | C3 | C3 | C3 | C3 | 2*C3 | 2*C3 | 2*C3 | 2*C3 | **13** |
| | | | | C4 | C4 | C4 | C4 | C4 | C4 | **6** |
| | | | | 2*D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | **12** |
| | | | | D2 | D2 | D2 | D2 | D2 | D2 | **6** |
| | | | | D4 | D4 | D4 | D4 | D4 | D4 | **6** |
| | D5 | D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | **16** |
| | | | | | | D7 | D7 | D7 | D7 | **4** |
| | | | | | D8 | D8 | D8 | D8 | D8 | **5** |
| **Total / week** | **4** | **4** | **5** | **11** | **12** | **14** | **14** | **14** | **14** | **92** |

(Note: Numbers against the code indicate that more than one of the processes investigated are affected by the characteristic, e.g. Selecting Team members and Structuring the Team.)

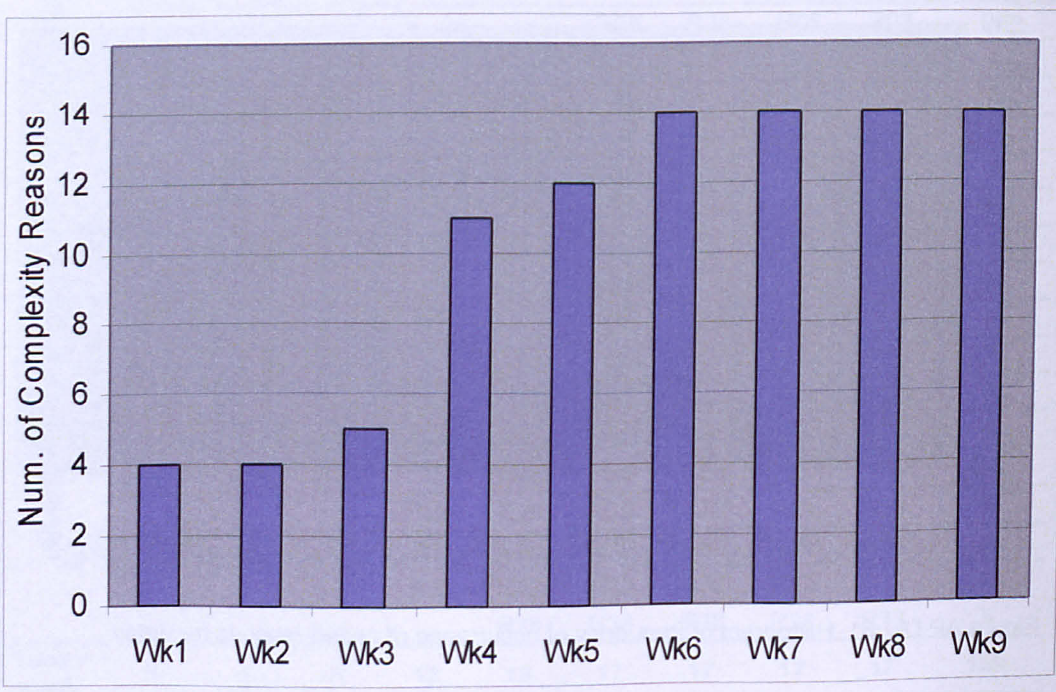



Figure AP.D-7.52 Weekly frequencies of complexity characteristics causing delay

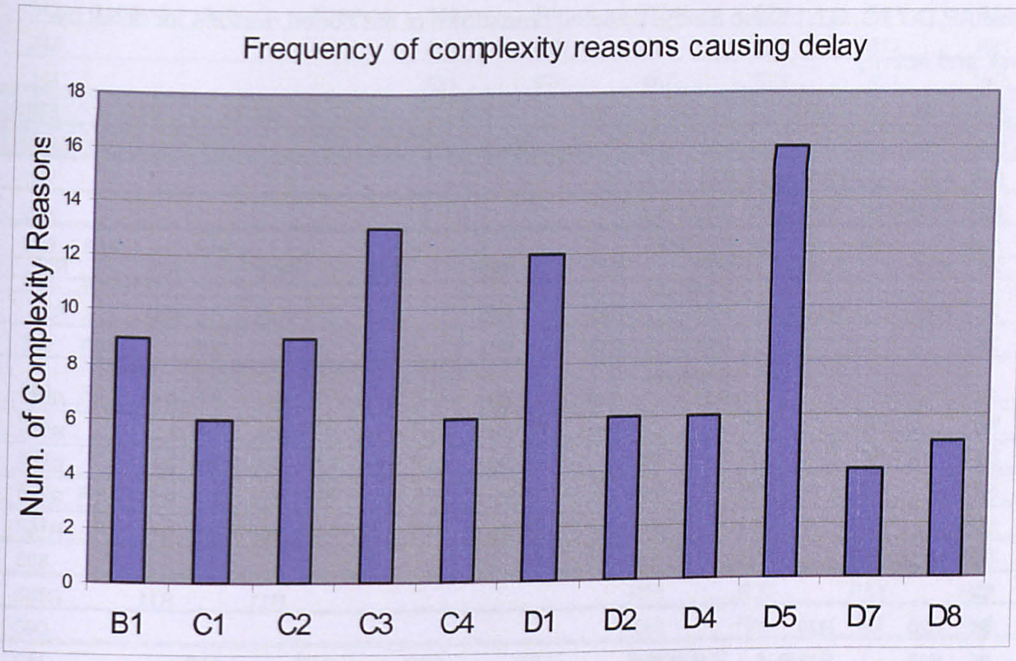



Figure AP.D-7.53 Frequency of complexity characteristics causing delay

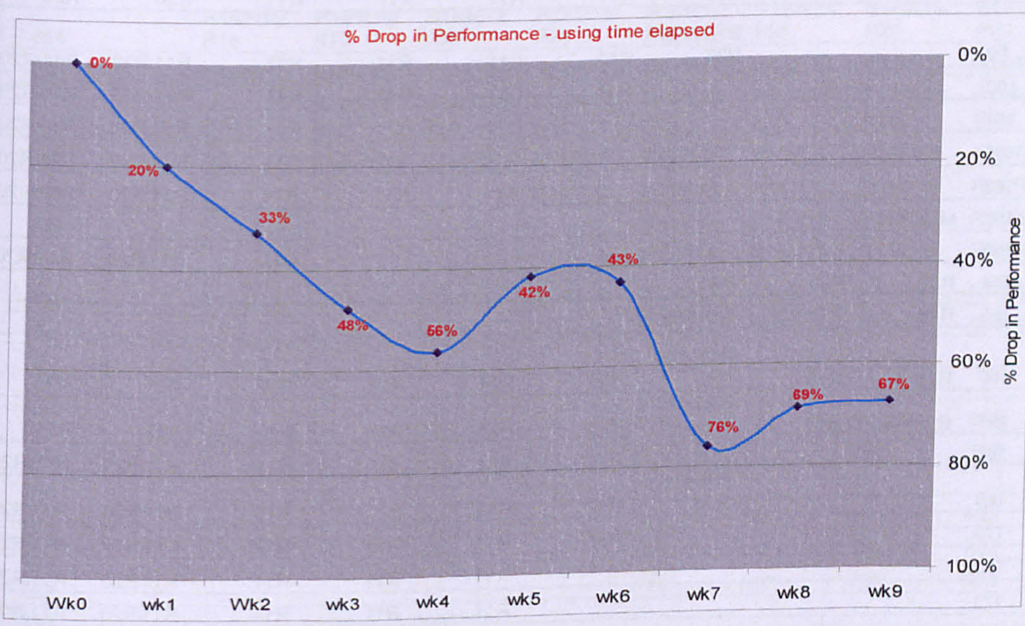



Figure AP.D-7.55 % drop in performance against time using time elapsed

## Case Study – G2.1

Table AP.D-7.89. G2.1 Case Study. Detailed breakdown of the coded reasons for delay by week and activity

| Activ | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | Coded Reasons for Delay | | | | | | | | |
| 24 | R20 | R20 | R20 | | | | | | |
| 25 | R18/R35 | R18/R35 | R26/R18 | | | | | | |
| 26 | R33 | R18 | R16/R18/ R26 | R23 | R23 | R23 | R23 | R23 | R23 |
| 27 | R34 | R18/R20 | R16/R18/ R20 | R23 | R23 | R23 | R23 | R23 | R23 |
| 28 | | | R18 | R11 | R11 | | | | |
| 29 | | | R16/R18/ R20 | R11 | R11 | R11 | R11 | R11 | R11 |
| 30 | | | | R11 | R11 | R11 | R11 | R11 | R11 |
| 31 | | | | | R11 | R11 | R11 | R11 | R11 |
| 32 | | | | | R11 | R11 | R11 | R11 | R11 |
| 33 | | | | | R11 | R11 | R11 | R11 | R11 |
| 35 | M-D/R21 | | | | | | | | |
| 36 | | | | | | | R11 | R11 | R11 |
| 94 | R20 | R20 | | | | | | | |
| 95 | R18 | R18/R35 | R18/R26 | | | | | | |
| 96 | R18 | R18 | R16/R18/ R26 | R20 | R20 | R20 | R20 | R23 | R23 |
| 97 | R18 | R18/R20 | R16/R18/ R20 | R23 | R23 | R23 | R23 | R23 | R23 |
| 98 | | | R18 | R11 | R11 | R11 | R11 | R20 | R20 |
| 99 | | | R16/R18/ R20 | R11 | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 100 | | | | R11 | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 101 | | | | | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 102 | | | | | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 103 | | | | | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 105 | M-D/R21 | | | | | | | | |
| 106 | | | | | | | R11 | R11/R20 | R11/R20 |
| 164 | R20 | R20 | R20 | | | | | | |
| 165 | R18 | R18/R35 | R18/R26 | | | | | | |
| 166 | R18 | R18 | R16/R18/ R26 | R20 | R20 | R20 | R20 | R23 | R23 |
| 167 | R18/R38 | R18 | R16/R18/ R20 | R23 | R23 | R23 | R23 | R23 | R23 |
| 168 | | | R18 | R11 | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 169 | | | R16/R18/ R20 | R11 | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 170 | | | | R11 | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 171 | | | | | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 172 | | | | | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 173 | | | | | R11 | R11 | R11 | R11/R20 | R11/R20 |
| 175 | M-D/R21 | | | | | | | | |
| 176 | | | | | | | R11 | R11/R20 | R11/R20 |
| 338 | | | | | | | | | |
| 339 | R20 | R20 | R20 | | | | | | |
| 340 | | R18/R35 | R18/R26 | | | | | | |
| 341 | R16/R18 | R18 | R18 | R21 | R21 | R21 | R21 | R21 | R21 |

| | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| 342 | R16/R18 | R18 | R18/R20 | R21 | R21 | R21 | R21 | R21 | R21 |
| 343 | | | | R21 | R21 | R21 | R21 | R21 | R21 |
| 344 | | | | R21 | R21 | R21 | R21 | R21 | R21 |
| 345 | | | | | R21 | R21 | R21 | R21 | R21 |
| 346 | | | | | | R21 | R21 | R21 | R21 |
| 347 | | | | | | R21 | R21 | R21 | R21 |
| 348 | | | | | | R21 | R21 | R21 | R21 |
| 349 | R18 | R18 | | | | | R21 | R21 | R21 |
| 350 | M-D/R21 | | | | | | | | |
| 582 | R16/R14/ R07 | R16/R14/ R07 | | | | | | | |
| 583 | R18/R14/ R07 | R18/R14/ R07 | R18/R14/ R07 | R18/R14/ R07 | | | | | |
| 584 | | R20 | R20 | R20 | R20 | R20 | R20 | R20 | R20 |
| 585 | | R18 | R18 | R23 | R23 | R23 | R23 | R23 | R23 |
| 586 | R18/R14 | R18 | R18 | R23 | R23 | R23 | R23 | R23 | R23 |
| 587 | | R18/R14 | R18/R20 | R23 | R23 | R23 | R23 | R23 | R23 |
| 588 | | | | | R23 | R23 | R23 | R23 | R23 |
| 589 | | | | | | R23 | R23 | R23 | R23 |
| 590 | | | | | | R23 | R23 | R23 | R23 |
| 594 | | R18 | R18 | R23 | R23 | R23 | | | |
| 595 | | | R18 | R23 | R23 | R23 | R23 | R23 | R23 |
| 652 | R18/R14 | R15 | | | | | | | |
| 653 | R14 | R14/R15/ R18 | R14/R15/ R18 | R14/R15/ R18 | | | | | |
| 654 | | R14/R15/ R18 | R14/R15/ R20 | R14/R15/ R20 | R14/R15/ R20 | R14/R15/ R20 | R14/R15/ R20 | R14/R15/ R20 | R14/R15/ R20 |
| 655 | | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 656 | R14/R17 | R18 | R14/R15/ R18 | R14/R15/ R18 | R14/R15/ R18 | R14/R15/ R18 | R14/R15/ R18 | R14/R15/ R18 | R14/R15/ R18 |
| 657 | | R18 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 658 | | | | | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 659 | | | | | | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 660 | | | | | | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 664 | | R16 /R17 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 665 | | | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 | R14/R15 |
| 826 | R07 | | | | | | | | |
| 827 | R07 | | | | | | | | |
| 828 | | R18 | R18 | R23 | R23 | R23 | R23 | R23 | R23 |
| 829 | | | R20 | R23 | R23 | R23 | R23 | R23 | R23 |
| 830 | | | R18 | | R23 | R23 | | | |
| 831 | R07 | R18 | R18 | R23 | R23 | R23 | R23 | R23 | R23 |
| 832 | | | R18 | R23 | R23 | R23 | R23 | R23 | R23 |
| 833 | | | | | | R23 | R23 | R23 | R23 |
| 839 | | | R06/R07 | R06/R07 | | | | | |
| 840 | | | | | R23 | R23 | R23 | R23 | R23 |

Table AP.D-7.90. Weekly count and frequency of occurrence of coded reasons for delay (as identified by Case Study PM and team)

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Coded Reasons for Delay** | | | R06 | R06 | | | | | | **2** |
| | R07 | R07 | R07 | R07 | | | | | | **4** |
| | | | | R11 | R11 | R11 | R11 | R11 | R11 | **6** |
| | R14 | R14 | R14 | R14 | R14 | R14 | R14 | R14 | R14 | **9** |
| | | R15 | R15 | R15 | R15 | R15 | R15 | R15 | R15 | **8** |
| | R16 | R16 | R16 | | | | | | | **3** |
| | R17 | R17 | | | | | | | | **2** |
| | R18 | R18 | R18 | R18 | R18 | R18 | R18 | R18 | R18 | **9** |
| | R20 | R20 | R20 | R20 | R20 | R20 | R20 | R20 | R20 | **9** |
| | R21 | | | R21 | R21 | R21 | R21 | R21 | R21 | **7** |
| | | | | R23 | R23 | R23 | R23 | R23 | R23 | **6** |
| | | | R26 | | | | | | | **1** |
| | R33 | | | | | | | | | **1** |
| | R34 | | | | | | | | | **1** |
| | R35 | R35 | | | | | | | | **2** |
| | R38 | | | | | | | | | **1** |
| **Total / week** | **11** | **8** | **8** | **9** | **7** | **7** | **7** | **7** | **7** | **71** |

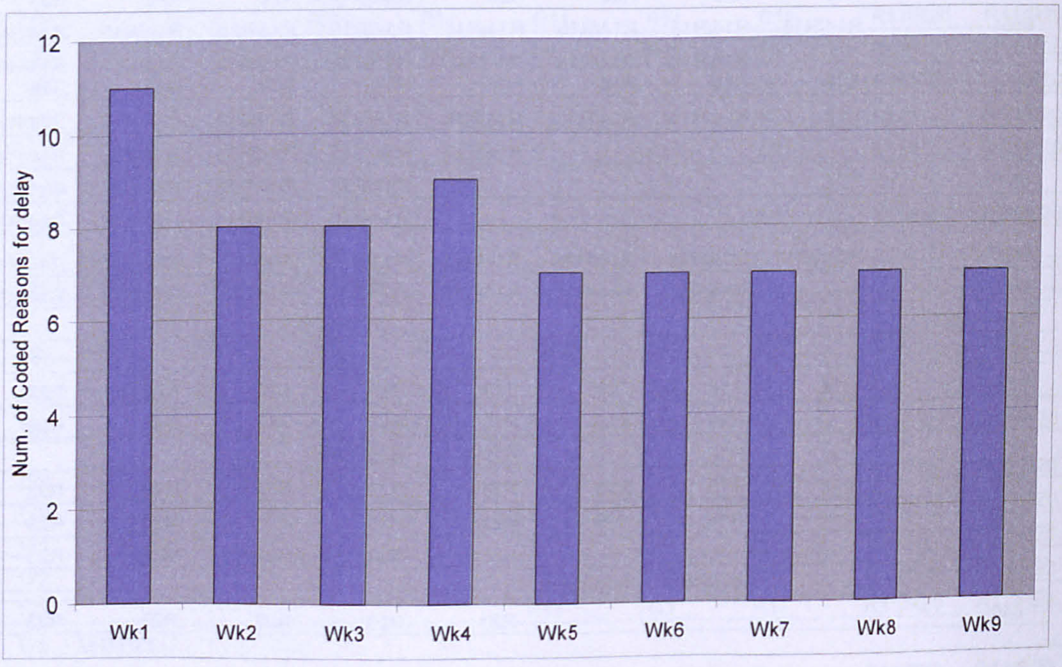



Figure AP.D-7.58. Histogram of weekly frequencies of coded reasons for delay

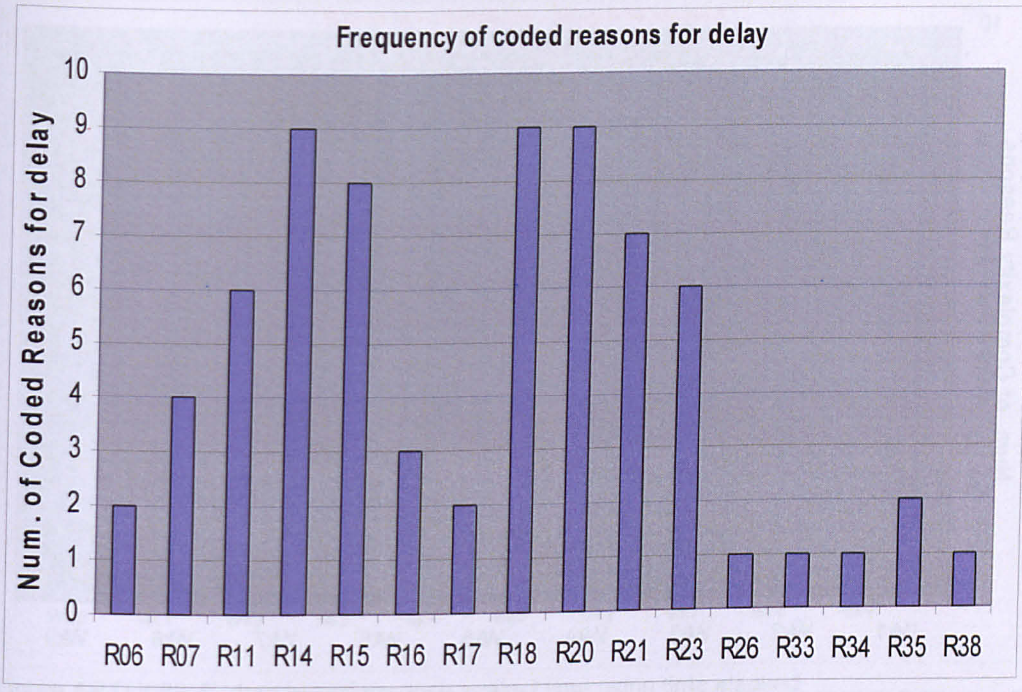



Figure AP.D-7.59. Histogram of frequency of occurrence of coded reasons for delay

Table AP.D-7.91. Weekly count and frequency of complexity characteristic(s) which caused delay

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| Weekly occurrence of Complexity characteristics which caused delay | C1 | C1 | C1 | C1 | | | | | | 4 |
| | C2 | C2 | C2 | | | | | | | 3 |
| | C3 | C3 | C3 | C3 | C3 | C3 | C3 | C3 | C3 | 9 |
| | D1 | D1 | 2*D1 | D1 | | | | | | 5 |
| | | | | D4 | D4 | D4 | D4 | D4 | D4 | 6 |
| | 3*D5 | 2*D5 | D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 2*D5 | 18 |
| | D8 | | | | | | | | | 1 |
| | B1 | B1 | B1 | B1 | B1 | B1 | B1 | B1 | B1 | 9 |
| **Total / week** | **9** | **7** | **7** | **7** | **5** | **5** | **5** | **5** | **5** | **55** |

(Note: Numbers against the code indicate that more than one of the processes investigated are affected by the characteristic, e.g. Selecting Team members and Structuring the Team.)

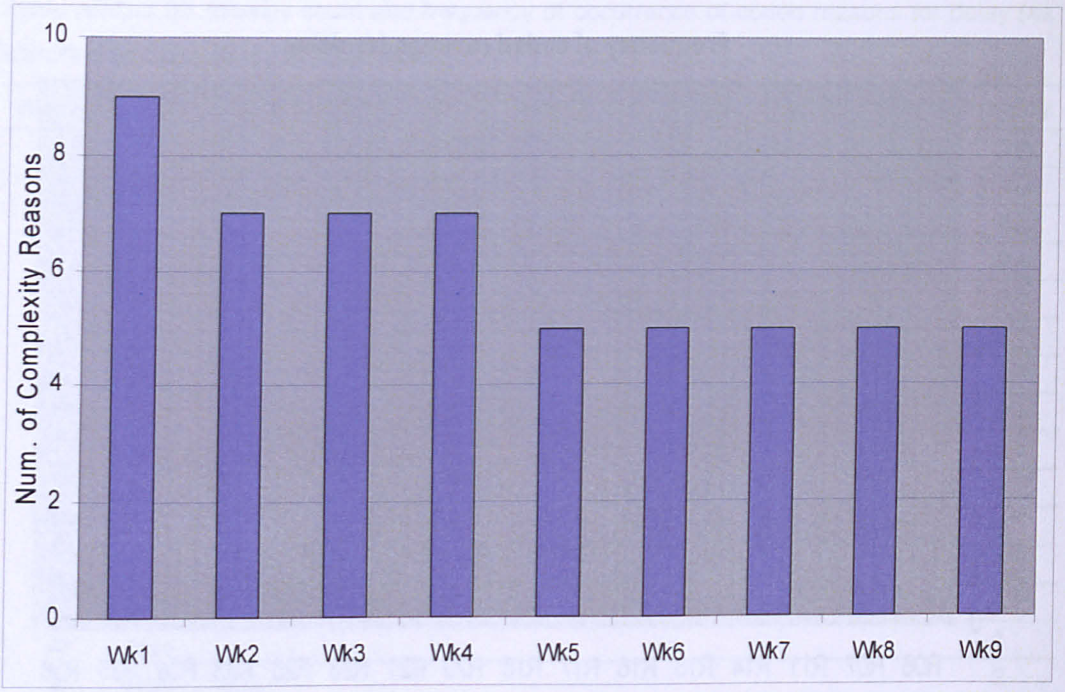



Figure AP.D-7.60 Weekly frequencies of complexity characteristics causing delay

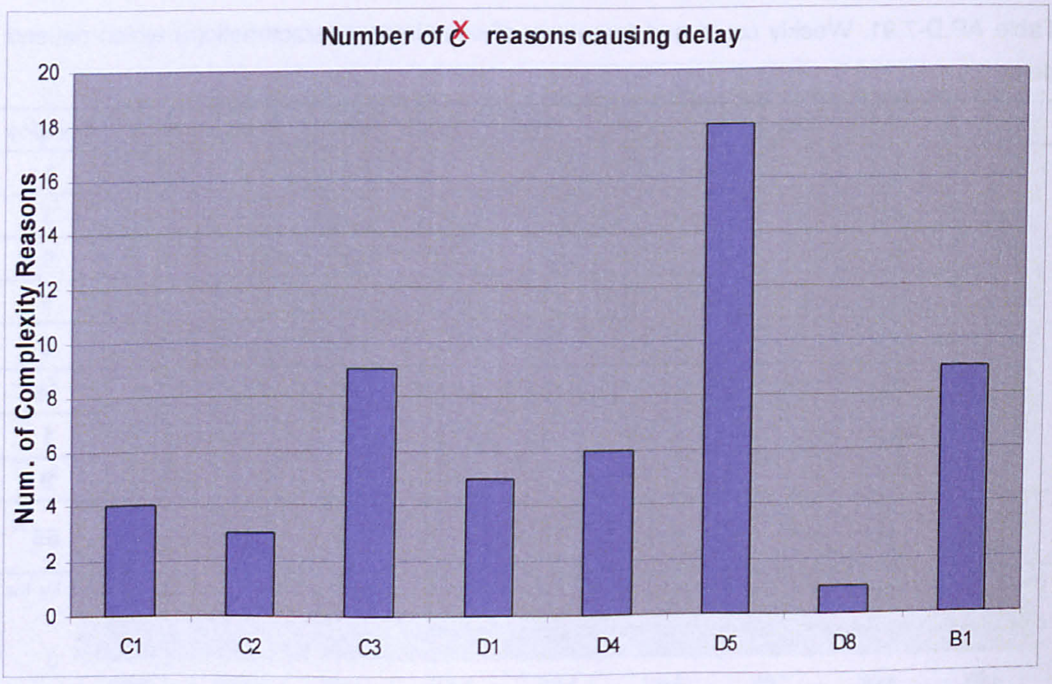



Figure AP.D-7.61. Frequency of complexity characteristics causing delay

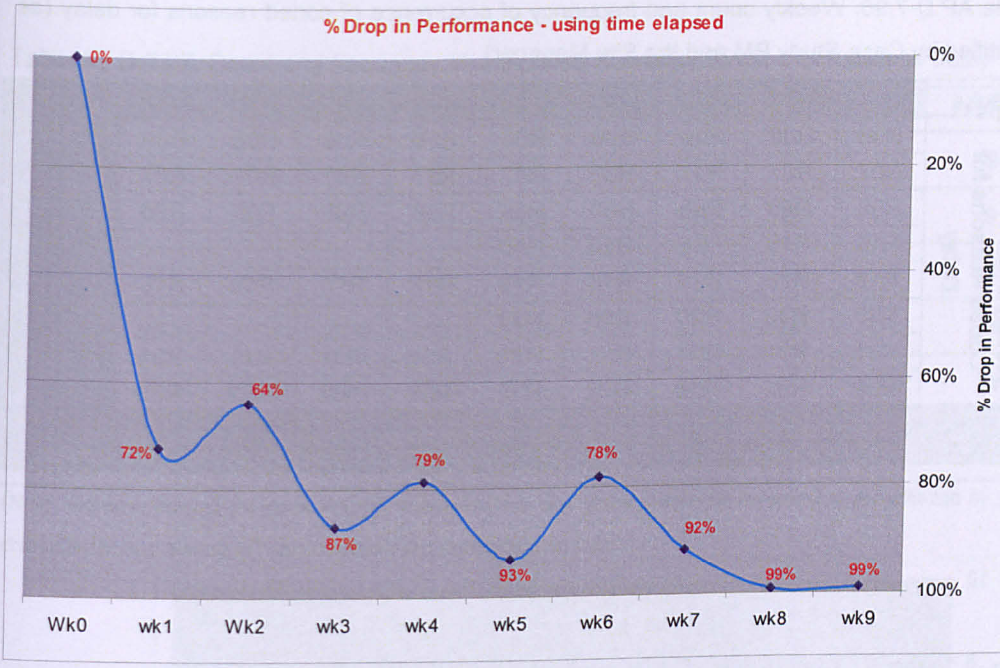



Figure AP.D-7.63. % drop in performance against time using time elapsed

## Case Study – G1.2

Table AP.D-7.95. G1.2 Case Study. Detailed breakdown of the coded reasons for delay by week and activity

| Activity | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 |
|---|---|---|---|---|---|---|---|---|---|
| | Coded Reasons for Delay | | | | | | | | |
| 4190 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08 | | | | | | |
| 3900 | R06,R07 R08 | | | | | | | | |
| 3905 | R18,R31 R32 | R18,R31 R32 | | | | | | | |
| 3910 | R16,R30 | R16,R30 | R16,R30 | R16,R30 | R16,R30 | | | | |
| 3800 | R16,R30 | R16,R30 | R16,R30 | R16,R30 | R16,R30 | | | | |
| 3860 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | | | | | | |
| 4010 | | | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 |
| 3940 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | R18,R31 R32 | | | | | |
| 3790 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08 | R06,R07 R08,R18 R31,R32 | R06,R07 R08,R18 R31,R32 |

Table AP.D-7.96. Weekly count and frequency of occurrence of coded reasons for delay (as identified by Case Study PM and the Site Manager)

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| Weekly occurrence of Coded Reasons for Delay | R06 | R06 | R06 | R06 | R06 | R06 | R06 | R06 | R06 | 8 |
| | R07 | R07 | R07 | R07 | R07 | R07 | R07 | R07 | R07 | 8 |
| | R08 | R08 | R08 | R08 | R08 | R08 | R08 | R08 | R08 | 8 |
| | R16 | R16 | R16 | R16 | R16 | | | | | 4 |
| | R18 | R18 | R18 | R18 | R18 | R18 | R18 | R18 | R18 | 8 |
| | R30 | R30 | R30 | R30 | R30 | | | | | 4 |
| | R31 | R31 | R31 | R31 | R31 | R31 | R31 | R31 | R31 | 8 |
| | R32 | R32 | R32 | R32 | R32 | R32 | R32 | R32 | R32 | 8 |
| **Total / week** | 8 | 8 | 8 | 8 | 8 | 6 | 6 | 6 | 6 | 64 |

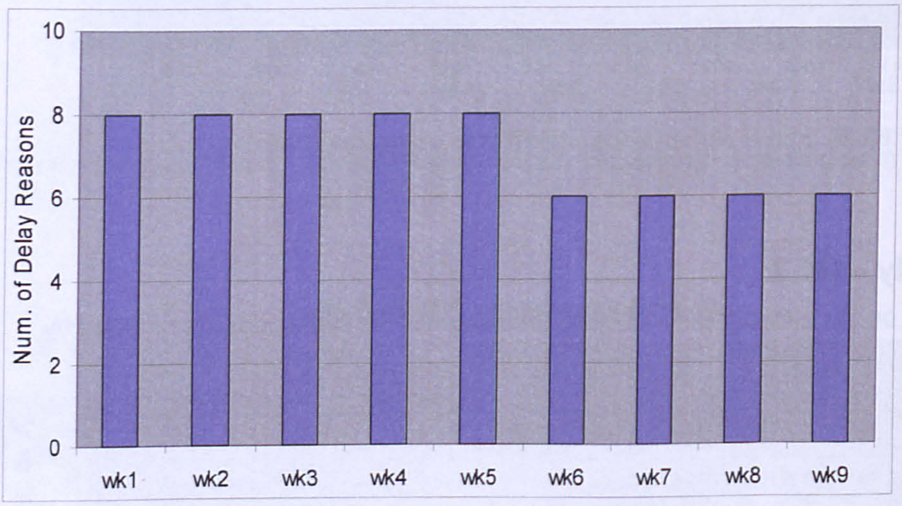



Figure AP.D-7.66. Histogram of weekly frequencies of coded reasons for delay

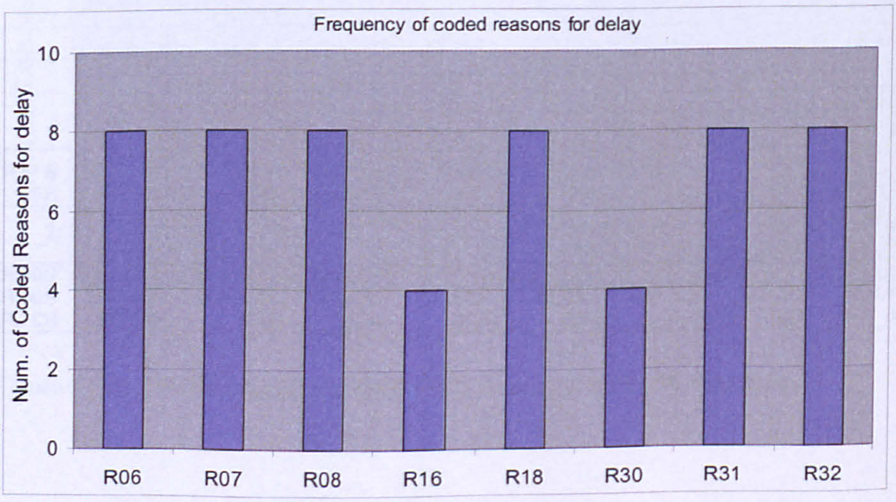



Figure AP.D-7.67. Histogram of frequency of occurrence of coded reasons for delay

Table AP.D-7.97. Count and frequency of complexity characteristic(s) which caused delay

| Weeks | Wk1 | Wk2 | Wk3 | Wk4 | Wk5 | Wk6 | Wk7 | Wk8 | Wk9 | Freq/cy |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weekly occurrence of Complexity characteristics which caused delay** | C1 | C1 | C1 | C1 | C1 | C1 | C1 | C1 | C1 | **9** |
| | C3 | C3 | C3 | C3 | C3 | C3 | C3 | C3 | C3 | **9** |
| | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | **9** |
| | 2*D1 | 2*D1 | 2*D1 | 2*D1 | 2*D1 | D1 | D1 | D1 | D1 | **14** |
| | 2*D2 | 2*D2 | 2*D2 | 2*D2 | 2*D2 | 2*D2 | 2*D2 | 2*D2 | 2*D2 | **18** |
| **Total / week** | **7** | **7** | **7** | **7** | **7** | **6** | **6** | **6** | **6** | **59** |

(Note: Numbers against the code indicate that more than one of the processes investigated are affected by the characteristic, e.g. Selecting Team members and Structuring the Team.)

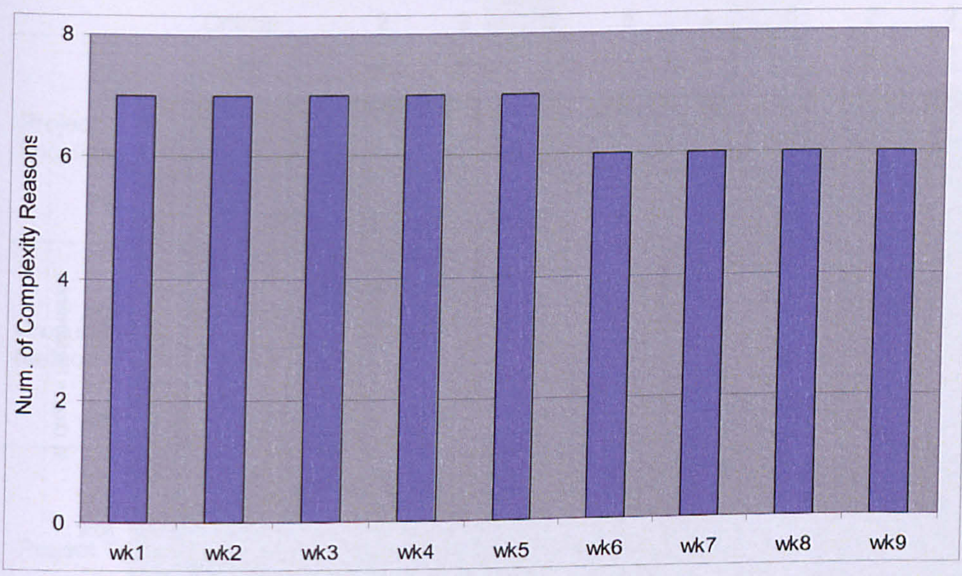



Figure AP.D-7.68 Weekly frequencies of complexity characteristics causing delay

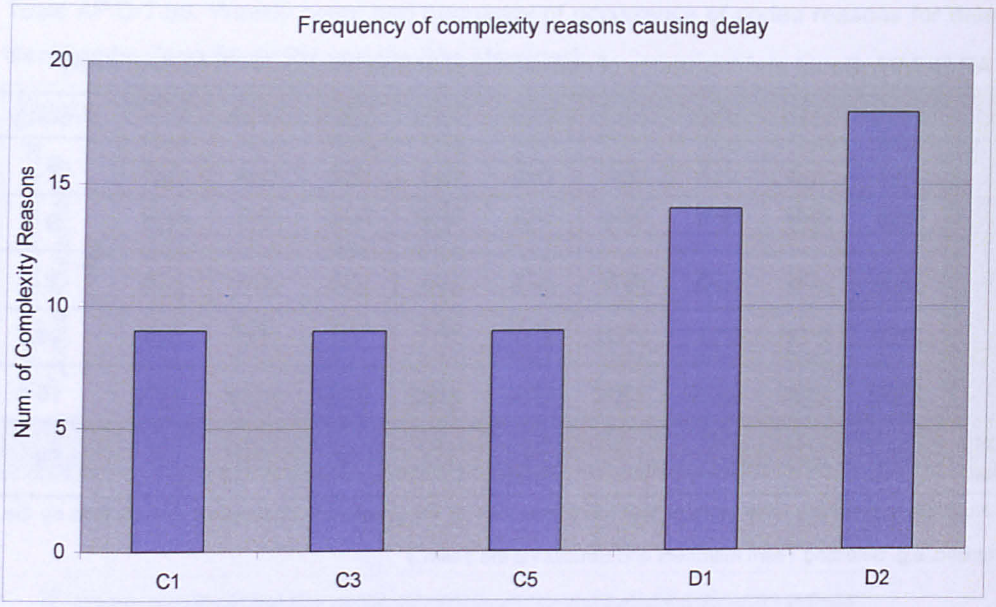



Figure AP.D-7.69 Frequency of complexity characteristics causing delay

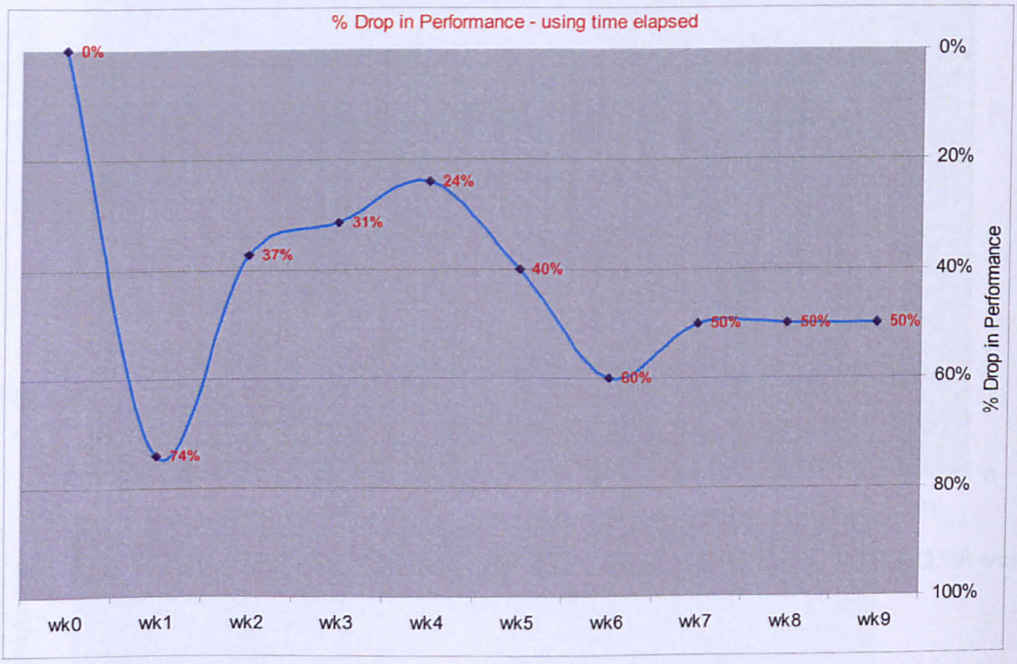



Figure AP.D-7.71 % drop in performance against time using time elapsed

## *Moderating Variables*

Table AP.D-7.100. Frequency of responses regarding the influence of moderating variables against the sub-processes under investigation

| Moderating Variable | | Team Selection | | | Team Structuring | | | Management Style | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Clnt Freq | Cntr Freq | Total Freq | Clnt Freq | Cntr Freq | Total Freq | Clnt Freq | Cntr Freq | Total Freq |
| Project Duration | VLittle | 4 | 2 | 6 | 3 | 2 | 5 | 3 | 2 | 5 |
| | Little | 9 | 9 | 18 | 10 | 9 | 19 | 19 | 8 | 27 |
| | Important | 22 | 15 | 37 | 16 | 14 | 30 | 12 | 14 | 26 |
| | VImport | 17 | 9 | 26 | 18 | 11 | 29 | 14 | 13 | 27 |
| | Critical | 0 | 4 | 4 | 5 | 3 | 8 | 4 | 2 | 6 |
| Project Budget | VLittle | 6 | 1 | 7 | 5 | 2 | 7 | 2 | 0 | 2 |
| | Little | 6 | 3 | 9 | 4 | 7 | 11 | 12 | 6 | 18 |
| | Important | 19 | 17 | 36 | 19 | 13 | 32 | 15 | 15 | 30 |
| | VImport | 19 | 15 | 34 | 19 | 14 | 33 | 21 | 16 | 37 |
| | Critical | 2 | 3 | 5 | 5 | 3 | 8 | 2 | 2 | 4 |
| Project Location | VLittle | 4 | 4 | 8 | 7 | 4 | 11 | 9 | 2 | 11 |
| | Little | 12 | 6 | 18 | 20 | 16 | 36 | 28 | 21 | 49 |
| | Important | 27 | 19 | 46 | 17 | 13 | 30 | 11 | 15 | 26 |
| | VImport | 9 | 10 | 19 | 8 | 6 | 14 | 4 | 1 | 5 |
| | Critical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Procurement Method | VLittle | 5 | 2 | 7 | 4 | 1 | 5 | 5 | 0 | 5 |
| | Little | 13 | 9 | 22 | 14 | 4 | 18 | 9 | 10 | 19 |
| | Important | 23 | 21 | 44 | 20 | 18 | 38 | 24 | 18 | 42 |
| | VImport | 10 | 5 | 15 | 13 | 15 | 28 | 13 | 8 | 21 |
| | Critical | 1 | 2 | 3 | 1 | 1 | 2 | 1 | 3 | 4 |
| Project Type | VLittle | 4 | 4 | 8 | 5 | 5 | 10 | 6 | 0 | 6 |
| | Little | 9 | 4 | 13 | 9 | 9 | 18 | 14 | 12 | 26 |
| | Important | 16 | 19 | 35 | 21 | 17 | 38 | 21 | 19 | 40 |
| | VImport | 22 | 10 | 32 | 15 | 7 | 22 | 9 | 5 | 14 |
| | Critical | 1 | 2 | 3 | 2 | 1 | 3 | 2 | 0 | 2 |

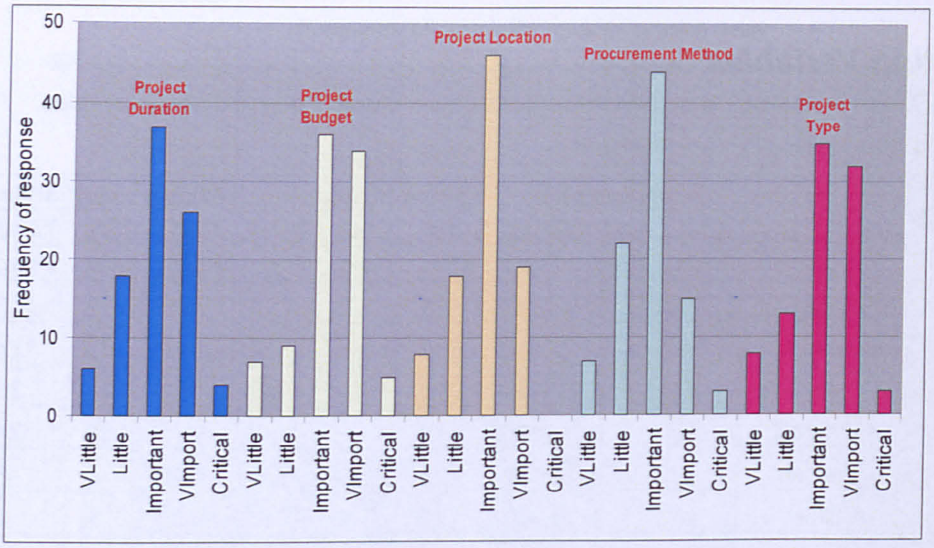



Figure AP.D-7.76. Histogram of responses on the influence of the moderating variables on Selecting Team members

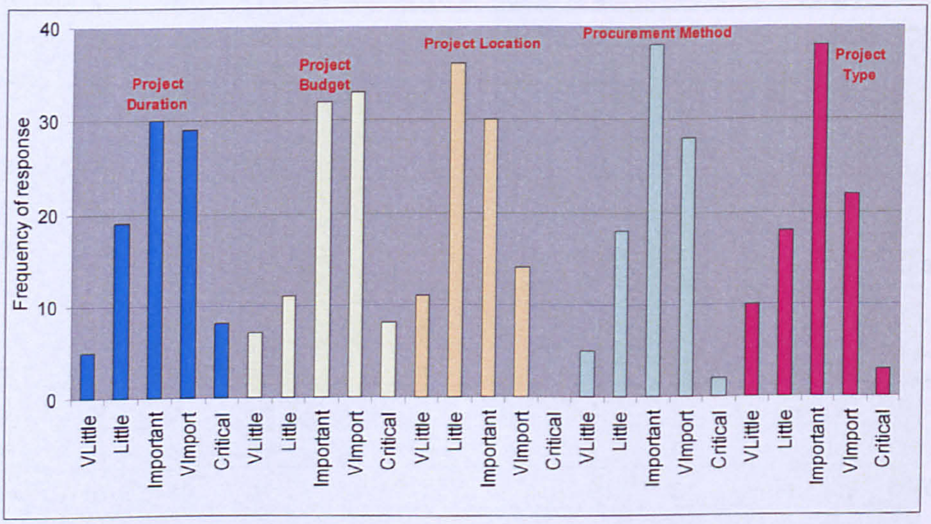



Figure AP.D-7.77. Histogram of responses on the influence of the moderating variables on Structuring the Team

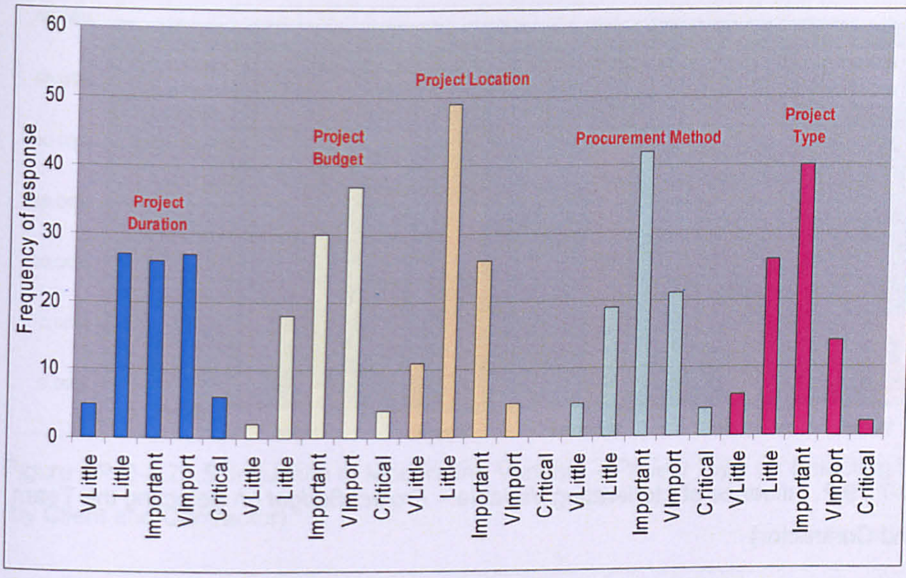



Figure AP.D-7.78. Histogram of responses on the influence of the moderating variables on the Management Style to be followed

As described in Section 7.6, a set of graphs have been created to compare the responses given regarding the influence that the moderating variables might have on the sub-processes under investigation.

**Graphs for Selecting the Team member**

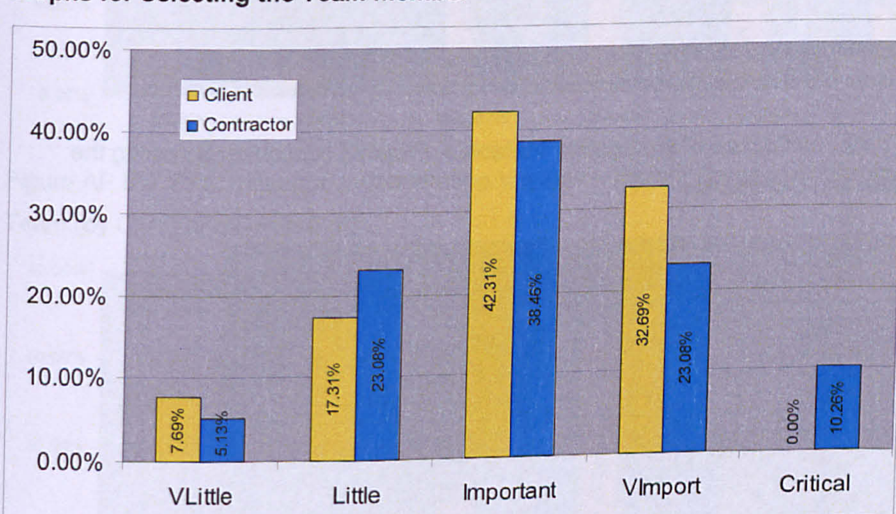



Figure AP.D-7.79.1. Influence of Moderating Variable – *Project Duration* on Selecting the Team (by Client and Contractor)

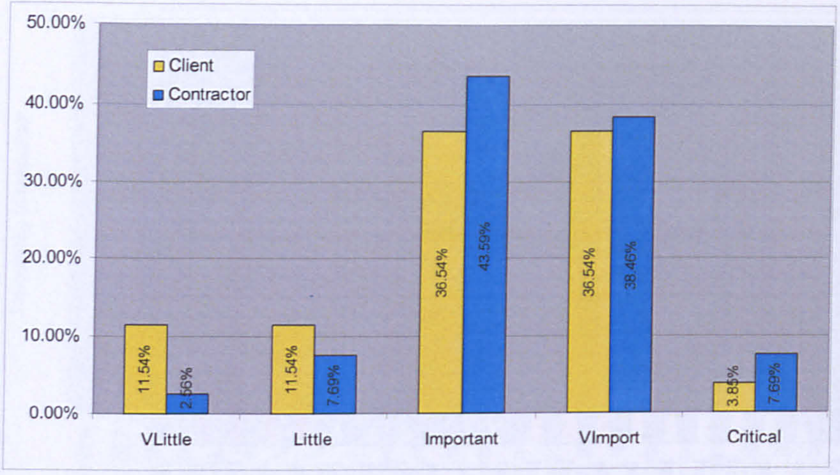



Figure AP.D-7.79.2. Influence of Moderating Variable – *Project Budget* on Selecting the Team (by Client and Contractor)

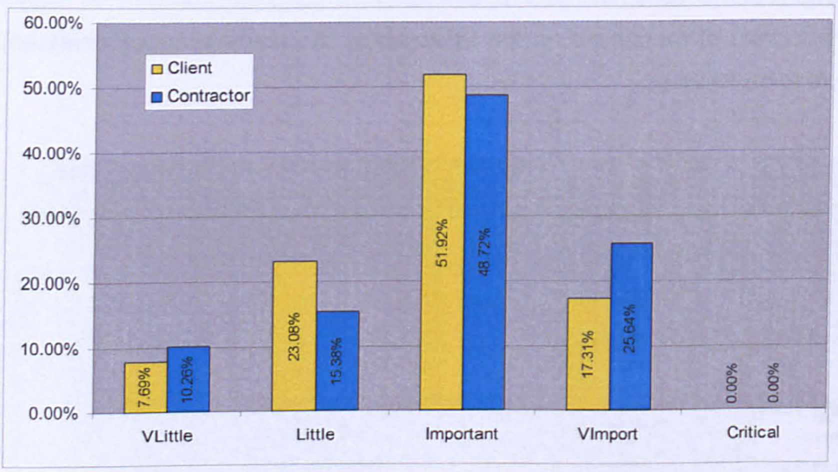



Figure AP.D-7.79.3. Influence of Moderating Variable – *Project Location* on Selecting the Team (by Client and Contractor)

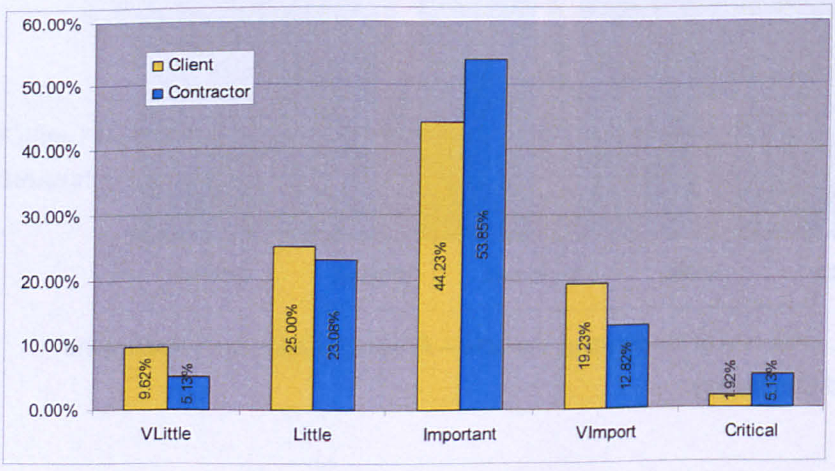



Figure AP.D-7.79.4. Influence of Moderating Variable – *Procurement Method* on Selecting the Team (by Client and Contractor)

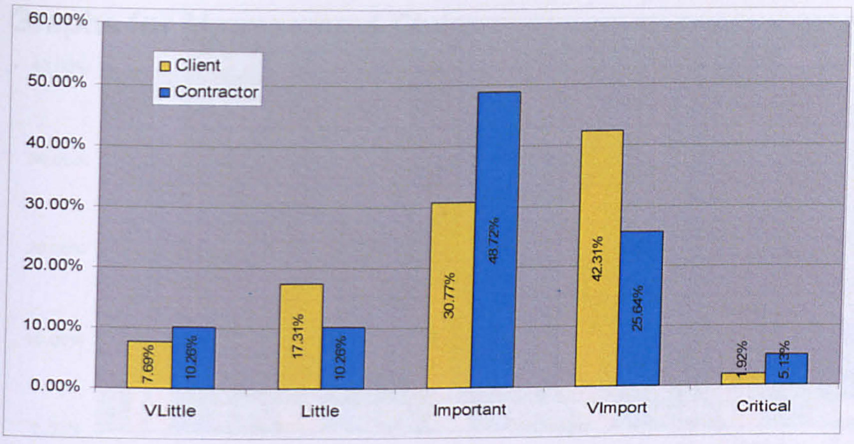



Figure AP.D-7.79.5. Influence of Moderating Variable – *Project Type* on Selecting the Team (by Client and Contractor)

## Graphs for Structuring the Team

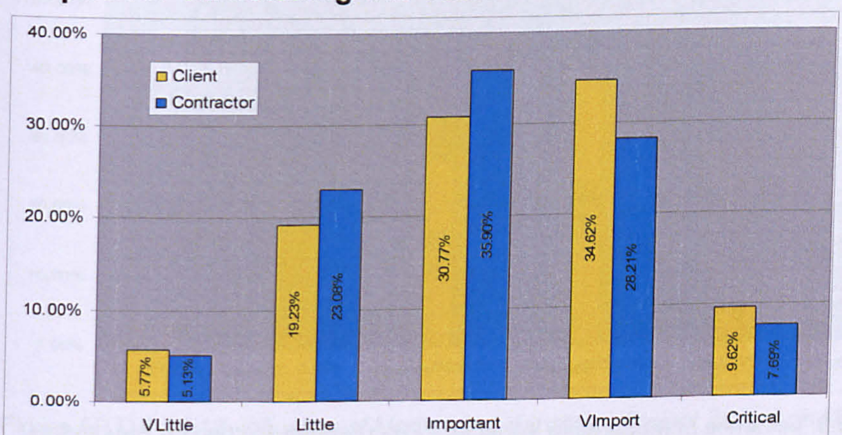



Figure AP.D-7.79.6. Influence of Moderating Variable – *Project Duration* on Structuring the Team (by Client and Contractor)

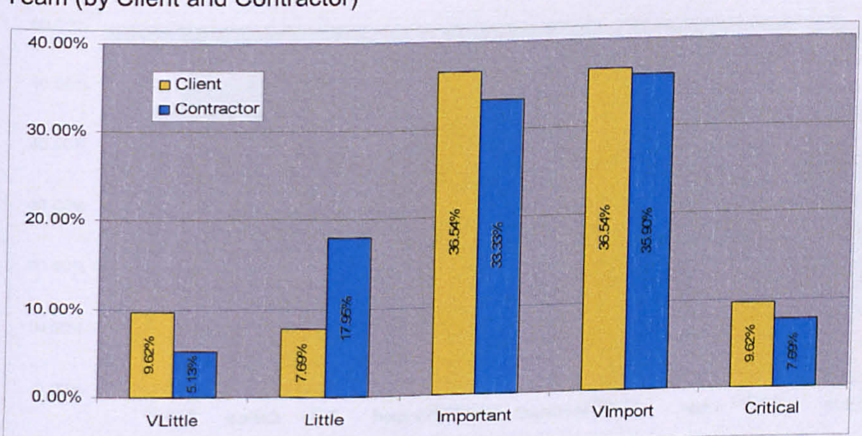



Figure AP.D-7.79.7. Influence of Moderating Variable – *Project Budget* on Structuring the Team (by Client and Contractor)

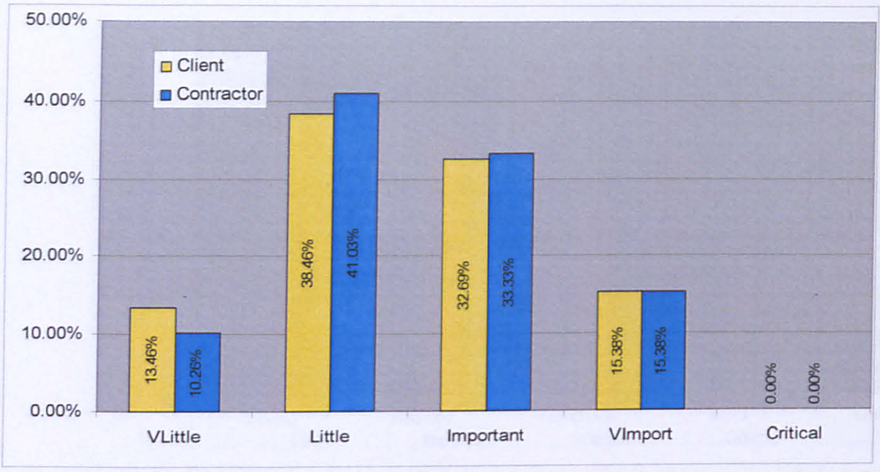



Figure AP.D-7.79.8. Influence of Moderating Variable – *Project Location* on Structuring the Team (by Client and Contractor)

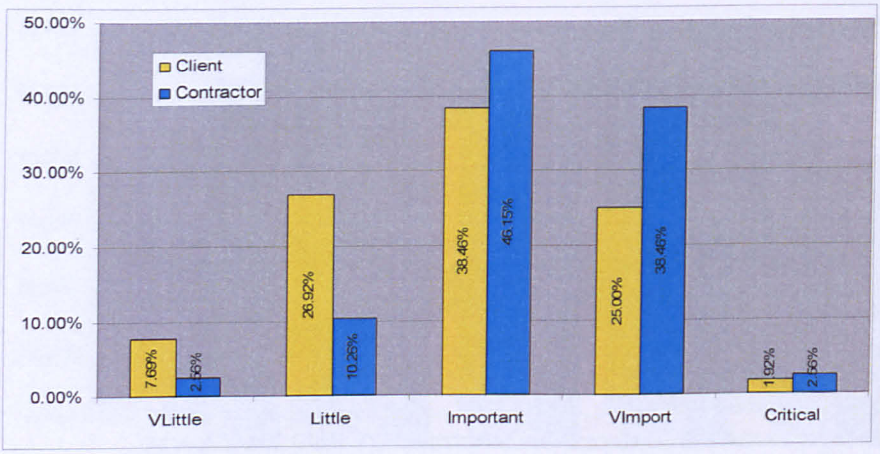



Figure AP.D-7.79.9. Influence of Moderating Variable – *Procurement Method* on Structuring the Team (by Client and Contractor)

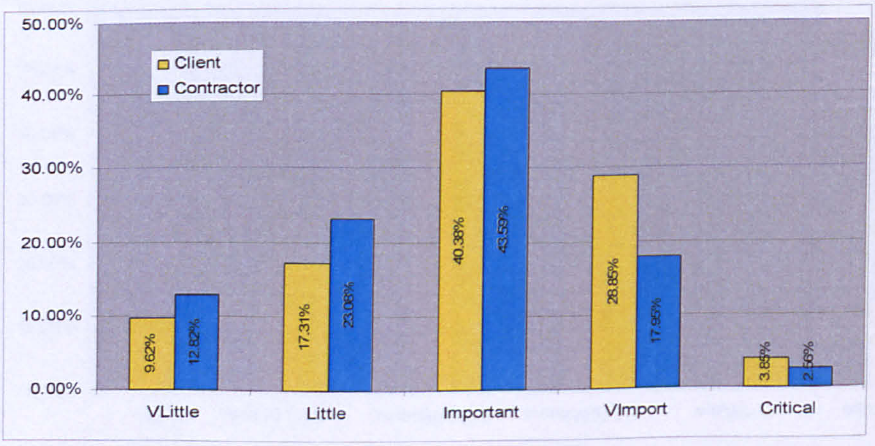



Figure AP.D-7.79.10. Influence of Moderating Variable – *Project Type* on Structuring the Team (by Client and Contractor)

## Graphs for Management Style

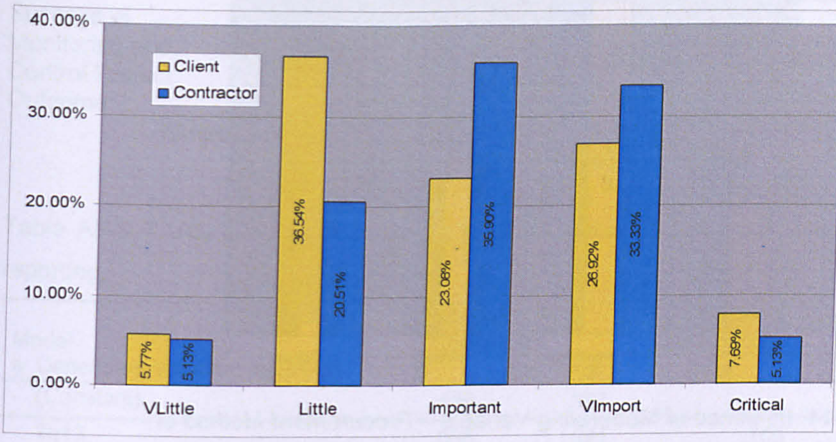



Figure AP.D-7.79.11. Influence of Moderating Variable – *Project Duration* on Management Style (by Client and Contractor)

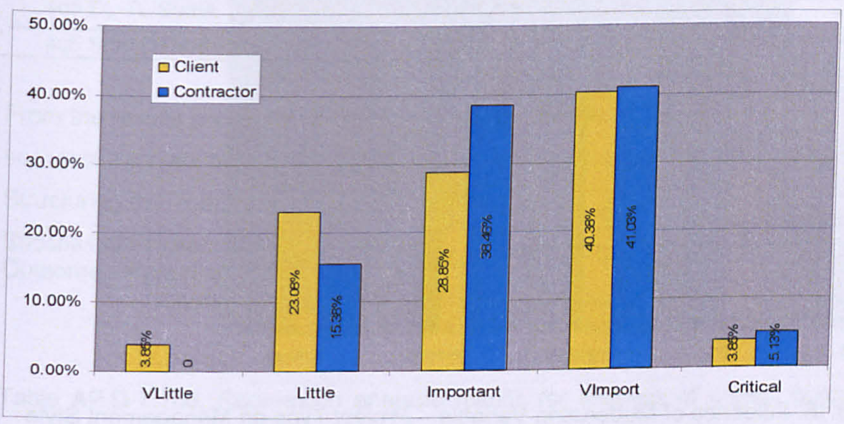



Figure AP.D-7.79.12. Influence of Moderating Variable – *Project Budget* on Management Style (by Client and Contractor)

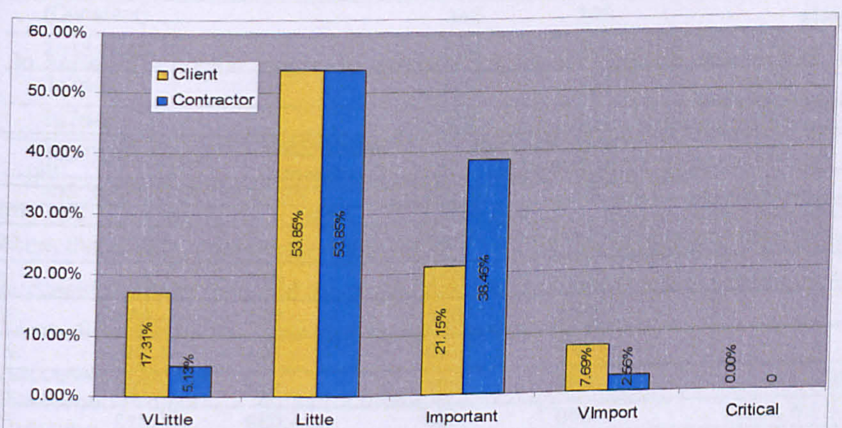



Figure AP.D-7.79.13. Influence of Moderating Variable – *Project Location* on Management Style (by Client and Contractor)

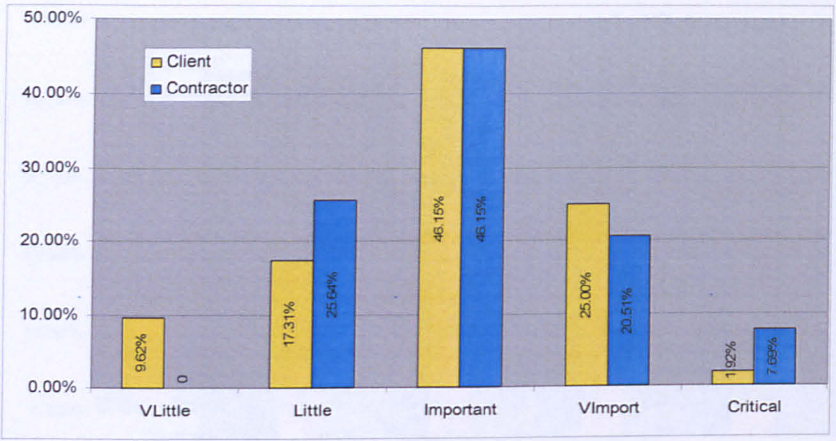



Figure AP.D-7.79.14. Influence of Moderating Variable – *Procurement Method* on Management Style (by Client and Contractor)

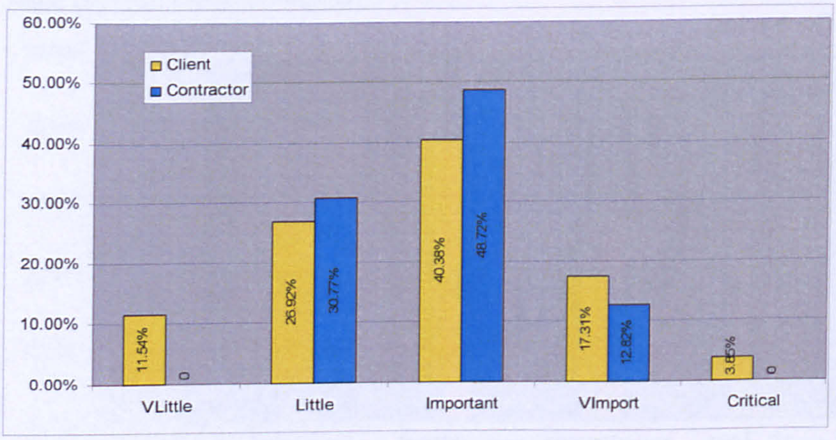



Figure AP.D-7.79.15. Influence of Moderating Variable – *Project Type* on Management Style (by Client and Contractor)

## Other Statistical results

### Regression analysis

Table AP.D-7.104. Regression analysis results for success of project outcome in terms of monitoring and control activities.

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| a Dependent Variable: 5q2d1-d3 | B | Std. Error | Beta | B | Std. Error |
| (Constant) | .810 | .345 | | 2.348 | .021 |
| 2q13 | -.120 | .081 | -.167 | -1.491 | .140 |
| 3q2 | -.023 | .025 | -.103 | -.933 | .354 |
| 3q7 | -.178 | .140 | -.143 | -1.265 | .210 |
| 4q5 DL-TL SumA | -.032 | .027 | -.149 | -1.196 | .235 |
| 4q5 Sprv-DTM-STM SumA | -.010 | .033 | -.039 | -.312 | .756 |

From the results presented in table AP.D-7.104 the following model can be generated for the successful project outcome for monitoring and control activities (in terms / as a function of

Selecting the Team, Structuring the Team and the Management Style):

| | |
|---|---|
| Success of Monitoring and Control Project Outcome | =0.810 - 0.120(A) – 0.023(B) - 0.178(C) - 0.032(D) - 0.010(E) |

Where: A = 2q13; B = 3q2; C = 3q7;
D = 4q5DL&TL; E = 4q5Sprv2STM

Table AP.D-7.105. Regression analysis results for success of project outcome in terms of reporting.

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| a Dependent Variable: 5q2e1-e3 | B | Std. Error | Beta | B | Std. Error |
| (Constant) | .435 | .391 | | 1.112 | .269 |
| 2q13 | .085 | .091 | .105 | .927 | .357 |
| 3q2 | -.010 | .028 | -.038 | -.340 | .735 |
| 3q7 | -.207 | .159 | -.149 | -1.300 | .197 |
| 4q5 DL-TL SumA | .005 | .030 | .019 | .153 | .879 |
| 4q5 Sprv-DTM-STM SumA | -.005 | .038 | -.018 | -.141 | .889 |

From the results presented in table AP.D-7.105 the following model can be generated for the successful project outcome for reporting (in terms / as a function of Selecting the Team, Structuring the Team and the Management Style):

| | |
|---|---|
| Success of Project Outcome - Reporting | =0.435 + 0.085(A) - 0.010(B) - 0.207(C) + 0.005(D) - 0.005(E) |

Where: A = 2q13; B = 3q2; C = 3q7
D = 4q5DL&TL; E = 4q5Sprv2STM

Table AP.D-7.106. Regression analysis results for success of project outcome in terms of conflict resolution.

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| a Dependent Variable: 5q2f1-f3 | B | Std. Error | Beta | B | Std. Error |
| (Constant) | .346 | .395 | | .875 | .384 |
| 2q13a1-a5 | .062 | .092 | .077 | .673 | .503 |
| 3q2a-e | .002 | .028 | .009 | .079 | .937 |
| 3q7a-e | -.026 | .161 | -.019 | -.161 | .872 |
| 4q5 DL-TL SumA | .017 | .031 | .072 | .568 | .572 |
| 4q5 Sprv-DTM-STM SumA | -.026 | .038 | -.087 | -.682 | .497 |

From the results presented in table AP.D-7.106 the following model can be generated for the successful project outcome for conflict resolution (in terms / as a function of Selecting the Team, Structuring the Team and the Management Style):

| | |
|---|---|
| Success of Conflict Resolution Project Outcome | =0.346 + 0.062(A) - 0.002(B) - 0.026(C) + 0.017(D) - 0.026(E) |

Where: A = 2q13; B = 3q2; C = 3q7;
D = 4q5DL&TL; E = 4q5Sprv2STM

Table AP.D-7.107. Regression analysis results for success of project outcome in terms of efficient use of resources.

| Model<br>a Dependent Variable: 5q2g1-g3 | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t<br>B | Sig.<br>Std. Error |
|---|---|---|---|---|---|
| (Constant) | -.368 | .359 | | -1.025 | .309 |
| 2q13a1-a5 | -.018 | .084 | -.022 | -.209 | .835 |
| 3q2a-e | -.050 | .026 | -.205 | -1.931 | .057 |
| 3q7a-e | .301 | .146 | .222 | 2.056 | .043 |
| 4q5 DL-TL SumA | .000 | .028 | .002 | .016 | .987 |
| 4q5 Sprv-DTM-STM SumA | .063 | .035 | .216 | 1.807 | .075 |

From the results presented in table AP.D-7.107 the following model can be generated for the successful project outcome for efficient usage of resources (in terms / as a function of Selecting the Team, Structuring the Team and the Management Style):

Success of Efficient use of Resources Project Outcome = - 0.368 - 0.018(A) - 0.050(B) + 0.301(C) + 0.000(D) + 0.063(E)

Where: A = 2q13; B = 3q2; C = 3q7; D = 4q5DL&TL; E = 4q5Sprv2STM

*It should be noted that in order to be able to utilise the above models as predictors these will need to be tested further by carrying case studies and verifying the results.*

## Factor Analysis

Continuation from Section 7.7.2 Chapter 7 of Factor Analysis of Coefficients of Successful and Acceptable Project Management Outcome against the remaining project management sub-processes for representative questions from the postal questionnaire

Tables AP.D-7.108.4 to AP.D-7.108.7. Factor Analysis of Coefficients of Successful and Acceptable Project Management Outcome against sub-processes investigated and remaining project outcome sub-processes

| Table AP.D-7.108.4<br>**Monitoring & Control** | Cases for which Monitoring & Control = **Successful** Project Outcome | | | Cases for which Monitoring & Control = **Acceptable** Project Outcome | |
|---|---|---|---|---|---|
| Component | 1 | 2 | 3 | 1 | 2 |
| 2q4 | -0.025 | 0.663 | 0.451 | 0.062 | -0.740 |
| 2q13 | -0.568 | 0.230 | 0.646 | 0.188 | 0.632 |
| 3q7 | 0.717 | -0.001 | -0.317 | 0.018 | 0.359 |
| 4q4a_Discipline Leader | 0.755 | 0.150 | 0.374 | 0.720 | 0.178 |
| 4q4b_Team Leader | 0.719 | 0.611 | -0.180 | 0.824 | 0.015 |
| 4q4c_Supervisor | 0.715 | 0.601 | -0.204 | 0.895 | -0.106 |
| 4q4d_Design Team Member | 0.712 | -0.297 | 0.009 | 0.853 | -0.022 |
| 4q4e_Site Team Member | 0.827 | -0.375 | 0.362 | 0.904 | -0.106 |
| 4q4f_Project Support | 0.832 | -0.376 | 0.353 | 0.837 | -0.013 |

Table AP.D-7.108.5
**Reporting**

| Component | Cases for which Reporting = **Successful** Project Outcome 1 | 2 | 3 | Cases for which Reporting = **Acceptable** Project Outcome 1 | 2 | 3 |
|---|---|---|---|---|---|---|
| 2q4 | 0.026 | 0.255 | 0.642 | 0.087 | -0.542 | 0.805 |
| 2q13 | -0.043 | -0.897 | 0.132 | 0.191 | 0.651 | 0.425 |
| 3q7 | -0.066 | 0.895 | -0.092 | 0.404 | 0.671 | 0.199 |
| 4q4a_Discipline Leader | 0.860 | -0.066 | -0.112 | 0.731 | 0.048 | 0.211 |
| 4q4b_Team Leader | 0.785 | 0.044 | 0.546 | 0.834 | 0.024 | -0.136 |
| 4q4c_Supervisor | 0.782 | 0.034 | 0.545 | 0.857 | -0.198 | -0.184 |
| 4q4d_Design Team Member | 0.876 | -0.081 | -0.213 | 0.849 | -0.092 | 0.096 |
| 4q4e_Site Team Member | 0.898 | 0.035 | -0.334 | 0.867 | -0.202 | 0.017 |
| 4q4f_Project Support | 0.894 | 0.054 | -0.323 | 0.859 | 0.022 | -0.245 |

Table AP.D-7.108.6
**Conflict Resolution**

| Component | Cases for which Conflict Resolution = **Successful** Project Outcome 1 | 2 | Cases for which Conflict Resolution = **Acceptable** Project Outcome 1 | 2 | 3 |
|---|---|---|---|---|---|
| 2q4 | 0.140 | -0.736 | 0.149 | 0.551 | -0.674 |
| 2q13 | -0.107 | 0.720 | 0.228 | 0.721 | 0.064 |
| 3q7 | 0.625 | 0.259 | 0.032 | 0.469 | 0.751 |
| 4q4a_Discipline Leader | 0.745 | 0.127 | 0.773 | 0.045 | 0.043 |
| 4q4b_Team Leader | 0.849 | 0.007 | 0.825 | 0.077 | -0.057 |
| 4q4c_Supervisor | 0.789 | -0.189 | 0.888 | -0.007 | -0.048 |
| 4q4d_Design Team Member | 0.852 | 0.137 | 0.840 | -0.284 | 0.080 |
| 4q4e_Site Team Member | 0.762 | -0.170 | 0.948 | -0.095 | 0.018 |
| 4q4f_Project Support | 0.680 | 0.116 | 0.937 | -0.027 | 0.035 |

Table AP.D-7.108.7
**Efficient Use of Resource**

| Component | Cases for which Efficient Resource usage = **Successful** Project Outcome 1 | 2 | Cases for which Efficient Resource usage = **Acceptable** Project Outcome 1 | 2 | 3 |
|---|---|---|---|---|---|
| 2q4 | 0.297 | -0.836 | 0.096 | 0.867 | 0.014 |
| 2q13 | -0.497 | 0.074 | 0.314 | -0.499 | 0.021 |
| 3q7 | -0.094 | 0.707 | 0.335 | 0.127 | 0.808 |
| 4q4a_Discipline Leader | 0.776 | -0.250 | 0.744 | -0.231 | 0.255 |
| 4q4b_Team Leader | 0.905 | 0.223 | 0.794 | 0.030 | 0.268 |
| 4q4c_Supervisor | 0.899 | 0.256 | 0.819 | 0.222 | -0.225 |
| 4q4d_Design Team Member | 0.889 | -0.006 | 0.847 | -0.001 | -0.016 |
| 4q4e_Site Team Member | 0.911 | -0.031 | 0.859 | 0.121 | -0.317 |
| 4q4f_Project Support | 0.922 | 0.159 | 0.797 | -0.132 | -0.266 |

# Appendix E – Chapter 9 – Discussion

Table E-9.1 Social Network Analysis properties, attributes and other characteristics as identified by various authors

| Tichy et al, 1979 | Loosemore, 1998 | Mead, 2001 | Behrend, 2006 |
|---|---|---|---|
| *Identified three properties* | *Investigated usefulness of centrality* | *Analysis in terms of specific attributes and characteristics* | *Investigates special network roles.* |
| **Transactional content** (what is exchanged) : | **Socio-centric centrality** -the degree to which info flows are centred on one or few organisational units | **Whole-networks** - looks at the whole network and for which we can easily establish the boundaries | Identified the ability to assign an '***actor** related **index***' against each person in the network, which will then indicate the individual's standing in the network, e.g. influence, prestige. |
| Expression of affect | **Ego-centric centrality** - the degree to which information flows focus upon a target individual | **Ego-centered** -looking at a particular person and the connections it has | |
| Influence attempt | | | |
| Exchange of information | | | |
| Exchange of goods / services | | | |
| **Nature of links** (strength of relation): | | | |
| Intensity | *Differentiation between:* | *Attributes:* | *Roles:* |
| Reciprocity | **Degree Centrality** - extent to which a person is connected to its immediate environ | **Roles** (provide depth to OBS): | **Central connectors** - high number of direct info relationships & organisational wisdom |
| Clarity of expectations | | Group member | |
| Multiplexity | | Group thinker | |
| **Structural characteristics** (pattern of relationship): | **Closeness Centrality** - for ego-centric it indicates the distance of the individual node in the network. At the socio-centric it indicates the extent to which the whole network is close to one or a few people | Isolate | **Peripheral players** - fewer tie, near the boundaries, dissatisfied, could provide innovative solutions |
| Size | | Star | |
| Density (connectedness) | | **Network Linkages** (properties): | |
| Clustering | | Symmetry | **Brokers** - have ties across sub-groups – unique ability to help integration |
| Openness | | Centrality | |
| Stability | **Betweenness Centrality** - measures the extent to which a particular point lies between other points in the network | Direction (up, down, horizontal) | |
| Reachability | | Reciprocity | |
| Centrality | | Multiplexity | |
| Star | | **Metrics** (features of the network): | |
| Liaison | | Size | |
| Bridge | | Density | |
| Gatekeeper | | | |
| Isolate | | | |

# Appendix F – Chapter 10 – Recommendations

# Appendix F-6.1 – Validation Questionnaire

A Framework for Managing the Complexity of Interconnections

# Questionnaire for the Validation of the F4MCI Framework for Managing Complexity of Interconnections

As part of the validation process we request your feedback on the Framework for Managing Complexity of Interconnections in the UK Construction industry. Please provide your feedback on the questions below by clicking on the scale provided (1 = Poor to 5 = Excellent).

| | YES | NO |
|---|---|---|
| Do you concur with the findings regarding complexity of interconnections? | ☐ | ☐ |

| Questions regarding the Complexity Framework | Poor | | | | Excellent |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1. Provides a systematic approach to managing complexity of interconnections in the sub-processes of selection of team members, structuring the project team and the management style followed | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2. Provides PMs with a tool to manage the effects of complexity of interconnections in the three sub-processes | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3. Provides PMs with adequate actions to manage the effects of complexity in the three sub-processes | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4. Improves the process of selecting project team members | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5. Improves the structuring of project teams | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6. Allows PMs to consider the management style to be followed | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7. Adaptable and easy to implement at any stage of the project | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8. Ease of implementation as new teams are formed in project | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9. Enables the setting up of continuous improvement targets? | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10. Provides PMs with the flexibility to add more actions? | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11. Ease of use of the framework | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12. Ease of understanding the framework | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13. Easy of understanding the outcome | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14. Ease of linking back to the actions required | ☐ | ☐ | ☐ | ☐ | ☐ |
| 15. Applicability to construction organisations | ☐ | ☐ | ☐ | ☐ | ☐ |

| | YES | NO |
|---|---|---|
| Would you recommend the use of the framework in the UK construction industry? | ☐ | ☐ |

Please provide additional comments in the space provided below:

| **Comments** |
|---|
| |

# Appendix F-6.2 – Framework Validation Interviewee Brief

A Framework for Managing the Complexity of Interconnections

# A Framework for the management of complexity from interconnections in project environments

## Background

Projects in engineering and construction increasingly reflect levels of complexity that transcend the technical aspects covering the social and managerial. On the practitioner's side little guidance is given in terms of defining and managing the effects of complexity

The management of such complexities to bring about successful delivery of projects rests on the ability of key project engineers and managers to identify the conditions and situations that give rise to the growing problem of complexity. The interview will present a framework for systematically identifying the conditions under which complexities in project environments arise.

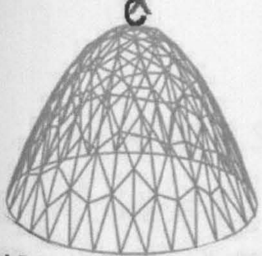
## About the Framework

### The Aim

The aim of the framework is to address and resolve complexity created by the interconnections between systems - individuals, parties / teams, on the project as well as complexity from the management style.

### The objectives

- To use the complexity characteristics to identify the actions to be taken in order to minimise or maximise the effects of complexity in the project management sub-processes of:
    - selecting team members,
    - structuring the team, and
    - the management style,
- To enable the understanding of complexity of interconnections,
- To improve the organisational set up and the management of projects
- To provide a flexible and adaptable framework that will be easy to implement at any stage of the project and continuously (preferably from the very early stages),
- To be linked to the number of times teams are formed or disbanded,
- To enable the setting up and following up of continuous improvement targets in the three sub-processes,
- The framework should fit the team and not the opposite.



A Framework for Managing the Complexity of Interconnections

## What is the Framework?

Using a set of assessment questions the framework enables the practitioner to establish current levels of managing complexity of interconnections.

In parallel with the assessment, the practitioner is given an indication of a minimal set of actions which when implemented will provide the means to deal with the effects of each complexity characteristic. It allows the practitioner to add more detail, in terms of actions, if required, *thus enabling it to be flexible and fit the* project requirements.

The assessment can be re-run at different stages, as teams are formed and disbanded, ensuring actions taken remain current, establishing progress achieved and indicating the next set of actions that should be taken engendering continuous improvement.

## About the Interviews

The aim of the interview will be to address the complexity of interconnections in the three project management sub-processes – selecting team members, structuring the team and management of the team / style, as well as seeking the validation of the framework developed to manage the complexity characteristics. It will cover:

- the topic of complexity of interconnections;
- the difficulties stemming from lack of definition of complexity;
- the aim and objectives of the research and the results obtained from the research multi-method implemented in the three sub-processes under investigation;
- the proposed framework, its purpose, how and when it should be used and what is the output.

The format of the interview is:

| | |
|---|---|
| Opening | |
| Topic Presentation | 15 minutes |
| Framework presentation | 20 minutes |
| Discussion | 15 minutes |
| Feedback and Closing | 10 minutes |

Participants will be given a copy of the framework ready to be used / implemented.

# Appendix F-6.3 – Supplementary Findings

# AP.F-6.3 Proposal for Finite Structure

## *AP.F-6.3.1 Introduction*

The particularly low results obtained from the quantitative and qualitative research method on the structuring of project teams, as well as the low ranking given by the respondents to the sub-process, despite extensive literature available, prompted the author to dwell on and propose an alternative approach.

Considering the project structure in three dimensions – time, project organisational depth and width, allows for improved visualisation as well as early consideration of the approach to be taken when structuring the project and for the duration of the project. It enables thus the translation of the current, inaccurate, cost spreadsheets into real project structure and cost.

Further on by considering individuals as nodal points in a 3D structure it facilitates:

- the introduction of complex adaptive systems;
- the establishment of the project functions of the structure;
- the formation of clusters and fractal structures of various shapes;
- the identification of key players / autonomous agents within the structure;
- improved accuracy of resource management;
- the introduction of theories such as finite element analysis, and string theory, which will allow for testing of hypothetical as well as real organisational structures under varying conditions – internal and external; and
- the incorporation of individuals' characteristics through personal profiling, psychometric tests, etc.

It is the integration of a number of theories from different fields of engineering, physics and psychology which allows for a holistic and non-mechanistic view of structuring project organisations.

Resource limitations as well as the extent of this research have not allowed for the testing of the above proposal, however, the remaining steps will be described below as part of the recommendations for future research.

The analysis and discussion of the research results indicated clearly that PM practitioners are not considering the current approach to project structuring as a process that contributes as much as it should / is described in project management literature.

Literature review also established that '*new models of human organisation are needed to replace hierarchical bureaucracies*' (Belbin, 2000) and studies carried out (Shirazi et al, 1996; Andersen, 2003; Green, 2006) indicate clearly that '*hierarchical elements of the project must be eliminated for a project to move closer to the prevalent task culture*' (Andersen, 2003). Belbin (2000) also confirms that '*if jobs are not formulated to hang together as a dynamic entity within a coherent system, the effectiveness of the whole will be severely weakened*' (Belbin, 2000). This is confirmed by the findings of the quantitative and qualitative results indicating that when structuring project teams PM practitioners simply follow experience and are not able to express this in such research methods as interview questionnaires, because of the effect of the observer and observed syndrome.

The above together with the demanding requirements transpiring from the definition of project management stated below require a different approach to structuring projects. The new approach should be one that will encompass the latest thinking and above all earn the confidence of the PM practitioners that as a project management sub-process it addresses the issues raised.

> Project Management definition
> The management of transient, dynamic and complex adaptive systems/agents, so as to deliver the expected change within certain parameters that are set by a seemingly ordered and stable environment

In order to provide clarity and a holistic view to what will be proposed from this research for further investigation a brief review of the relevant topics in the supporting literature will be carried out, followed by the proposal for a Finite Structure (FS) approach to organising and structuring projects in construction.

## AP.F-6.3.2 Review and Initial Concepts

**Social Network Theory**

The Social Network Analysis (SNA) properties, attributes and roles identified by Tichy et al., (1979), Loosemore (1998) and others and shown in Appendix 5, can be utilised to describe a number of properties within Finite Structure (FS). The extensive correlation between SNA and complexity can be appreciated when considering the basic principles in SNA (Loosemore, 1998:316):

- *People are interdependent rather than dependent*; Therefore establishing interconnections and supporting the complexity of interconnections characteristic of autonomous agents;
- *People are embedded in complex and dynamic social networks which influence their behaviour.* Since people deliver projects and people form complex and dynamic social networks complexity characteristics apply;
- *Relationships*, considered as behavioural interconnections, *are as important as individuals in determining behaviours*;
- *The change is a constant feature of social life and must be accounted for in a research context.* This also supports Lucas' (2000a) definition of complexity.

Considering the above one of the SNA tools that can be used in conjunction with FS is the 'Network Sociogram' (Mead, 2001), which gives a graphical representation of the linkage between the team members. The communicational characteristics of each node could be combined with the other characteristics to create a much more accurate picture of the Complex Adaptive System (CAS).

What also has to be considered is the effect, or rather how, the node (the individuals) with its distinctive characteristics will affect the link(s) / interconnections and even more, what link(s) is it likely to set up. For example an extrovert will, very likely, set up links with high intensity and reciprocity, express affect and attempt to influence others. However, an introvert is highly unlikely that will be comfortable doing so. Therefore we see that the appropriate links are very much dependant upon the characteristics of the node.

This is where the FS contributes to a holistic approach to organising in dynamic environments. In FS the whole concept will be represented for both the linkages and the nodes and we are able to define at an earlier stage the required structural characteristics of the system.

By setting up clusters, within the project, it will be possible to define a number of structural characteristics that the project network (of people) should have. This is not necessarily a set up to predetermine the project outcome and each move during the project life, because this will be defeating the object in a Creative Reflective framework, but rather as an initial guidance to a successful outcome.

The properties of centrality and its sub-processes (Loosemore, 1998) can be considered and resolve a number of details of the FS, as will be described below.

The properties of centrality can be one of the characteristics on the FS clusters. As information flows in the FS clusters centrality will be one of the fundamental drivers for the self-managed units. It will be important to define the degree of that flow which could be to individuals or groups respectively. The former will be when the project is in the construction phase where extensive levels of information flow to different clusters. The latter will be during the very early phases or during commissioning, where a smaller number of groups have to interface and retrieve information generated at early project phases.

Some of the most important properties of centrality that can be considered are reviewed below:

- Degree centrality (Loosemore, 1998). This property will be used at a lower level within the clusters to indicate which member of the cluster, or even which cluster should have a high index of in-degree or out-degree centrality. This SNA property will be combined with the groups' or individual's characteristics in order to match the individual's strength to that required by the role.
- Closeness centrality (Loosemore, 1998). The level of working independently in the FS cluster will not be an issue because the members of the cluster will have to work independently carrying out the task for which they have been brought into the cluster. What will be utilised here is the rapid dissemination of information between the members. Therefore the degree of closeness centrality will be a characteristic of the framework.

- Betweenness centrality (Loosemore, 1998). This characteristic will be a safeguarding characteristic within FS. Identifying the level of acceptability of betweenness centrality within the framework will allow for triggering an alarm when this is exceeded by any member of the cluster. It will also be a testing trigger when setting up the FS cluster.

**Sub-assemblies / Clusters**

By creating low level stable subassemblies and then linking those together to create larger ones, until the overall structure has been formed, enables the creation of a very stable and flexible / adaptable structure with fewer interdependencies (Breuner, 1995).

The concept of subassemblies / clusters, as will be described below, can support the FS approach to structuring a Project Team. The size of the subassemblies could contain up to ten individuals, which as indicated by Maylor (1996) is the size of a team that works best in construction. Weick's (1979) rules will also be used for setting up interacts / dependencies in the FS mesh (individuals and subassemblies) and in particular for assembling the double interacts.

**Emergence**

To overcome the organisational inadequacy (Shirazi et al, 1996) the PM is required to organise a self managing / self organising system in a distributed responsibility approach and the inclusion of autonomous agents. Establishing clusters and in particular multi-skilled ones and relying on autonomous agents (diversity agents – Breuner, 1995) creates emergence, improves the problem solving capacity and minimises complexity both in the construction as well as the human system (Bertelsen, 2004).

**Differentiation and Interconnections**

Clustering introduces differentiation which requires more integration (Lawrence and Lorch, 1967), in order to bring together the various teams. However, the demand for more integration increases administration (Yuan and Pheng, 1992) and complexity of interconnections (Lucas, 2000a) and because interconnections expand, information / communication demands more. However, complexity of interconnections will be managed with the framework (F4MCI) proposed by this thesis and the information demands will be managed using Weick's (1979) rules.

In addition to the required integration the proposed changes introduce more 'weight' / cost to the project and as a consequence another problem is added. However, if we consider the parallel of the aircraft frame where the use of a lighter frame, honeycomb structures, enables the plane to fly, a similar structure can be set up in teams.

The honeycomb structure panels provide the required strength, can take the required load and perform in a similar manner to solid panels. This 'property' will be discussed further below.

**Fractals**

In addition to the above, Moore (2002) describes how by using the fractals theory, structural chromosomes can be linked via the strange attractors, which are points towards which systems are drawn to. Depending on the complexity of the project organism genome these could have single point of attraction for a simple genome and the more complex ones a larger number of attractors.

This is where a parallel with the Mandlebrot fractal can be drawn (Williams, 1999). The multiplicity of goals and the stakeholders as well as the multifaceted / multi-project environment within which the individual project exists can be visualised in the M-fractal. However, whereas the structure of the M-fractal in infinite, a project structure is finite, therefore it should be possible to establish a solution at / from the right level upwards and towards the centre. The M-fractal approach to Project Management allows also the concept of multiple PMs within a project (Williams, 1999).

**Strange Attractors**

The importance of the strange attractors was reviewed in the Complexity Chapter.
Human / social systems are dynamic and complex and project structures are no exception to this. Identifying the strange attractor in which the project operates will be very difficult. However, understanding and accepting their existence will allow team members to explore the patterns and use appropriate behaviour(s), focus on the real dynamics of human interactions and even identify individuals (autonomous agents) that will drive towards acceptable patterns. In the case of construction projects the industry has designed a number of roles which are there to minimise instability, introduce mutability and non-uniformity to avert 'flipping' into chaotic status. For example Health & Safety Managers and Quality Managers could be considered for such roles. The important action is to define such roles at the lower levels, within the clusters / subassemblies, which are not necessarily carried out by the team leaders.

**Cross-functional Team Behaviours**

Johns (1995) indicates that within teamwork cross-functional teams improve the quality of the work. This, however, requires people with different '*cognitive problem solving styles*' and Johns (1995) identified two different types, the N-type and the S-type. These two types could be considered in FS when establishing / identifying autonomous agents. The N-Type / Intuitive one is looking at the big picture attempting different approaches, and the S-Type / Systems – Sensation type who pay attention to the detail and prefer stable conditions. A balance of these two types in a cross-functional team will produce the best output.

In addition to the role that the two types of autonomous agents will have on the clusters it will mean that each party to the project has selected its project team members using personal profiling and / or team selection techniques.

## *AP.F-6.3.3 The proposed Finite Structure (FS)*

**From 2D to 3D Structure**

The current approach to project organisational structures is hierarchical and two dimensional. Project structures are drawn at the beginning of the project and at high levels (Moore, 2002), introduced in Project Management Plans (PMP) and most of the times are never to be revisited. At most, resource profiles are provided but these do not provide any information with regard to organisational structure. The only level where detailed team information exists is for cost reports, which have nothing to do with structuring project team.

Therefore, and as discussed earlier, the process is not providing any support and does not give any confidence to PM practitioners. Also the lack of depth, in terms of organisation levels and the static approach taken does not help either.

A new approach would have to consider:

1. Depth of the Organisational Breakdown Structure (OBS), as the structure is considered to the lowest level
2. Length of the OBS, as the project (therefore the structure) travels in time through the phases and stages of the project.
3. Width of the OBS, as the structure is considered in terms of the number of teams / clusters that are operating on the project.

A pictorial view of the 2D (from bullet points 1 and 2) and 3D (all three bullet points) are shown below in Figures AP.F-6.1 and AP.F-6.2.

Therefore, from Figures AP.F-6.1, the structure is travelling on a time axis and obviously changes and varies in depth as the project progresses. It includes the whole of the organisational structure not only the project's (that is all the contributors to the project) at the appropriate level of responsibility, e.g. the owner of the project from every organisation, which is the person that can make decisions. With this approach the problem of 'lack of responsibility' within the various levels of the project is minimised.

The level of the organisational structure is on y-axis so that it depicts the depth of the structure.

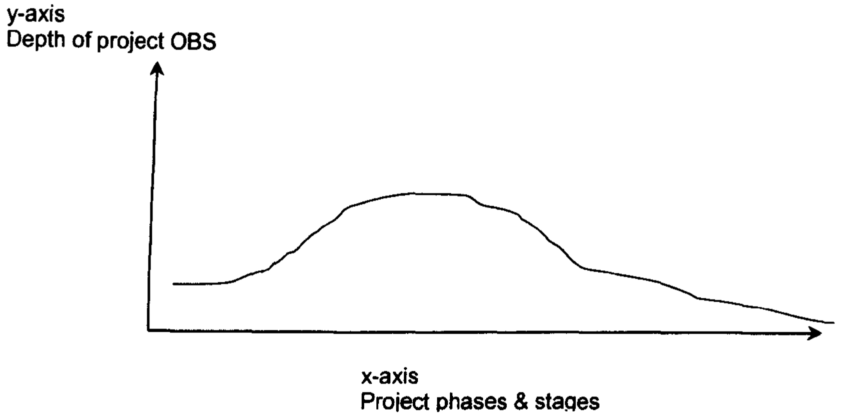


Figure AP.F-6.1. Pictorial representation of the 2D proposed approach to presenting project structuring

The proposed approach will also highlight and support the importance of early involvement of contractors – at design stage - and continuous support by the design team – during handover – as well as flexibility in starting works early (e.g. enabling works).

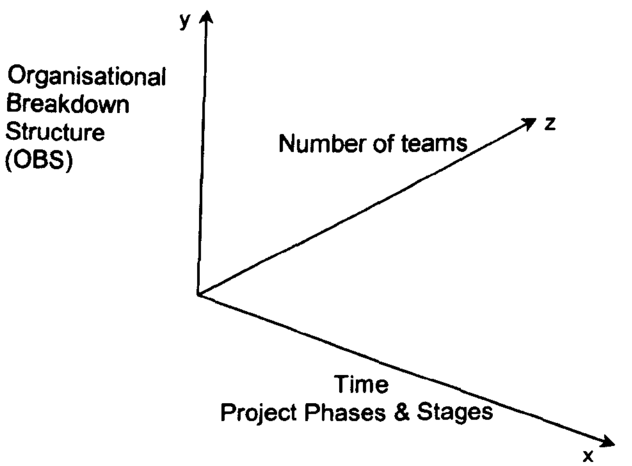


Figure AP.F-6.2. Pictorial representation of the 3D proposed approach to presenting project structuring.

In terms of presenting the structure in 3D it will:

- in the x-axis: enable for improved understanding of team / cluster contribution to project, time management and delivery of the project;
- in the y-axis: allow for improved responsibility, accountability, and coordination. It will also set the OBS in a continuous time axis, indicating that is a live structure and not something that is set up once;
- in the z-axis: it will allow for:

- easy formation of clusters;
- more accurate resource management with improved certainty;
- the use of different methods of forming clusters;
- reduction of fragmentation

The whole 3D approach allows for faster and better understanding of the teams involved (and by all parties), establishing requirements early in the project and improving earlier involvement of the required parties.

As the various organisational levels of the project are represented in 3D it will be easy to form clusters according to the project requirements and at different levels. Also it will be possible to form clusters between the teams at different stages, e.g. design and construction, or construction and commissioning. Additionally, since individuals are identified as nodes, then it will be possible to identify each individual's required characteristics. The significance of this point will be described below. It should also be easy to identify and plan for interconnections between different clusters, groups of clusters and companies at the different phases and stages. Thus, using the F4MCI to manage complexity.

Since each node is identifiable as a person and the whole represents a project organisational structure there are techniques - to be described below - which can test structures down to node / individual's level, on requirements, prevailing conditions, or other possible scenarios.

The proposed 3D finite structure can also be depicted as an elliptical shape, see Figure AP.F-6.3. The reason the project structure is depicted as such is because most of the teams are present towards the middle of the project life cycle (as also shown in Figure AP.F-6.1). The structure flattens on the sides because it is populated by either the suppliers or the support and overhead departments or disciplines that are there in order to provide material or services.

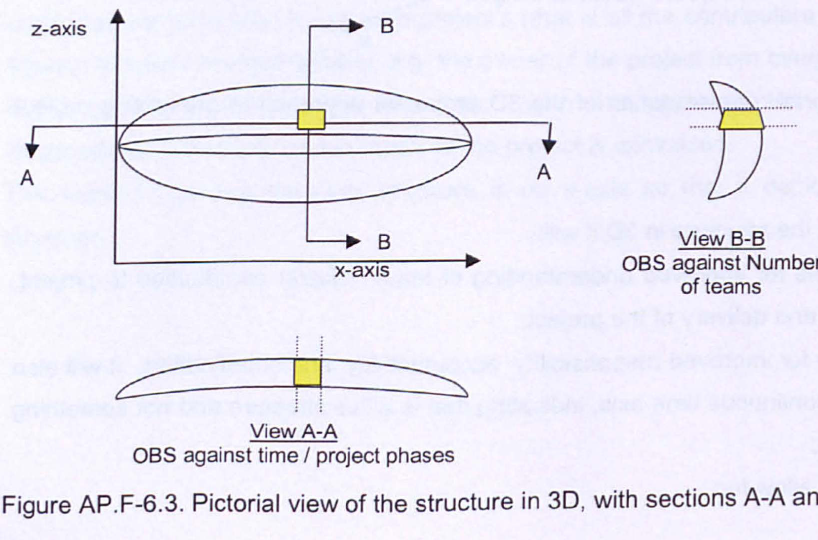



Figure AP.F-6.3. Pictorial view of the structure in 3D, with sections A-A and B-B

Viewing the structure in the x-z axis (see view BB in Figure Ap6-6.3) presents pockets of clusters (at different levels) with different content.

At the fringes of the structure we find, as said above, the small suppliers / sub-suppliers / consultants with their small teams that also contribute towards the project and they were never before indicated in the Project Organisational Structure.

**Finite Element within Finite Structure (FS) – the future**

Generating a finite structure will mean that the following will have to be reflected on:

1. At a higher level a cluster of professionals / managers is set up.
2. At the lowest level there are team clusters.
3. Each cluster is made up of 6 and up to 10 multi-skilled individuals, which in an FS are considered as individual 'nodes'.
4. At all required levels companies provide individuals who populate team clusters of multi-skilled teams which form and carry out work at the lowest level of the project.
5. Clusters are formed by selecting the individuals that fit the environment.
6. The environment has been considered and analysed by the enterprises (including the Client) that come together to deliver the project.
4. Contractual obligations do not interfere with the work that the team is delivering.
5. Work is coordinated by the clusters in a self-organising, self-maintaining approach, and depending on the size of the project, by a cellular approach.
6. As far as the Delivery clusters/teams is concerned Management is a virtual team.
7. The Management team points outside, towards the environment. Delivery clusters point inside, towards the deliverable. This is in a similar manner to that described by Walker (1996) – management and operational systems - but the management team incorporates other managers and not just those from the client.
8. The Management team also forms cluster.
9. The Management team meets the Operational teams in predefined intervals to give guidance only on questions raised, or to discuss / be advised on changes that will be feasible to be implemented at that stage.
10. The Management team, which comprises from the enterprises that are to deliver the project, meet separately to review progress, financial matters, change and Risk management at higher level. They also consider possible effects from the external environment, which could require change in the team, the approach, the influence of the process within the clusters
11. The interface between the Management cluster and the Operational cluster is through the Project Leader of the Phase. The types of interfaces and the structure at the lowest level are presented in Figure AP.F-6.4 and described in the following sections.
12. The teams / clusters are given:
    a. The scope

b. The proposed work breakdown
c. The necessary parameters and the software systems

13. The clusters interact continuously and if required virtually. For example during Design the design-cluster is in frequent contact with the construction-cluster(s) in order to obtain practical advice, or establish a datum. During Construction the construction-cluster(s) obtains advice regarding finishes from the design-cluster.
14. Clusters are provided with an interactive system for placing orders for delivery of materials, through the Management Cluster
15. The Delivery teams/clusters are incentivised by a mutual establishment of performance targets – *not to pressurise / penalise them.*
16. Autonomous agents have been identified, within the cluster(s) and for each phase. When uncertainty arises autonomous agents understand or even drive towards the prevailing strange attractor and provide the necessary bifurcation points in order to minimise complexity until stabilisation returns.

**Clusters**

Complex Adaptive Systems (CAS) have many autonomous parts, which self-organise to improve functionality, they are able to respond to external changes and form self-maintaining systems with internal feedback paths.

CAS are not fixed; they might require more or less freedom depending on the conditions and they change their composition "*to fit the changing patterns they encounter*" (Lucas, 2000b). Therefore it can be said that in construction we have clusters which change their composition to fit the landscape or the changing pattern of the project. So as the project moves between phases and within these between stages the composition changes fitness to the environment is achieved and the cluster moves on progressing with the project.
Lucas (2000b) indicates that "*this adaptation internalises environmental information, the system generates a model of the world outside, a distributed set of rules corresponding to the interesting or valuable aspects of their context*".

The FS generates '*a model of the world outside*', with a distributed set of rules which could be set up prior to the project commencing and with the clusters been set up '*corresponding to the interesting*' aspects, e.g. progress, fit out information or valuable aspects of their context which is the final outcome - the project.

Lucas (2000b) identified three types of interactions which involve the agents of a CAS at any level:

1. Intrasystem, or Intralevel: for interactions within the system, which he supports the view that this is about self-organisation to an internal attractor.

2. Intersystem: for interactions between systems, which he states is co-evolution, "*changing the fitness landscape*".
3. Interlevel, or Hierarchical: for agents interacting within vertical hierarchies, which is emergence.

When considering the above interactions a factor that has to be understood is the strength of the interlinks between the different interconnects as it is highly possible that these could exist between individuals in a cluster.

Figures AP.F-6.4 and AP.F-6.5 depict the structure and the interconnections at the lowest levels for construction (Figure AP.F-6.5) and the generic one as described by Lucas (2000b) (Figure AP.F-6.4)

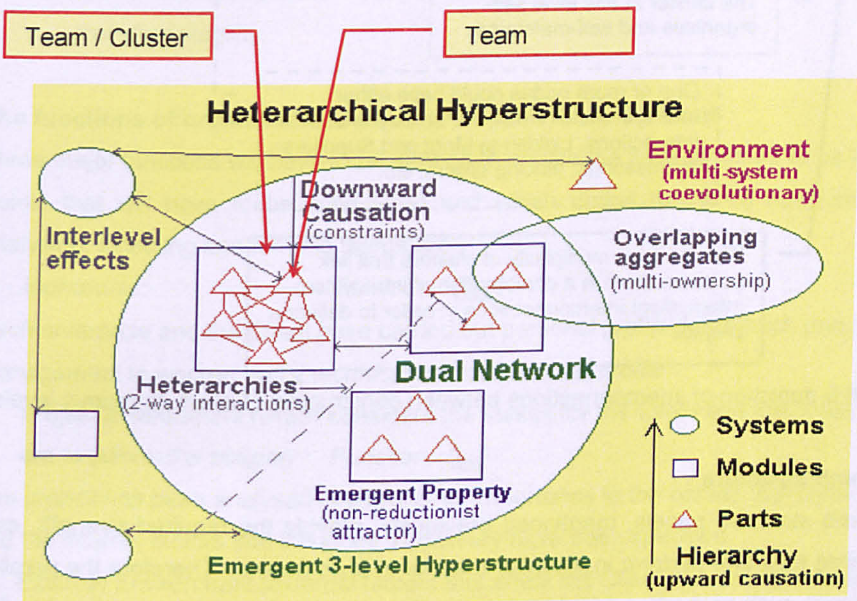



Figure. AP.F-6.4 Heterarchical Hyperstructure as described by Lucas (2000b)

Figure AP.F-6.5 below highlights the importance of the interlinks (or interactions) and how clusters or a number of them would link up or sideways to others in order to deliver a project. Therefore management of complexity of interconnections becomes an important sub-process for the delivery of the project.

In terms of construction the three characteristic interlinks can be presented as follows:

- Intrasystem: will represent interactions / interlinks within the project
- Intersystem: will be the interlink(s) between project and supplier(s)
- Interlevel: will be the interaction/interlinking between cluster(s) (or project team members / agents) and management clusters.

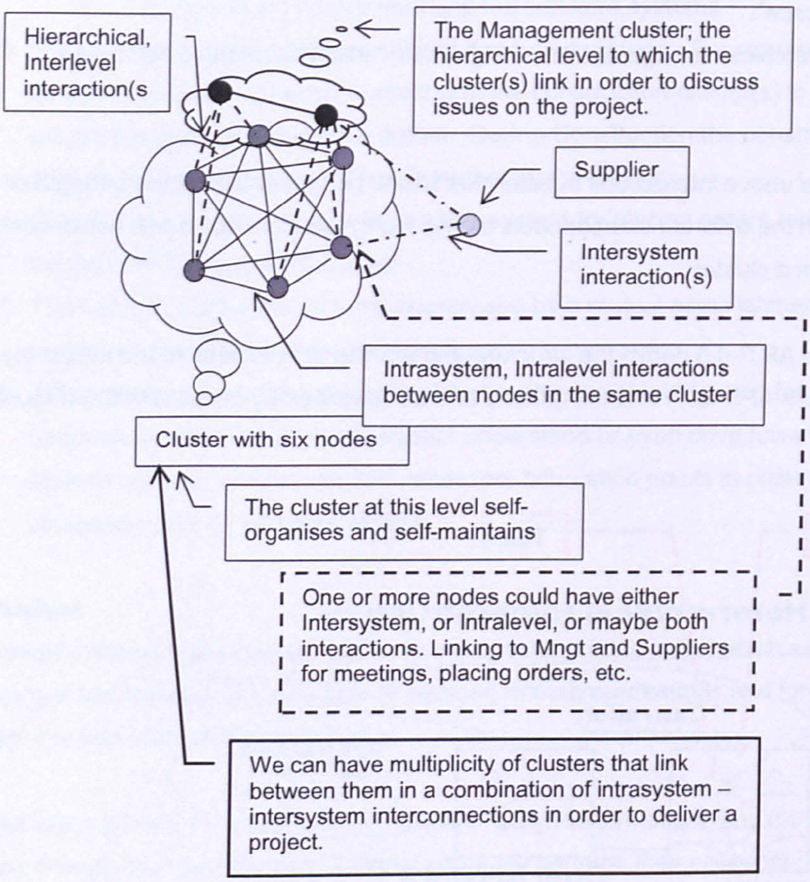



Figure. AP.F-6.5 depiction of interconnections between construction clusters at various levels.

**The honeycomb structure**

The honeycomb structure panels, mentioned previously, provide the required strength, can take the required load and perform in a similar manner to solid panels. Therefore the parallel of a structure with such properties could be (physically and metaphorically) considered in the structuring of project teams / clusters.

Considering the above Figure AP.F-6.6 provides a pictorial view of a honeycomb structure of the project organisation – at cluster / subassembly level.

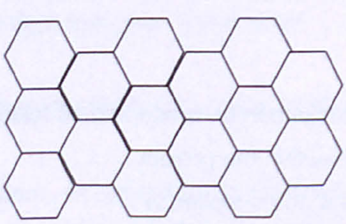


Figure. AP.F-6.6 Proposed honeycomb project organisational structure

The proposed structure provides:

- clear and minimum number of communication lines, therefore interconnections
- rigidity as well as flexibility
- prevention of deformation which cannot propagate through the structure (advantage of the hollow cells / team clusters)
- the benefits of the fractal structure which serves several purposes:
    1. replication of the structure throughout the project organisation levels
    2. reduction of risks by insulating other subassemblies or agents from the failure of any other one;
    3. allows for information to be passed easily between subassemblies or agents since it is highly reusable given the similar structures of the others; and
    4. allows the independent entities to be loosely coupled and not over-connected, providing stability.

**The functions of organisational structure within Finite Element**

Three major functions will have to be defined to enable the finite structure to be tested.

Points that will have to be considered and which define the three functions in terms of analysing, selecting and forming teams are:

1. Individuals: Function: $\{\underline{\mathbf{R}_{(x)}}\}$

Each enterprise and the Client have carried out personal profiling and each person, from management to worker, has a technical and behavioural profile.

2. Project Environment (which considers the stakes for the Client and the enterprises that are to deliver the project): Function: $\{\underline{\mathbf{I}_{(x)}}\}$

The project has been analysed in terms of its importance to the parties that come together and the internal factors that influence its delivery have been specified.

3. External Environment (external factors that affect the Client, the enterprises that come together and the Project): Function: $\{\underline{\mathbf{E}_{(x)}}\}$

The external environment has been analysed in terms of its importance to the Project, the Client and the enterprises and the level of influence / factors have been identified (as described by Hughes, 1989).

Having identified the functions that will affect each node within each cluster and the environment within which the cluster of nodes will have to function we use Finite Element Analysis (FEA) to identify:

a) The nodes that could prove problematic
b) The appropriate structural elements to be used. In terms of loading (preferably under heat/thermal loading) and how FEA will be implemented.

Considering the structure of elements within the FS we can easily extrapolate similarities between them and fractals. Taking this approach further, fractals are two dimensional (2D) whereas FS is three dimensional (3D) and therefore it deals with all the dimensions which could be taken to be the other organisations' structures and not only the project's.

Different geometrical shapes, in addition to the honeycomb structure, could be selected to represent the different (types) of organisations, e.g. construction, manufacturing, consultancies, client, that come together to deliver the project. Thus allowing for the project to accommodate for a parent organisational structure (at higher levels or points of intersystem links) and taking care of the problem identified by Moore (2002) where parent organisations impose their structure on the project.

Using the three functions [$\{\underline{\mathbf{R}_{(x)}}\}$, $\{\underline{\mathbf{I}_{(x)}}\}$, $\{\underline{\mathbf{E}_{(x)}}\}$] the FS will enable better understanding of the behaviour of the project structure in its environment.

The basic characteristics that need to be defined and to which parallels can be seen in FEA theory are:

- Stiffness matrix and Internal forces
- External forces and Boundary conditions (External environment)
- Internal forces (Project Environment)
- Boundary conditions (from intersystem links)
- Reactions known from particular loading (or characteristics of clusters which are explained below under 'strings')

Figure AP.F-6.7 below, provides an example of the possible FS of a project with two 'square' shaped clusters at the lowest level.

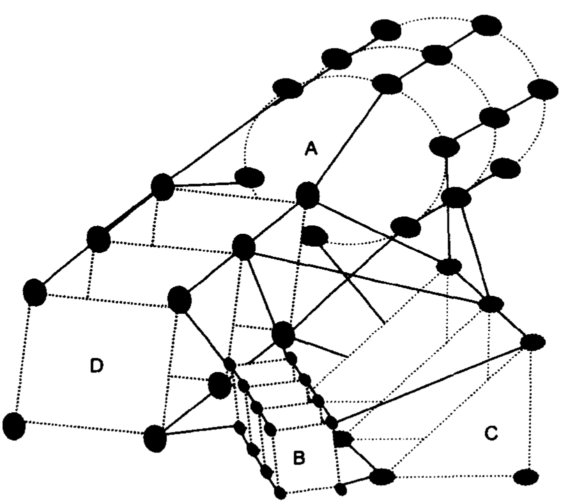



Figure AP.F-6.7 Example of a possible finite structure of a project with two square shaped lower level clusters

**Autonomous Agents**

One of the important facets of FS is self-organisation. Therefore the need to identify what are / could be the internal attractors and appoint roles of autonomous agents is of paramount significance.

Autonomous agents have to carry, within FS, important characteristics which will become pivotal when the 'heat-load' (representing complexity) increases. They could be:

- People, with specific tasks and maybe special characteristics
- A 'cause', which during uncertain conditions, unites clusters of various levels and at different stages and becomes an attractor towards which people autonomous agents drive the cluster (for some if not for all nodes in a self-organising approach),
- A company / project mission (similar to the above more higher in level)
- A deliverable / product placed above everything for / by the cluster.

**Strings**

Individuals come together, or join existing groups to form a company.

Consider these individuals as strings (or loops as described by string theory, Greene (1999)). Each individual / string has its own characteristics, drives behaviours, thus it has a frequency of vibration (as part of the 11 dimensions defined by string theory, Greene, 1999). The aggregation of frequencies defines a company frequency which means that the company also has its own characteristics and by certain means enforces certain characteristics on individuals.

For the individuals (strings) vibrations occur because in each physical dimension the string is attempting to balance between the absolute position (what is commonly acceptable or theoretically right) and the one the string itself believes to be right. It could even be that in each physical dimension the vibration is caused by the string as it pulsates between three points:

1. the absolute position
2. the current position and
3. the position the string is aiming to attain/achieve.

The important element here is the individuals' unique frequency / characteristic that develops the 'string's characteristics' and how this then is combined with the other strings to form an organisation.

When considering a construction project, made up of a number of strings (nodes), forming clusters, which are part of the finite structure, the nodes in a cluster are not motionless but they have a unique frequency characteristic. These unique frequencies identify 'reactions known from particular loading', as mentioned above, and other characteristics that will enable the implementation of FEA.

An example of what is proposed, where string theory is combined with Finite Element theory (through the finite structure) and the Organisational theory, can be found in the automotive industry. There individuals / strings come together to form multi-skilled 'clusters' that deliver a complete car from beginning to end. The cluster contains all the necessary skills that can complete the job. Each string has its own characteristics and skills (unique frequency) and the whole unit then integrates to perform as a cluster that delivers a car. In the case of Toyota (Liker, 2004) it takes up to 2 years to train each string so that it can be positioned at the right place within a cluster.

However, construction cannot be considered the same with the automotive industry. One of the reasons it is different is the fact that at the highest level (the project level) it never delivers the same exactly overall product. Nevertheless at a low enough level the tasks performed are always the same. In some occasions an attempt to manage technical complexity is through the use modular products (e.g. BAA, McDonalds, etc.). It is this modularisation of the product as well as the standard / simple activities that will enable clustering of personnel at the lowest level. By identifying the individual string characteristics and knowing the overall standardised requirements we will be able to build clusters that will perform to the required level.

This is where FEA can be used because by knowing the overall characteristics clusters and individual strings (nodes) can be tested by imposing output requirements / functions.

**String theory at company level**

At company level each organisation can be represented as a group of strings with an overall frequency. This overall frequency, which is an amalgamation of frequencies from all the personnel, equipment, technology and everything else that makes a company, still has 11 dimensions and each dimension represents a characteristic or a quality like, Organisational structure, Stakeholders, Behaviour (e.g. is the company an IPP - Investors in People – company?), Cost, Quality, Standards, etc.

So in construction when a Client organisation issues a tender it defines parameters against which the Construction companies are trying to much their frequencies, or the frequency of the particular bid, in order to win the job. Therefore the characteristic of 'frequency of the job/project' is one of the parameters.

The process of bidding becomes one of looking for and identifying the right frequency.
A number of steps that have to be taken are:

- Establish how are these frequencies defined and what are the characteristics;

- Identify how do these frequencies come together to form one common profile;
- Identify how each job/project gets its frequency, or that unique client characteristic; and
- Finally identify which are the prevailing characteristics that shape the frequency.

Therefore the overall approach should be to differentiate down to elemental level and then integrate these elements in order to display an overall view of the Company.

### *AP.F-6.3.4 Conclusion*

This approach could be considered as a mechanistic view of an organism, however by introducing elements to the lowest level and considering the individuals' characteristics we take into account the individuals' contribution(s) towards the 'organism'. Therefore we have a 'live' system. The type of organisation being that organic, bureaucratic, adhocracy, or any other one, will be defined by the 'Organisation frequency'.

The above can be brought together with the string theory approach and whatever the type of organisation each organisation represents a living organism and not a rigid formation, as presented by the current organigrams. The structures are continuously moving (using their frequency), re-shaping themselves. Therefore what we have is a real representation (model and perhaps a computerised model) of an organisation and in particular a project organisation.

Therefore the proposed Finite Structure can enhance the approach to organising projects and enable a number of processes to be combined so that structuring project teams remains a 'live' process throughout the duration of the project. However, this proposal will have to be finalised and validated.