Understanding and Managing

Project Complexity

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Abbreviations

3P's	People, Project and Process
ACAT	Acquisition Categorization
AIPM	Australian Institute of Project Management
ANOVA	Analysis of Variance
APM	Association of Project Management
BoK	Body of Knowledge
CAS	Complex Adaptive Systems
CP	Current Project
CSF	Critical Success Factor
CIFTER	Crawford-Ishikura Factor Table for Evaluating Roles
CoPS	Complex Product Systems
CRC	Cooperative Research Centre
CRI	Construction Research Institute
DMO	Defence Material Organization (Australia)
Exp.	Experience
GAPPS	Global Alliance for Project Performance Standards
HRM	Human Resource Management
ICB	IPMA Competence Baseline
IPMA	International Project Management Association
MBWA	Management by Walking Around
MODeST	Mission, Organization, Delivery, Stakeholders, Team
NTCP	Novelty, Technology, Complexity, Pace
PLC	Project Life Cycle
PM	Project Management
P2M	Project and Program Management
PMBoK	Project Management Body of Knowledge
PMI	Project Management Institute
PMPDP	Project Management Professional Development Program
SBAC	Society of British Aerospace Companies
UoM	The University of Manchester

Abstract

This research focuses on project complexity with the aim to better understand it and to highlight the factors that affect / contribute to it. In addition, this research also highlights key project management practices and project critical success factors considered important to manage project complexity / complex projects.

The two main motivating factors behind this research were, the lack of understanding of complex projects and the lack of relevance of project management theory to practice, which have been highlighted by many researchers. Since projects in different sectors are increasingly being characterised as complex, this entails a better project management knowledge base focusing on the dynamic, social and complex contexts of projects, so that the interrelationships, interdependencies and uncertainties between different project interfaces can be understood and managed properly. In order to understand this *'project actuality'*, it was necessary to obtain the views from practitioners working in these project settings and managing project dynamics and intricacies.

To establish this pragmatic view, a series of interviews and questionnaire surveys was carried out and all efforts were made to select the participants working on complex projects with complex products falling under the Complex Product Systems – CoPS category which was the case in the 2nd phase interviews and questionnaire, whereas in the 1st phase practitioners with industrial experience and also involved and/or in the process of getting academic qualification in project management were preferred. The first phase helped in establishing the theoretical and pragmatic perspective and the 2nd phase in refining and validating the findings. The questions were in line with the research focus mentioned earlier.

The main findings of the research show that the perception of project complexity and its contributing factors were very much influenced by the project context, i.e. from organization level to work discipline level. No difference in the practitioners' perception of project complexity and its contributing factors was observed among the practitioners based in a similar organization and project setting. Novelty was found to be one of the key project complexity characteristics related to three project elements-people, product and process.

In terms of key project management practices and skills considered important in managing project complexity, soft skills were reported useful by majority of the participants. The key processes found useful were either the ones which focused on people or others which helped to manage changes / deviations in projects. Influence and relationship, delegation, flexibility and trust were the main project critical success factors which emerged out of this research for complex projects.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Statement

Acknowledgement

In the name of Allah the most gracious, the most beneficent.

'Are those equal, those who know and those who do not know? It is those who are endued with understanding that receive admonition.'
(Quran: Ch 39, Verse 9)

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List of Publications

A) Refereed Journal Papers

1. **Azim, S. W**., Gale, A., Lawlor-Wright, T., Kirkham, R., Khan, A. Alam, M. "*The importance of soft skills in complex projects"*. International Journal of Managing Projects in Business, 2010, Vol. 3**,** No.3, pp. 387-401.

B) Refereed Conference Papers

1. **Azim, S**. **W**., Gale, A., Khan, A. I. *"The edge of soft skills in complex projects: The reality of actuality"*. Accepted for publication in 23rd IPMA World Congress, Helsinki, 15th – 17th Jun 2009.
2. Khan, A. I., Gale, A. W., Rowley, M., Brown, M., MacGregor, J., **Azim, S. W**., Alam, M. *"Transformation from Traditional to Service-based Programmes: Key Project Management Aspects"*. Accepted for publication in 23rd IPMA World Congress, Helsinki, 15th – 17th June 2009.
3. Khan, A. I**.**, Gale, A. W., Rowley, M., Brown, M., MacGregor, J., **Azim, S. W**., Alam, M. *"Key Management Aspects in Concept and In-Service Support Phases of TotalCare® Programme"*. Accepted for publication in 23rd IPMA World Congress, Helsinki, 15th – 17th June 2009.

C) Posters

1. **Azim, S. W., Gale, A. "***Project Complexity – A Pragmatic View"*. Post Graduate Research Conference, School of MACE, The University of Manchester, 1st July 2010.
2. **Azim, S. W., Gale, A. "***Realizing the Importance of Project Complexity in Engineering Projects"*. Post Graduate Research Conference, School of MACE, The University of Manchester, 11th June 2009.

Chapter 1

Introduction

1.0 Research Overview

Projects in different industrial sectors are increasingly being characterised as complex, as they are and have always been complex. Research on 'project complexity' or 'complexity of projects' is becoming more recognised, with researchers trying to focus on this issue using different platforms, ranging from simple classification by types in terms of their properties, to using complex systems theory to gain a better understanding in terms of their behaviours (Geraldi and Adlbrecht, 2007). However, with the increase in recognition and understanding of project complexity, current project management research attracts criticism for its lack of relevance to practice. As project management research continues to grow, there is still limited research evidence that links adherence to these project standards to better project performance, as these standards lack to measure the contextual understanding of the complex web of interrelated factors, relationships and activities that need to be taken into account in a holistic manner (Thomas and Mullaly, 2007). This is also attributed to its limitations in addressing the dynamic, social and complex contexts of projects due to a hard systems approach. Although project management practices are becoming increasingly important as more and more work is organised through projects / programmes, but still it '*attracts criticism for its lack of relevance to practice'* (Winter et al., 2006).

Cicmil *et al* (2006) realising this need to understand the complex social processes that exist in various levels of project settings, highlighted the need to better understand '*project actuality*', which is '*characterized by tensions between unpredictability, control and collaborative interactions among diverse participants on any project'*. Project actuality, thus encompasses the lived experience of organisational members in their respective project environment.

Keeping in view the dynamic, social and complex contexts of projects, the recognition of project complexity is gaining attention and various researchers have made an effort to better understand it. In the recent years, there has been much discussion on project complexity and despite all that has been written and said, it has created more confusion than clarity as complexity and project complexity has been interpreted in many ways. *"While many project managers use the term 'a complex project', there is no clear definition what is meant. There is a general acceptance, however that it means something more than a 'big' project"* (Williams, 2002*)*. Researchers specifically focusing on project complexity have tried to explain it using the simplest dictionary definition – 'consisting of many interconnected parts' in terms of physical elements and their interdependencies, and also by adding the uncertainty element to it e.g., Baccarini (1996),Williams (1999), Geraldi and Adlbrecht (2007). While others have tried to explain it using complexity theory e.g., Remington and Pollack (2007), Cooke-Davies et al. (2007). All of these authors have highlighted the risk associated to linguistic use of project complexity, as people are expected to have their own understanding and perceptions of these terms.

In addition to the above, the professional associations on the other hand are in the process of introducing standards and certifications, and organizations are equally investing in getting their resource trained, but there is no evidence that these trained and or certified project managers are any more successful than *'accidental'* project managers in today's complex world, as the behavioural and personal competencies of project managers appear to be more relevant to the workplace performance (Crawford, 2005, Thomas and Mengel, 2008).

Summarising the above, firstly, there is lack of understanding of project complexity, as the literature on it focuses more on its typology and fails to identify factors that contribute to and/or affect project complexity. Secondly, the lack of relevance of project management theory to practice, as the project management literature focuses more on the hard aspects, based on linear, analytic and rational approaches, emphasizing planning and control dimensions of project management whereas in *"actuality"* projects are characterised as taking place within a human and social context (a social process), occurring in a dynamic environment which is continually changing.

The two highlighted issues form the basis for this research, and the research problem, aims and objectives focus on these issues as discussed in the following sections.

1.1 Research Problem

As highlighted in the research overview section, on one hand there has been an increase in recognition of project complexity but it still lacks a clear perspective, and on the other the formal project management knowledge base is criticised for its lack of its relevance to practice. With this need to have a better understanding of project complexity and highlighting suitable ways to manage it, this research investigates these problems by exploring the project *actuality* so that a better understanding of project complexity can be obtained which is based on practitioners' valuable experience.

1.2 Research Aims and Objectives

The aim of this research is to investigate the practitioners' perception of project complexity and its contributing factors, and to highlight key project management processes and project critical success factors that are based on practitioners' experience of working in actual project settings.

The objectives of the research are:

i. To review the existing theoretical perspective of project complexity in order to understand its concepts and to investigate the perceived gap between theory and practice.

ii. To investigate the pragmatic view of project complexity by obtaining the views of practitioners through qualitative and quantitative research, in order to make a comparison to give a better perspective, useful for both academicians and practitioners.

iii. To investigate the factors that contributes to complexity in actual project settings.

iv. To identify key project management processes and skills required by project managers to manage project complexity.

v. To identify critical success factors, useful for practitioners managing complex projects.

The research aims and objectives are discussed in detail in chapters 5-8 in conjunction with the 1st and 2nd phase studies and are also summarised in the conclusion chapter 9 in light of literature review and the studies carried out in both the phases.

1.3 Research Questions

The primary questions for this research are:

i. How do PM practitioners perceive project complexity and its contributing factors, and the basis of variation of these perceptions?

ii. Are there any specific set of key project management processes and skills to manage project complexity?

iii. Are there any specific project critical success factors for complex projects?

1.4 Research Hypotheses

The research hypotheses tested using statistical techniques are,

Hypothesis 1

H_0: There is no difference in the ranking of **project complexity <u>groups</u>** (proposed people, product and process groups) with practitioners' age, qualification, work discipline, work experience and project type.
H_1: There is difference in the ranking of **project complexity <u>groups</u>** (proposed people, product and process groups) with practitioners' age, qualification, work discipline, work experience and project type.

Hypothesis 2

H_0: There is no difference between **project complexity <u>contributing factors</u>** with work location, practitioners' age, total work experience, work role and project type.
H_1: There is a difference between the **project complexity <u>contributing factors</u>** with work location, practitioners' age, total work experience, work role and project type.

1.5 Research Strategy

The research strategy adapted for this study has been detailed in Chapter 4; however it is briefly outlined sequentially below.

- In order to grasp the theoretical perspective on project complexity, a literature review was undertaken to establish the basis for comparison with the pragmatic view. Although the literature specifically focusing on project complexity was sparse, however on complexity per se, the research to date had multiple dimensions, but it helped to focus in the relevant direction in the context of project complexity. The next step was to get the feed back from practitioners on the subject to get to know their point of view.

- **1st phase interviews** were the starting point of the research and were carried out to explore the pragmatic perception of project complexity in order to compare it with the theoretical perspective. These interviews were carried out with senior practitioners who had rich industrial experience and were also actively involved with academics. The interviewees were perceived to highlight their point of view based on their experience and also in the context of their project management knowledge. A total of 5 semi-structured interviews were conducted with practitioners with work experience ranging from 6 to 36 years and with a number of project participated varying from 6 to 50+ years. These interviews helped to establish the initial framework for further analysis.

- **1st phase questionnaire** was prepared based on the analysis of the 1st phase interviews and the literature review carried out. The questionnaire was distributed to practitioners with industrial experience who were also involved in enhancing their project management knowledge through Project Management Professional Development Program (PMPDP) at the University of Manchester. In this phase questionnaires were distributed to a total of 120 delegates attending the PMPDP plenary session April '09. However 47 delegates answered and returned the questionnaire. Thus making a total response of 39%. The first phase questionnaire not only helped to establish the validity of the findings of the first phase interviews but also highlighted the factors contributing to project complexity. The analysis of the 1st phase interviews and questionnaire highlighted the requirement to carry out case study to assess project complexity in the actual project settings as influence of context in the perception of project complexity factors was highlighted by the analysis and results of 1st phase studies. It was important to understand project complexity in a particular setting by exploring the project actuality.

- **2nd phase interviews** were conducted at a leading European aerospace company which used as a case study, with the objective to explore the practitioners' perception of project complexity, the factors contributing to project complexity, the key project management processes and skills, and critical success factors, all based on their experience of working in actual project settings. The aim was to get the underlying reasons behind the practitioners' responses in order to have a better understanding of the pragmatic view on project complexity, and to validate the findings of the 1st phase results. In total 16 in-depth interviews were conducted with personnel which were working at various project management levels. Out of which 13 were working senior executive/program manager level.

- **2nd phase questionnaire** were prepared on the basis of the analysis of the 2nd phase interviews, with the objective to not only validate the findings of the 2nd phase interviews, but also test the hypotheses and to validate and triangulate the previous studies. Questionnaires were distributed within the case study organization at two different business units. A total of 200 questionnaires were distributed, only 47 questionnaires were received, making a total response of 27%.

The next section outlines the structure of this report.

1.6 Structure of the Thesis

The thesis is organised into nine chapters as shown below,

- **Chapter 1 – *Introduction:*** This chapter presents the research overview, research aims and objectives, and research questions and hypotheses. Also briefly highlights the research methodology and details the structure of this thesis.

- **Chapter 2 – *Literature Review (Part I):*** This chapter presents the literature review focusing only on project complexity. In order to understand this concept, discussion on terms complex and complicated has been presented, along with the underlying concepts used by different researchers to explain project complexity.

- **Chapter 3 – *Literature Review (Part II):*** This chapter presents literature review on the other two aspects of this research, that is the key project management processes/skills, and the project critical success factors. The views of various researchers on project management processes and skills and their applicability and usefulness in the actual project settings have been presented.

- **Chapter 4 – *Research Design and Methodology:*** This chapter presents in detail the research philosophy, approach, strategy and design, and methods used to address the research questions and to test the research hypotheses. Both research methodology and methods have been discussed in this chapter and the rationale for the selection of appropriate methods has also been presented.

- **Chapter 5 – *1st Phase Interviews:*** This chapter presents the analysis and findings of the initial first phase interviews. The primary aim of these interviews was to get an initial exploratory view on project complexity based on the actuality of projects, and compare this practitioners' perspective with the theoretical concepts.

- **Chapter 6 – *1st Phase Questionnaire Survey:*** This chapter details the analysis, results, and findings of the first phase questionnaire survey. The purpose of this questionnaire was to assess the importance of the complexity groups and their attributes proposed on the basis of the 1st phase interviews and literature review, to test the hypotheses and to validate the findings of the 1st phase interviews.

- **Chapter 7 – *2nd Phase Interviews:*** This chapter presents the results and analysis of second phase in-depth interviews, carried out with practitioners at a leading European aerospace company. The purpose of these interviews was to further investigate and validate the findings of the previous studies, based on the practitioners' experience of working in actual project settings.

- **Chapter 8 – *2nd Phase Questionnaire Survey:*** This chapter represents the results of the questionnaire administered after the 2nd phase interviews. The purpose was to test the hypotheses and to validate and triangulate the findings of the previous studies, specially the 2nd phase interviews.

- **Chapter 9 - *Discussion, Conclusions and Recommendations:*** In this chapter the results and analysis of the four studies have been summarised and the findings have been discussed in relation to the previous researches, highlighting their implications to academic and industrial perspective. Also the limitations of this research and recommendations for future research have been presented.

The next section, i.e. Chapter 2 presents the literature review on project complexity, which was the starting point of this research.

Chapter 2

Literature Review – Part I

2.0 Introduction

The literature review chapter is divided into two parts,

Part I : Focuses on Project Complexity
Part II : Focuses on Project Management Processes and Project Critical Success Factors

Literature review of the areas relevant to this research has been presented in this and the next chapter. The objective of the literature review was to gain a better understanding of the theoretical perspective and to keep abreast with the research on the subject.

Figure 2-1 below shows the relevant areas that were explored to get a better understanding of project complexity.

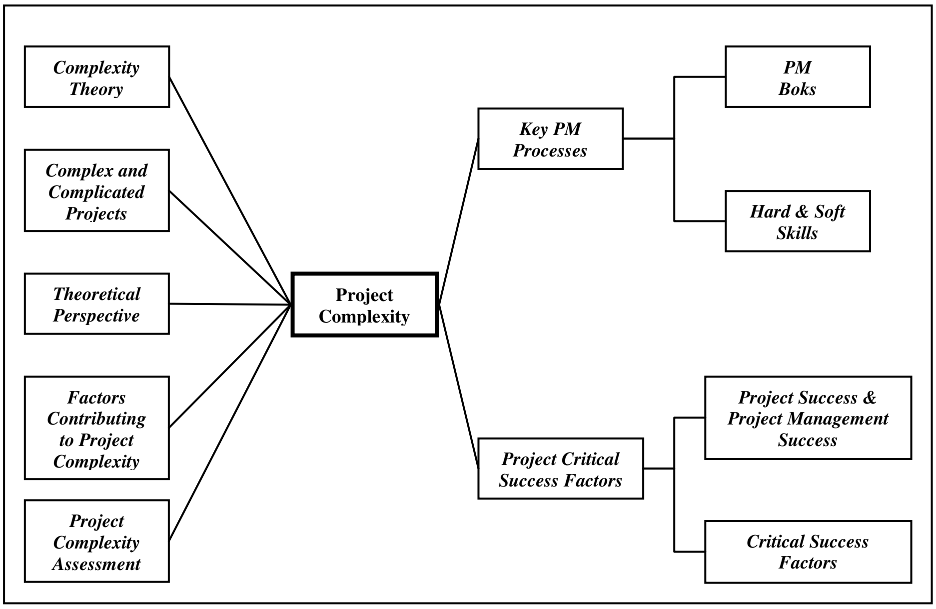

Figure 2-1 : Overview of the key areas of literature search

The areas presented in the above figure focus on understanding and managing project complexity. Developing a better understanding by exploring the theoretical perspectives on complexity theory and project complexity and acquiring views on complex and complicated projects, factors contributing to project complexity and assessment of project complexity. Highlighting key project managements processes/skills identified in the BoKs and their relevance in the context of project complexity and also the project critical success factors to gain a better understanding to successfully manage complex projects.

2.1 Project Complexity

Project complexity is the key research area/topic, rather the core of this research, as the discussion on all the other areas revolve and evolve around it. It is very important to get an in-depth understanding of this multi-faceted phenomenon by analysing different ways researchers have explained it, and its implications for project management practice.

The realization of complexity and its importance is highlighted by the following two quotations,

> *"I think the next century will be the century of complexity".*
>
> Stephen Hawking January 2000 cited in (Sanders, 2003)

> *"Every decade or so, a grandiose theory comes along, bearing similar aspirations and often brandishing an ominous-sounding C-name. In the 1960 it was cybernetics. In the '70s it was catastrophe theory. Then came chaos theory in the '80s and complexity theory in the '90s".*
>
> Strogatz cited in (Whitty and Maylor, 2009)

Projects have always been complex and will remain complex (Frame, 2002). In other words the complexities in projects have always been there. Realization of project complexity is on the rise, due to the reason that the existing critique, emerging propositions and research findings have exposed deficiencies and controversies associated with traditional project management, highlighting its linear-rational paradigms of decision making without explicitly allowing for dynamics, inconsistencies, iterations and uncertainty (Cicmil et al., 2009). While some researchers referred this focus on project complexity to project management's '*addiction to fads and fashions*' (Whitty and Maylor, 2009), others emphasize on looking into the reality of projects (Cicmil et al., 2006) to better understand and manage project complexity keeping in view the dynamic, social and uncertain project settings. The importance of exploring the project reality is highlighted by Frame (2002) as,

'In the management arena, the concept of messiness is nothing new to those who practice project management. Whereas the traditional management focuses on things like chains of command, and tying authority to responsibility, project management has centred its attention on getting the job done in an environment where authority is lacking, goals are subject to multiple interpretations, and the rules of behaviour are ill-defined'.

However, the more these words, 'complex' and/or 'complexity' are becoming part of everyday language, the question is rarely asked as to what is really meant by them, as they are interchangeably used and lesser attention is given to their significance and relevance. These words are inevitably used to express and explain the nature of problems and challenges people experience in project actuality. (Cicmil et al., 2009)

The word 'complex' is increasingly being used to define the actuality of the world we are living in. Indeed, we are living in a world which can be termed as complex, a fact which is undisputable. However, the concept of complexity is disputable, as there is still no agreed definition (Ameen and Jacob, 2009, Corning, 1998). The term complexity has been interpreted in many ways by researchers, creating more confusion than clarity. Any discussion on the broad concept of complexity is bound to encounter risks associated to its linguistic use, as people are expected to have their own understanding and perception of what the term means (Cooke-Davies et al., 2007). This fact is also highlighted as follows,

"There is no single concept of complexity that can adequately capture our intuitive notion of what the word ought to mean" (Sinha et al., 2001)

The only definition of complexity which is widely accepted is the dictionary definition, Oxford online dictionary (Dictionary) defines the word ‘complex’ as

(i) consisting of many different and connected parts.

(ii) not easy to understand; complicated or intricate.

Otherwise, complexity has been understood in different ways by researchers and there is a lack of agreement (Morel and Ramanujam, 1999).

Originally, the term ‘complex’ originates from Latin, *cum* (together, linked) and *plexus* (braided, plaited). Viewing the above definitions, complex in general refers to something which has many parts that are interrelated or connected; and has an element of difficulty, obscurity and complication.

The first part of the definition is fairly simple to apprehend and has been used by many researchers as a basis to define project complexity in particular; whereas the second part of the definition, ‘complicated’, which often give rise to the question, ‘*What is the difference between complicated and complex?’*

2.2 Complex and Complicated

It is important to distinguish between the terms ‘complex’ and ‘complicated’, as these words are interchangeably used in everyday language without having a clear distinction to their meaning, and also to form a basis which will then help to better understand ‘complexity’. A simple definition given by Cilliers (1998) highlights the difference between ‘*complex’* and ‘*complicated’*:

> *‘The concept of ‘complexity’ is not univocal. Firstly it is useful to distinguish between the terms ‘complex’ and ‘complicated’. If a system – despite the fact that it may consist of a huge number of components – can be given a complete description in terms of its individual constituents, such a system is merely complicated. Things like jumbo jets or computers are complicated. In a complex system, on the other hand,*

the interaction among the constituents of the system, and the interaction between the system and its environment, is of such a nature that the system as whole cannot be fully understood simply by analysing its components. Moreover, these relationships are not fixed, but shift and change, often as a result of self-organization. This can result in novel features, usually referred to in terms of emergent properties. The brain, natural language and social systems are complex'

The following examples would help to explain the above definition in a more practical and easy to understand approach given by Johnnie Moore cited in (Paterson, 2006),

"*The wiring on an aircraft is complicated. To figure out where everything goes would take a long time. But if you studied it for long enough, you could know with (near) certainty what each electrical circuit does and how to control it. The system is ultimately knowable. If understanding it is important, the effort to study it and make a detailed diagram of it would be worthwhile.*

So complicated = not simple, but ultimately knowable.

Now, put a crew and passengers in that aircraft and try to figure out what will happen on the flight. Suddenly we go from complicated to complex. You could study the lives of all these people for years, but you could never know all there is to know about how they will interact. You could make some guesses, but you can never know for sure. And the effort to study all the elements in more and more detail will never give you that certainty.

So complex = not simple and never fully knowable. Just too many variables interact.

Managing humans will never be complicated. It will always be complex. So no book or diagram or expert is ever going to reveal the truth about managing people."

In a web article on Complex Adaptive Systems (CAS), Eoyang (2004) highlights that it is difficult to understand complex and complicated patterns, for each of them require different methods to evaluate them as their nature of ambiguities are different. A complicated system (pattern) is intricate due to the number of parts in them and their relationship, such a system appears to be folded, hiding the certain parts. In order to understand such a complicated system, unfolding and separating each part would give a clear understanding of the parts and their relationships to other parts in the system. Although it may take a long time but a complicated system can be analysed and understood in terms of its parts, implying that reductionism is an effective method in understanding the nature of complicated patterns/systems. Complex pattern/systems on the other hand, involves *weaving together* of parts into intricate whole, each part is entangled in such a way that the complex pattern cannot be discerned from its parts and the whole emerges from the interaction of the parts and if the whole of the system is different from the sum of its parts, then it is complex. *'Good evaluation of a complicated system involves repetition, replication, predictability, and infinite detail. Good evaluation of a complex system involves pattern description, contextualization, and dynamic evolution.*(Eoyang, 2004)

Summarising the aforementioned premise, it can be seen that the number of parts, is common to both complicated and/or complex systems, but it is the interaction of the parts and the level of predictability of outcome of these parts working as a whole that gives the distinction between complex and complicated. The above examples help us to create a view point about complex and complicated, but do not give us a discrete definition to clearly differentiate between them. These are view points from various people in different areas which are based on their perspective and context. Seth Lloyd, in his book 'Programming the Universe' (Lloyd, 2006) gave 32 definitions of complexity *(the quality or condition of being complex)* however once when asked to define it, he gave the following remarks, highlighting the difficulty and lack of univocal definition of complexity,

"I can't define it for you, but I know it when I see it." (Seth Lloyd)

The other reason for not having a univocal definition of complexity is that it is relative and very much dependant on perception. As cited by Geraldi and Adlbrecht (2007), the perception of complexity is idiosyncratic that it is based on individual's perspective, the same is stated by Baccarini (1996) as, '*the interpretation of complexity is in the eyes of observer'.* The following quote cited by Corning (1998) further strengthens the fact the interpretation of complexity is very much dependant on the observer,

"Everybody talks about it. [But] in the absence of a good definition, complexity is pretty much in the eye of the beholder." - Dan Stein, Dean of Science, NYU

John Casti (1994) states that *'when we speak of something being complex, what we are doing is making use of everyday language to express a feeling or impression that we dignify with the label complex.'* He deliberates on the fact that the meaning given to the word complex is dependent on the context, as the complexity of a system or a situation is not an inherent aspect when considered in isolation but is a property of the interactions between two systems arising in the relationship between observer and the observed.

The next section covers view points and approaches on 'complexity' which shall help in understanding 'project complexity' in particular, as like complexity, there will be different perceptions to it (Cicmil et al., 2009).

2.3 Complexity

The word complexity is generally used to characterise something which is made up or has many parts which are intricately arranged. The simple dictionary meaning is '*the quality or condition of being complex'*. Wikipedia in defining complexity highlights the fact that definitions of complexity is often tied to the concept of a system and also highlighting that it is not univocal.

A *'system'* is defined as a set of interacting or interdependent parts which form an integrated whole, which is to some extent similar to the definition of the word '*complex'*, i.e. consisting of many different and connected parts. Many researchers in the scientific field commonly use the word 'system' in conjunction with the word complex, such as complex system or complicated system, where complex or complicated emphasizes the degree of interconnectedness. A complex system is a system composed of interconnected parts that as a whole exhibit one or more properties (behavior among the possible properties) not obvious from the properties of the individual parts. Simon (1962) defines a complex system as,

"One made up of a large number of parts that interact in a non-simple way. In such systems the whole is more than the sum of the parts, not in an ultimate, metaphysical sense but in the important pragmatic sense that, given the properties of the parts and the laws of interaction, it is not a trivial matter to infer the properties of the whole" (Simon, 1962).

Complexity has always been there as a part of our environment and therefore many fields have dealt with complex systems and phenomena. 'Complexity theory can be defined broadly as study of how ordered, structured patterns, and novelty arise from extremely complicated apparently chaotic systems and conversely, how complex behavior emerges from simple underlying rules' (Cicmil et al., 2009, p. 22). Complexity theory has also been referred to the study of complex systems, computational complexity theory, computational theory and organizations, and complexity economics. Complexity theory and organizations have been influential in strategic management and organizational studies and incorporate the study of Complex Adaptive Systems (2009a).

Before discussing the application of complexity theory to project management, it is important to keep in mind the following remarks by Cicmil *et al* (2009) ,

'*Project management itself embodies a paradigm that is more coherent more binding and more complete than a theory on which it is based and behind this paradigm lies a mechanistic world deriving from Cartesian philosophy, a Newtonian understanding of the nature of reality, and an Enlightenment epistemology whereby the nature of the world we live in will be ultimately comprehensible through empirical research and that the nature of the deep themes that are emerging from complexity theory can be said to amount nothing less than an expansion and enrichment of the Cartesian/Newtonion/Enlightment paradigm from which the practice of project management has emerged' (Cicmil et al., 2009, p 21)*

Complexity theory can be applied to projects in the similar way it has been applied to organizations (Remington and Pollack, 2007), as the complexity of projects may entail a focus on the level of non-linearity, evolution, emergence and radical unpredictability in the interaction among human and non-human elements (Cicmil et al., 2009). According to Remington and Pollack, well defined projects (in terms of their outcomes and control) can be viewed as simple systems possessing *interconnectedness, hierarchy, communication and control,* while others projects large or small in addition to the aforementioned attributes exhibit *phase transition, adaptiveness, emergence and sensitivity to initial conditions,* which are the characteristics of complex adaptive systems.

The special characteristics of Complex Adaptive Systems (CAS) agreed upon by many authors are (Remington and Pollack, 2007):

Hierarchy: Systems have subsystems and are a sub-set of larger systems and the relationships in them are complicated and enmeshed. (Eoyang and Berkas, 1999).

Communication: Information regarding the internal and external state of the system across its boundaries is passed between the elements of the system.

Control: In order to maintain the stability of relationship between the parts in the system and its existence, the systems exhibits element of control, in order to keep the parts together to ensure stability.

Emergence: It is a property of stable relationship between the parts and not the parts alone, which emerge at different levels of the system which are not apparent at levels below. This property exists at the level as whole and does not exist for any part individually. It is the property that appears when all the parts of the system interact stably together and cannot be assessed by looking at the individual property of the parts.

Phase Transition: A complex adaptive system internally can suddenly response to an external change to take up a new form. It is the same system exhibiting different properties in responding to different environmental constraints.

Nonlinearity: As a result of feedback flows and emergent behaviors, the evolutionary path of the system gets nonlinear over time. Large perturbations from the exogenous environment thus may have small effects on the system, and small perturbations may have large effects on the system.

Adaptiveness: In response to external environment conditions and changes, complex systems adapt to accommodate and/or take advantages to maintain and/or to improve.

Sensitive Dependence to Initial Conditions**:** This is the famous *'butterfly effect'*, i.e. even small differences in the initial conditions in a complex system can produce unexpected and often disastrous effects.

Indeterminacy: It is the recognition of the inherent indeterminacy of the future of complex dynamical systems, and thus the physical universe itself. Its about the inherent uncertainty that physical matters contains as demonstrated by pioneers of quantum theory (Cicmil et al., 2009).

Many researchers have used Complex Adaptive System's theory to address or define complexity and, in turn project complexity, for the reason ratified by Laszlo cited in Cicmil *et al* (2009, p. 30) as,

'*Project management can no longer be seen as orderly pursuit of preconceived plans towards the achievement of predetermined goals, but an ongoing play with chance and probability in environment where not only the players but also the rule of the games are subject to change'*.

It is important to highlight another strand of theory within the emerging field of complexity science that is grounded in reality, which is the concept known as *'Complex Responsive Processes of Relating* (CRPR) in organizations' (Stacey, 1996, Cicmil et al., 2009, Cooke-Davies et al., 2007, Suchman, 2002). CRPR is a theoretical concept based on the complexity thinking in general and complex adaptive systems in particular. Drawing on the key properties of landscape of complexity thinking such as non-linearity, emergence, evolution, adaptation, self organization and radical predictability, this concept highlights complexity of organizations, organizing, managing and knowing, in a particular way in which the 'organization' is considered as an emergent property of many individual human beings interacting together in a responsive manner. Thereby, making it the first strand of complexity theory specifically written about human thought and communication, as compared to others which have their basis in natural or biological sciences and are applied to humans by means of analogy or metaphor (Suchman, 2002). The theory focuses on the processes that managers are engaged in reality, whereas the previous theories lack to do so. This concept is supported by the argument given by the advocates of this theory that everything emerges from the interaction between human beings, i.e. from complex processes of responsive relating among individuals and groups in their work and life. CRPR takes an alternate view and approach on management of organizational arrangement, method of enquiry in creating practical knowledge, the possibility of control and the role of the individual and the groups in these processes (Cicmil et al., 2009). It puts ordinary processes of bodily and conversational interaction between human persons and processes of the human mind to the centre stage of human action and organizational life, drawing from the George Herbert Mead's processual view of the human mind and self and social forms (Luoma et al., 2007). In a nutshell it emphasizes (Cicmil et al., 2009),

- *Self-referential, reflex nature of humans*
- *Essentially responsive and participative nature of human process of relating*
- *Radical unpredictability of there evolution and outcomes over time*

So, looking at the actuality of projects, it exhibits a level of non-linearity, evolution, emergence and uncertainty in the interactions and its outcomes, related to both human and non-human elements. Researchers have used the afore-mentioned applicable theories as basis to explain project complexity or complexity in projects.

Finally, a different approach adapted by Schlindwein and Ison (2004) towards understanding complexity, is seen useful in investigating project complexity. Schlindwein and Ison have not attempted to establish a paradigm, but have categorised it into more practical and logical terms. They state the following in this regard,

'One of the strongest claims of the scientific revolution is that science provides an objective and better description of the natural world than other ways of knowing. However, the 'real-world' of human affairs seems to us to be different than the world simplified by science - we experience it as complex, or more complex than the world and the issues that are usually addressed by 'normal' science and its methods. (Schlindwein and Ison, 2004).

Schlindwein and Ison (2004) does not give a particular definition but categorise it into 'descriptive complexity' and 'perceived complexity'. 'Descriptive complexity' encompasses all the approaches in which complexity is understood as an intrinsic property of a system, concentrating on quantifying or measuring complexity. 'Perceived complexity' relates to perception of an observer in a situation, which is more subjective, recognising the role of the observer in the acknowledgement of complexity. Perceived project complexity is in a way investigating the '*actuality*' of projects, as it will be very much influenced by the project context and also on an individual's experience in terms of variety and number of projects experienced (Geraldi and Adlbrecht, 2007, Remington and Pollack, 2008).

Summarising, complexity has been interpreted in many different ways in different fields. The understanding of project complexity is multifaceted, ranging from size (property) to relating them to complex adaptive systems (behaviour) and to its perception made by an observer.

The next section covers the concept of project complexity, as different researchers have used the aforementioned concepts to address it.

2.4 Complex Projects

The term 'project' has a very clear, distinct definition in the project management literature; however, the definition of 'project complexity' varies, as it is represented by an individual's perspective (Geraldi and Adlbrecht, 2007). In the recent years, there has been much discussion on project complexity and despite all that has been written and said, it has created more confusion than clarity, as complexity and in turn project complexity, has been in interpreted in many ways.

"While many project managers use the term 'a complex project', there is no clear definition what is meant. There is a general acceptance, however that it means something more than a 'big' project" (Williams, 2002).

The literature review given below specially focuses on complexity in the project context, i.e. 'project complexity', as this is one of the key aspects of the research undertaken. Before presenting the research to date on project complexity, one aspect needs to be discussed and that is the perceptions about 'complex projects' and 'complicated projects'.

2.4.1 Complex and Complicated Projects

Project managers perceive and use the term 'complex' in a very wide and diversified way, due to the lack of clear distinction between complex and complicated. Projects have been described as complex system, not only due to the technical issues but also due to the wider organizational factors which are usually beyond project manager's control (Whitty and Maylor, 2009). The next paragraphs present the efforts of different researchers to draw the distinction between complex and complicated, in terms of either projects and/or in relation to organizations.

Projects may be considered complicated when their output is tangible and models developed for such projects can simulate the interactions, interdependencies and the impact of their many parts with a high level of reliability. For projects, specially with non-tangible end products, are very much dependant on the participation, reactions, and interactions of people, thus making these interdependencies hard to model and thus making them to unpredictable to some extent.

'*Even projects of the type for which project management was initially developed, which may be considered inherently complicated rather than complex, are becoming more complex as their recognition and management as projects is extended beyond the execution phase to encompass a broader spectrum of the product life cycle. An engineering or construction project may be essentially well defined in the execution phase but becomes a more complex endeavour if the focus is extended to include its genesis, maintenance and disposal'*(Crawford et al., 2006).

Crawford's definition and continuum of complex and complicated cited in Wheeler (2008) differentiate the two, as complicated projects have focus on achieving the goals as they are generally clear and well defined initially whereas complex projects multiple objectives and goals which are initially ill-defined and may eventually emerge during the course of project as result of *'negotiation and consensus building throughout the project'*. The continuum from complicated to complex project is given as follow

Complicated	Complex
Tangible end products	Intangible end products
Well defined	Ill-defined
Hard, clear boundaries	Soft, permeable boundaries
Unambiguous	Ambiguous
Goal Achievement	Multi purposes and consensus building
Best solution exists	Debate leads to solution
Management	Facilitation
Planned Strategy	Emergent Strategy
Uncertainty reduction	Ambiguity reduction
'Hard' systems	'Soft' systems

Table 2-1: Continuum from Complicated to Complex Projects (Adapted from Wheeler 2008)

Looking at Table 2-1, it can be seen the major difference is due to uncertainty in different aspects, and this lack of clarity and ambiguity becomes a differentiating factor in the above complicated and complex continuum.

Another useful map for navigating the concepts and field of complexity is "The Stacey Matrix" (Stacey, 1996), in which the complexity is analysed using the two dimensions, *the degree of certainty and the level of agreement*, on the basis of which it draws distinction between simple, complicated, complex and anarchy. It basically presents a method to select the appropriate management actions in a complex adaptive system based on the *degree of certainty* and *level of agreement*, focusing on the choice between management or leadership approaches and helping in sense making in decisions, importance of communication and coping uncertainty.

In Figure 2-2, we can see that it takes two dimensions into consideration, certainty and agreement, and based on these different zones, regions for simple, complicated, complex and anarchy are given. The two representations of this matrix are shown below; one is the basic zone classification and the other shows the key features and management characteristics. The five zones (Zimmerman, 2001, Stacey, 1996) are briefly discussed below,

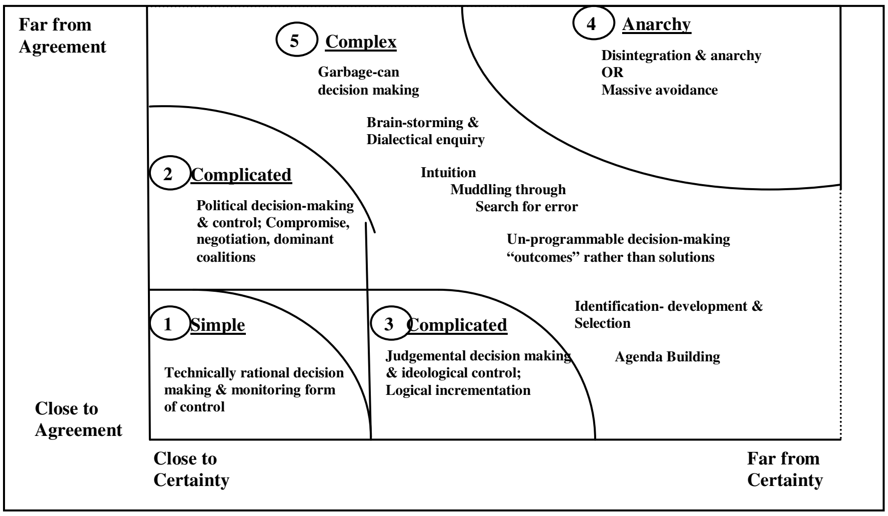

Figure 2-2 : The Stacey Matrix **(Adapted from (Zimmerman, 2001)**

Simple *(Zone 1)*: *Close to agreement & close to certainty*

Signifying projects where there is rational decision making and there is an agreement and clarity of goals. The effort is to identify right processes to maximise efficiency and effectiveness. The traditional management approach works best and most of the management literature and theory address this region (Stacey, 1996).

Complicated *(Zone 2): Far from agreement & close to certainty*

Signifying projects in which there may be an agreement on how outcomes are created, but there are disagreements on which outcomes are desirable. It is the area where neither plans nor mission is likely to work, and that's where the politics plays an important role, requiring coalition building, negotiation and compromise. There are a lot of political motivations and hidden agendas.

Complicated *(Zone 3): Close to agreement & far from certainty*

Signifying projects in which ultimate goals have been agreed upon, but there is no surety as how to achieve these goals. Traditional project management approaches may not work as there are no predetermined plans. However, a strong sense of achieving mission or vision prevails, with the goal to work for the agreed upon future objective.

Anarchy *(Zone 4): Far from agreement & far from certainty*

Signifying situations where there is no agreement on plans and there is a high level of uncertainty, resulting in a breakdown or anarchy. Traditional methods of planning, visioning and negotiation are insufficient and the only strategy suitable is that of avoidance, which may work for a short term. This is the region organizations should avoid for its disastrous in the long run.

Complexity *(Zone 5): The edge of chaos (complexity zone)*

It is the zone called by Stacey as complex whereas others call it the edge of chaos. It is a zone of high creativity, innovation and breaking from the past, where new modes of operation are created departing from the traditional management approaches.

Looking at the above classification of simple, complicated, complex and chaos, the classification focuses on two aspects, level of agreement and level of certainty, with the primary relationship to people and organizations, presenting different approaches to manage it.

The differentiation between complex and complicated (situations in management) is also pragmatically highlighted in article titled *'A leader's framework for decision making',* by Snowden and Boone (2007) shown below in Figure 2-3,

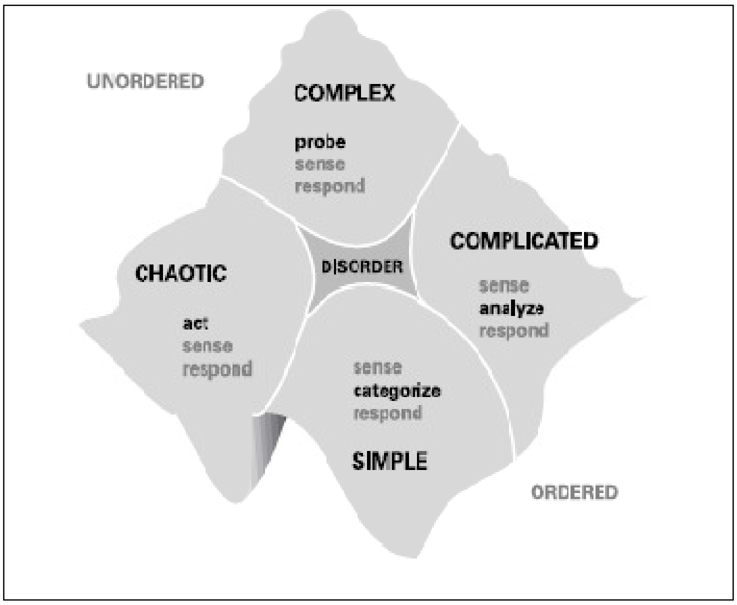

Figure 2-3 : The Cynefin Framework (Snowden and Boone, 2007)

As explained by Snowden and Boone ,

'Simple and complicated contexts assume an ordered universe, where cause-and-effect relationships are perceptible, and right answers can be determined based on the facts. Complex and chaotic contexts are unordered—there is no immediately apparent relationship between cause and effect, and the way forward is determined based on emerging patterns. The ordered world is the world of fact-based management; the unordered world represents pattern based management. The very nature of the fifth context, disorder, makes it particularly difficult to recognize when one is in it. Here, multiple perspectives jostle for prominence, factional leaders argue with one another, and cacophony rules. The way out of this realm is to break down the situation into constituent parts and assign each to one of the other four realms. Leaders can then make decisions and intervene in contextually appropriate ways.' (Snowden and Boone, 2007, p. 4)

The context characteristics for each domain are summarised in Table 2-2 below

	The Context's Characteristics
Simple	• Repeating patterns and consistent events • Clear cause-and-effect relationships evident to everyone; right answer exists • Known knowns • Fact based management
Complicated	• Expert Diagnosis required • Cause-and-effect relationships discoverable but not immediately apparent to everyone; more than one right answer possible • Known unknowns • Fact-based management
Complex	• Flux and unpredictability • No right answers; emergent instructive patterns • Unknown unknowns • Many competing ideas • A need for creative and innovative approaches • Pattern-based leadership
Chaotic	• High turbulence • No clear cause-and-effect relationship, so no point in looking for right answers • Unknowables • Many decisions to make and no time to think • High tension • Pattern-leadership

Table 2-2 : The Context's Characteristics (Snowden and Boone, 2007)

Based on the above context characteristics Snowden's '*Cynefin Framework'* helps leaders to determine the prevailing operative context that is based on the above characteristics and facilitating them to make appropriate choices and decisions. Simple contexts are characterized by stability and cause-and-effect relationships that are in terms easily understood by all. Each domain requires different actions (Snowden and Boone, 2007).

Another work which is worth mentioning is the Tuner and Cochrane (1993) matrix shown in Figure 2-4, which takes into consideration methods and goals in categorising projects. The reason for mentioning this matrix here is the aspect of certainty and clarity attached to methods and goals, which is one important characteristic used by many in explaining complexity and project complexity.

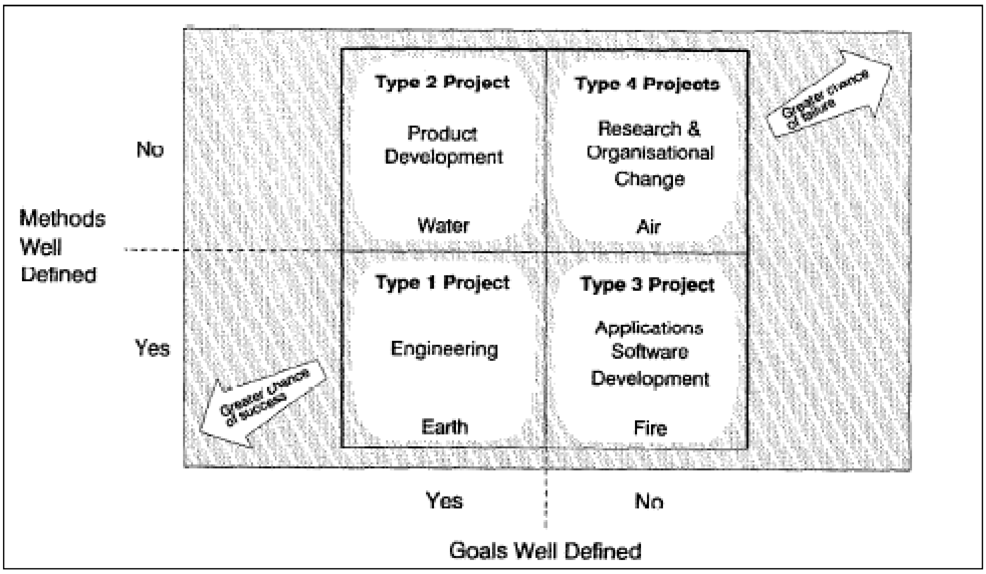

Figure 2-4 : Turner and Cochrane's' Goals and Method Matrix (Turner and Cochrane, 1993)

Turner (1993), while stating the importance of goals and objective of the projects as one of the important parameter for judging the project, emphasizes the fact that although different project definitions assume that the objective of the projects and methods of achieving them are known and well understood but in reality it is different and keeping the goals and methods basis to judge the projects, classify them into four types. The classification focuses on the element of certainty in respect to the goals and methods to achieve them.

- ***Type 1 Projects*** – in which the goals and methods are well defined, which may be due to the historical experience, similarity due to the past project, therefore the work have the clear definition of what and how the work has to be done
- ***Type 2 Project*** – in which the goals are well defined but the methods of achieving these goals are not clear. The focus is therefore on the definition of scope of work and the mode of operation of the project team.
- ***Type 3 Project*** – in which the goals are not well defined but the methods are clear. The focus is to define the purpose and objective of the project with constant interaction and negotiation with the team and project sponsor to finalise the goals during the course of the project.

- ***Type 4 Project*** **–** in which neither the goals nor methods of achieving them are clear. The project goes through an iterative process in order to get the goals and method defined.

Shenhar and associates, following the basis of the previous literature, used the dimensions of uncertainty (mainly technological), complexity and pace to distinguish among projects and to create the UCP (Uncertainty, Complexity & Pace) model. Several studies tested the validity of the UCP model, however on the basis of further studies uncertainty was further divided into to Novelty and Technology. Technology (technological uncertainty) which defines how much new technology is required to develop and produce the product (Shenhar, 2001). The addition of a fourth dimension, Novelty, enables a more accurate classification of projects (Malach-Pines et al., 2009). The four dimensions of the model: novelty; complexity; technological uncertainty; and pace are presented in Figure 2-5,

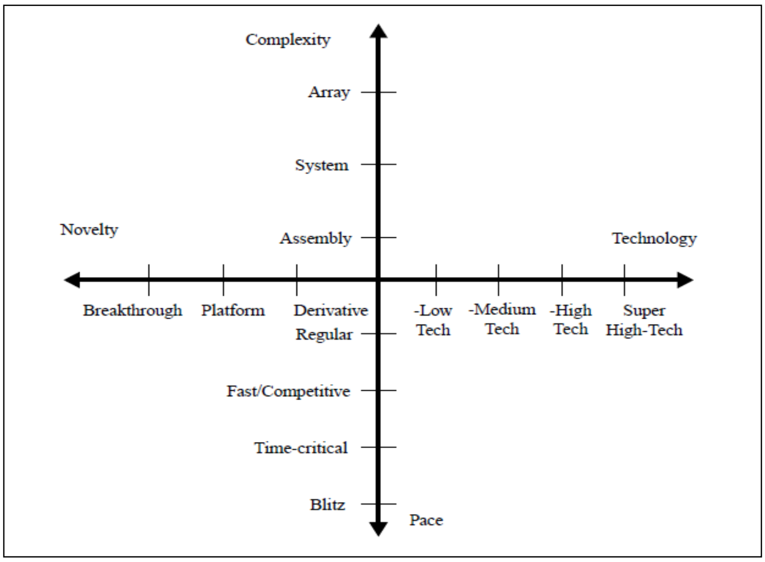

Figure 2-5 : The NTCP Model (Shenhar, 2001)

Once a project is classified based on these four dimensions, it defines certain characteristics for that project that makes it unique in terms of its management approach (Sauser, 2006).

Summarising the discussion about 'complex and complicated projects', the difference in them can be related to and is similar to the ones used for the terms 'complex and complicated' and can be adapted in simply presented as,

So complicated (projects) = *not simple, but ultimately knowable.*
So complex (projects) = *not simple and never fully knowable. Just too many variables interact.*

However looking at the above classifications, the important point to note is that there is no consideration of the physical characteristics of the projects, which at time are perceived to be making projects complex.

Summarising, Dombkins' viewpoint on complex and complicated projects:

'The differences between complicated and complex projects are not readily understood by many. Complicated projects are relatively common and are usually delivered by decomposing the project into subprojects, and then resolving inter-dependencies (integration) between subproject boundaries. To many, complicated projects will seem complex. Complicated projects, although usually very large, are able to have their scope defined to a high degree of accuracy at project inception and throughout the design phase. This is in stark contrast to complex projects where it is very often impossible to undertake accurate detailed long term planning' (Dombkins, 2008).

Comparing Stacey's and Snowden and Boone's categorization discussed above, it can be seen that uncertainty is the common and important criterion, however in Stacey's categorization the focus is more on the relationship among people.

The next section covers the theoretical approaches in defining and characterising 'project complexity', as the understanding of complex projects is multifaceted, ranging from size (property) to relating them to complex adaptive systems (behaviour) (Geraldi and Adlbrecht, 2007).

2.5 Project Complexity

The literature review on project complexity presented in this section can be placed in the '*descriptive category*', whereas the objective of this research on getting the pragmatic view comes under '*perceived complexity*'. Perceived project complexity is in a way investigating the 'actuality' of projects, Complexity in the management context is a matter of perception and ambiguity, the assessment of a situation being complex is linked with how it is perceived and also related to experience in that particular area (Remington and Pollack, 2007).

The literature review from the papers published by different researchers specifically with the aim to define 'Project Complexity' is addressed below in chronological order,

Baccarini (1996): The concept of project complexity-a review

Baccarini (1996) defines project complexity as comprising of many varied interrelated parts and operationalize them in terms of *'differentiation and interdependency'*. Differentiation signifying the number of varied elements such as tasks, specialists and components, whereas, interdependency signifying the degree of interrelatedness between the elements.

Describing project complexity in terms of

- Organisational Complexity
- Technological Complexity

Further explaining the above two types in terms of differentiation and interdependencies.

- **<u>Organisational Complexity</u>**

Organisational complexities in terms of differentiation are the 'Vertical Differentiation' and 'Horizontal Differentiation'. Vertical differentiation referring to the organisational hierarchal structure and its depth i.e. the number of levels in it. Horizontal differentiation is divided into two categories, Organisational Units and Task Structure, with the former referred to number of departments or groups and the latter in terms of division of tasks, which may be routine tasks and/or specialised tasks. Specialised tasks are performed by specialists, and the number of specialists involved represents a respective specialization area and the greater the number adds to complexity.

Defining organisational complexities in terms of interdependencies is basically the interaction and operational dependencies of the project organisational elements. Citing Thompson Baccarini continues that the organisational interdependencies can be classified into three types, pooled, sequential and reciprocal with the last one representing the highest level of complexity especially in the construction process.

- **Technological Complexity**

Similarly defining Technological Complexity in terms of differentiation and interdependency; by differentiation it is referred to variety or diversity of some aspect of tasks, as technology is usually interpreted in terms of difficulty of task performance. Technology complexity in terms of interdependency, is defined similarly as for the organisational interdependencies i.e., interaction, reliance and dependency among the tasks.

The above definition of the project complexity can be applied in the various project dimensions but the important point is to state very clearly which type of complexity is being dealt when addressing project complexity. However, based on the well established views the way to manage differentiation and interdependencies is by integration and in the project management concept it can be dealt by effective ‘co-ordination, communication and control’ (Baccarini, 1996).

Williams (1999): The need for new paradigms for complex projects

Williams adds another perspective in defining the complexity in projects i.e., *uncertainty*. Following Baccarini's work, he terms the complexity described by Baccarini as 'Structural Complexity'. In describing the project (structural) complexity he links it to the product (structural) complexity and highlights it as a major source to the former, especially in the case design-and-manufacture or design-and-build. More the complex product to be developed, normally more the project complexity will be. The product structural complexity will be the number of subsystems in the product and their interdependencies. However, merely the number of interdependencies is not sufficient but the nature of these interdependencies needs to be considered and are of importance (Williams, 1999) .

In describing uncertainty, Williams (1999) cites Jone's (1993) definition of technical complexity which comprises of variety of tasks, the level of their interdependencies and "the instability of the assumptions upon which the tasks are based", the first two are similar to Baccarini's definition of complexity whereas the last one relates to uncertainty, thus giving another dimension to the term complexity. The theme of the paper, according to him, is on the fact that uncertainty adds to complexity and can be added as a basic dimension to complexity. Thus defining project complexity in terms of 'Structural Complexity' and 'Uncertainty' as shown below in Figure 2-6,

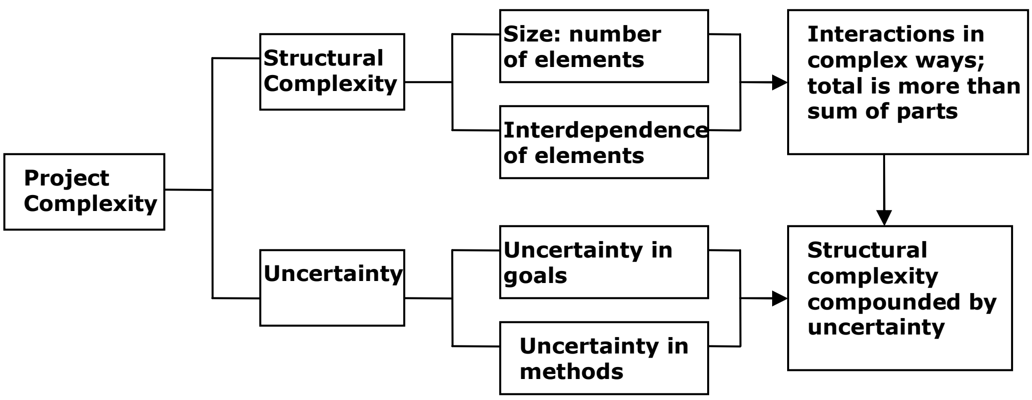

Figure 2-6: Dimensions of project complexity (Williams, 2002)

According to Williams, the complexity in projects is increasing and the reasons given by him are in the two domains i.e., structural complexity in project is increasing due to its relationship established with the product, as advancement in technology is progressing the products are becoming complex due to compactness, more inter-connectivity and increased functionality, which is based on author's experience of design-and-manufacture and software projects. The second reason for the increased in the structural complexity is the reduction in time in delivering the projects, as timely delivery is essence in the current competitive environment. Regarding 'Goal Uncertainty', there is a mix view; on one hand the increase in the importance of specifications is reducing this uncertainty but on the other hand the advancement in technologies is increasing the 'Method Uncertainty'.

The work of the previously mentioned researchers has been the benchmark in defining the project complexity. The literature published on project complexity uses structural complexity and uncertainty as the widely accepted groupings (Geraldi and Adlbrecht, 2007).

Geraldi and Adlbrecht (2007).: On faith, fact, and interactions in projects

The work and effort to define project complexity pragmatically is done by Geraldi (Geraldi and Adlbrecht, 2007). Taking the basis of structural complexity and uncertainty, she has termed these terms into 'complexity of fact' and 'complexity of faith' respectively to define the 'pattern of complexity (Geraldi and Adlbrecht, 2007)' as shown in Figure 2-7, which is intended not to define or explain complexity or provide solutions but to represent the term complexity as perceived in reality and practicality.

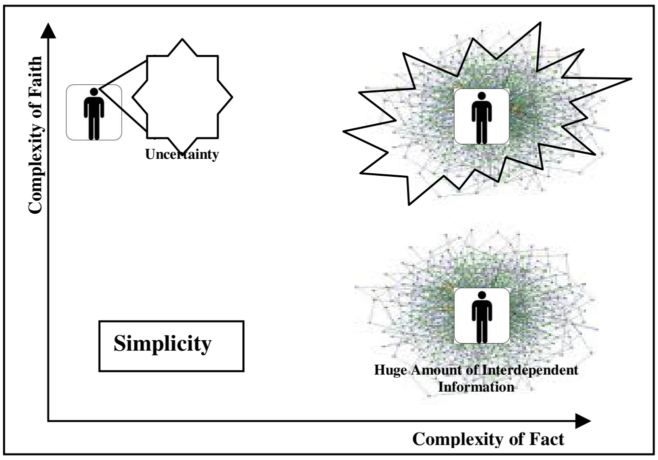

Figure 2-7: Complexity of Faith vs Complexity of Fact (Geraldi and Adlbrecht, 2007)

- **<u>Complexity of Faith</u>**

The complexity of faith is the type which arises from dealing with the newness of a product or developing a new technology, in terms something which is being done for the first time which will have an element of uncertainty embedded in it, as for instance the methods or goals for achieving might not be clear. The lack of factual information leaves team to multiple options and/or solutions to a unique problem, and in the extreme situations where the feasibility or success is vague, it is the '*faith*' which makes the project team going. So the term '*complexity of faith'* basically covers and is based on the well used type of project complexity i.e., uncertainty.

- **<u>Complexity of Fact</u>**

The complexity of fact relates to the well acknowledged type of complexity i.e., structural complexity, arising from dealing with a many varied and interlinked amount of information. Thus, relating to differentiation and interdependency as defined by Baccarini (1996).

- **<u>Complexity of Interaction</u>**

The third proposed type or group of complexity is in the terms of interactions, focusing more on the softer aspect of projects. The interfaces and interactions within the project organization internally, or externally with the client etc is basically the essence of the term complexity of interaction. The complexity of interaction emerges from two or more locations and arising from politics, culture, internationality etc.

Expanding the above into more practical terms as, ,

Group	Characteristics	Translation
Fact	Size	Size of the project
Fact	Interdependency	Dependency of others departments
Fact	Interdependency	Dependency of other companies
Fact	Number of sources	Quantity of information analyse
Fact	Number of sources	Quantity of sources of information
Fact	Number of sources	Quantity of partner and contact persons
Faith	Maturity	Low level of maturity
Faith	Uniqueness	New technology
Faith	Uniqueness	New partners
Faith	Uniqueness	New processes
Faith	Dynamics	Dynamic (changing information, specifications, change orders etc.)
Faith	Dynamics	Various and open options
Interaction		People
Interaction	Transparency	Company politics
Interaction	Multi-reference	Internationality
Interaction	Multi-reference	Multidisciplinary
Interaction		Client

Table 2-3: Complexity of Fact, Faith and Interaction (Geraldi and Adlbrecht 2007)

The important point to note in the above Table 2-3, is that complexity translation to project context seems to highlight the importance of relationship of 3P's (People, Product and Processes) with project complexity.

Remington and Pollack (2007) : Tools for Complex Projects

Remington and Pollack (2007), explained the types of complexity in relation to complexity theory, describing projects as complex adaptive systems than as simple systems, although some projects (with well-defined outputs) can be considered as simple systems (Remington and Pollack, 2007). Projects as complex adaptive systems, exhibit characteristics such as phase transition, adaptiveness, emergence, non-linearity and sensitivity to initial conditions. In general, interconnectedness, hierarchy, communication and control are attributed to all kinds of systems. Similarly as the previous researchers have indentified the types of complexity, Remington and Pollack suggest four types of project complexity.

- **Structural Complexity** – *(in the same terms as defined by Williams (1999))*

This type of complexity is present in most large projects, because of the knowledge based management in these types of projects, they are also termed as complicated rather than complex, which is mainly due the familiarity with the project type. The complexity specific to these types of projects arise from managing and keeping track of huge number of inter-connected tasks and activities. To manage these projects, outcomes are divided into many small deliverables such as discrete units with an underlying assumption that the individual units will come together to make the required whole. *The major challenges arise from project organization, scheduling, interdependencies and contract management*.

- **Technical Complexity** – (*technical or design problems associated with new products and/or new processes required; related more to uncertainty in methods (Turner and Cochrane, 1993, Williams, 1999))*

This type of complexity is related to projects that face technical or design problems associated with novel or bespoke products which have not produced before and have no precedence of proven or tested techniques. The project management challenges faced in these projects are usually managing the critical design phases, managing contracts to deliver solutions to ill-defined design and technical problems, and managing the expectations of key stakeholders.

- **Directional Complexity** – *(characterised by unshared goals and ambiguity in objectives (Turner and Cochrane, 1993, Williams, 1999))*

This type of complexity is found in projects which are characterised by unshared goals and objectives which are overshadowed by unclear meanings and hidden agendas, arising as the consequence of ambiguities and uncertainties attached with multiple interpretations of goals and objectives. The management challenges tend to be associated with the allocation of adequate time during initial project definition stages to facilitate sharing and develop understanding and giving time to for hidden agendas to emerge, for which the key to success is by managing relationships and organizational politics. Political awareness and cultural sensitivity are two fundamental capabilities needed to manage these projects.

- **Temporal Complexity** – *(influenced by dynamic and shifting environment outside the direct control of project team).*

This type of complexity is found in projects which are characterised by shifting environment and strategic directions, which at times are beyond the control of the project team and give rise to uncertainty regarding future constraints, expectation of change and possibly even concern regarding the future existence of the system. In these types of projects the focus is not on whether the project goal is going to change but rather on when it will change and in which direction. *Timing and positioning through analysis and predictive mapping may be more significant to success than efficiency and control in these types of projects.*

Projects, especially big projects or programmes are more likely to exhibit all four types of complexity in one form or the other and with varying intensity during the project life cycle. *Thinking and research in project management have emphasized structurally complex projects,* therefore many project management techniques can be effectively adapted for structurally complex projects, which can be assumed to be the most common form of complexity that nearly in exist in projects. (Remington and Pollack, 2007)

Finally a few definitions to highlight how complex projects are defined in different standards and recognised project management bodies e.g., IPMA Competence Baseline, Version 3.0 (IPMA, 2006) and Complex Project Managers Standard Version 2.0 (CCPM, 2006). Both describe complex projects in terms of their properties and however the latter standard focuses more on the uncertainty and in light of complexity theory.

According to IPMA Competence Baseline, projects which fulfil the following criteria are termed as complex projects,

- Comprising of many interrelated subsystems / sub-projects and elements within the project structure and the organisational context
- Involvement of several organisation or different units in the same organisation
- Several different disciplines involved
- Managing several different overlapping phases
- Application of many project management methods, tools and techniques

Whereas in the Complex Project Managers Standard Version 2.0 (CCPM, 2006), differentiation between complex and traditional project is given as,

- Complex project are differentiated from traditional projects by degree of disorder, instability, emergence, non-linearity, recursiveness, irregularities and randomness which are present in them in at any given stage and condition;
- There is a dynamic complexity due to the changing interactions of parts in a system and due to the outcome of these interactions/reactions;
- There is high uncertainty about the objectives and their implementation, which varies depending on the maturity of individual/organization;
- There is a high pluralist environment with multiple and divergent views existing across the stakeholders;
- Project strategy is emergent and requires constant renegotiation;

- Complex projects require changing the rules of their development as they evolve over time. Perhaps complex projects are not just ‘complex adaptive systems’ but rather *‘complex evolving systems’*, as they do not simply adapt to their environment, but evolve with them.

The views on the concept presented so far covers the theoretical aspect, where the researchers have made efforts to characterise project complexity in terms of its properties and/or behaviours.

2.6 Complexities in Projects – Pragmatic View

As cited in the editorial of *‘Project Perspective 2008’* (2008b), the importance of the term ‘complexity’ is on the rise. The complexity in modern projects can arise in different forms and from a variety of sources related to commercial, technological, organisational and human aspects of the projects.

While defining the inherent complexity of Large Scale Engineering (LSE) projects, Girmscheid and Brockmann (2007) define complexity as the degree of *‘manifoldness’*, *‘interrelatedness’* and *‘consequential impact of a decision field’*. Relating them in the organisational context, *manifoldness* is being referred to as the differentiation of the functions in LSE as the players involved such as client, designer, contractor or the internal contractors’ organisation ; *interrelatedness* defining the interaction between the system or sub-systems ; and *consequential impact* refers to complexity arising due to a decision.

However, five areas contributing to complexity in LSE projects are task, social, cultural, operative and cognitive complexities. The authors’ focus is more on the task, social and cultural complexities, omitting the other two with the reason that owing to the project characteristics such as time and pace, operative and cognitive complexities have no time to develop.

- ***Task Complexity*** referring to ‘*the density of activities in a given spatial and temporal frame’*;

- ***Social Complexity*** referring to *'the number and diversity of actors communicating and working with each other'*;
- ***Cultural Complexity*** referring to *'history, experience, and sense-making processes of the different groups that join their efforts in a LSE projects and that have taken place before it starts'*;
- ***Operative Complexity*** referring to *' the degree to which organisations of the project are independent when defining their operations to achieve given goals';*
- ***Cognitive Complexity*** *'can be treated on the level of a person or the level of a group'.*

Gidado (1996), while keeping the similar basis of complexity, defines project complexity (focusing on construction industry) into two perspectives, *'managerial'* and *'operative & technological'*.

- Managerial, relating to the planning aspect
- Operative and Technological, relating to the technical difficulties arising from the performing of these activities/tasks.

Pheng et al (2006) defined complexity (build projects) in two ways, as project size increases the difficulty in coordination increases, thereby increasing the complexity in terms of management; and secondly in terms of build ability of a design.

Maylor *et al's* (2008) recent study which is similar in approach to this research, reports an investigation into project managers' perceptions of managerial complexity. The findings are presented in terms of basic or structural complexity, which are further expanded into five dimensions to cater for the project and project environment, *Mission, Organization, Delivery, Stakeholders, and Team, - the MODeST Model,* which is shown below in Table 2-4,

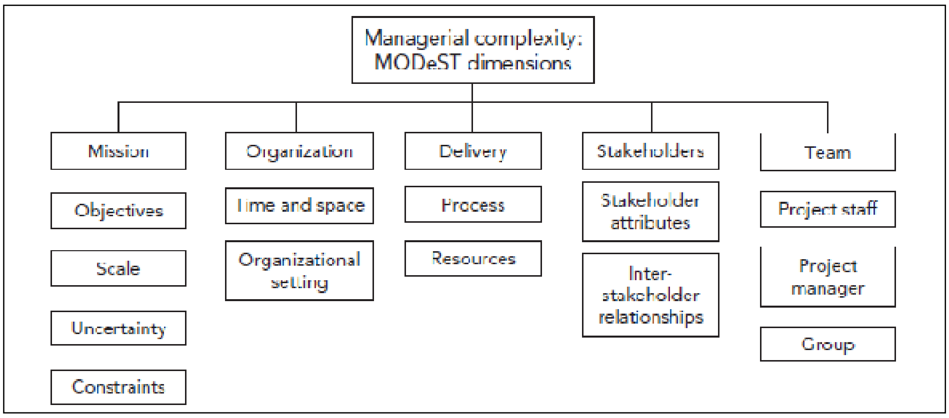

Table 2-4 : The MODeST Model (Maylor et al., 2008)

However, their findings suggest that complexity has a bipartite nature, static and dynamic as shown in the Table 2-5 below

	Structural Dimension	Dynamic Dimension
Mission	Are the requirements clear?	How frequently do the requirements change?
Organization	Is there a mismatch between matrix structure of project and department structure of organization?	Is there ongoing organizational restructuring that impacts the project?
Delivery	How well does the project team understand the project management methodology?	Is a new project management methodology being introduced?
Stakeholders	How many stakeholders are there?	Are the stakeholders changing?
Team	Are the team members motivated?	Is the level of motivation of team members changing?

Table 2-5: The MODeST Dimensions (Maylor et al., 2008)

2.7 Assessing Project Complexity

The previous sections have highlighted theoretical concepts and practical approaches in defining and understanding project complexity. Alongside this quest to understand project complexity, the other area of interest to many researchers and institutions has been to classify/categorise project complexity and to come up with a framework or an index to assess project complexity. Most of these frameworks end up giving a numerical value, which can be then read on scale to identify the level of complexity of a project rather project management, e.g. can be used such as assigning suitable project manager. The next section discusses some of the recognised methods of assessing project complexity.

'Many organizations have attempted to classify or categorize their projects in some fashion. These taxonomies usually involve size (cost, duration, number of people) or technical complexity. Unfortunately, these characteristics don't always correlate well with management complexity' (Duncan, 2006).

As seen from the previous section on complexity, the focus of categorising complexity by Stacey (1996), Snowden and Boone (2007) and Turner and Cochrane (Turner and Cochrane, 1993), has been more on facilitating in choosing the appropriate leadership style and/or management aspects, in other words providing the possible management solutions/options in each scenario, as guidelines for the leaders and executives. Similarly the focus on assessing project complexity is more on assigning a suitable program / project manager to a program rather than realization of the source and understanding of factors contributing to project complexity.

Several models exist which focus on reducing complexity to a single number with the aim of assigning a suitable experienced program / manager based on a pre-established relationship to that number. Some of these models use cost, size, and number of people, where as the others take into the perspective the reality of project i.e. environment and issues related to people, product and process. There is a variety of project categorization methods presented in the literature that uses either project complexity as one of the factor in assessing project complexity whereas others are based on different attributes related to project complexity. Some of the authors have specifically used project complexity in categorising engineering projects, e.g. Dvir (2006) used project complexity in the Novelty, Technology, Complexity and Pace (NTCP) framework, while others presented types or classification of project complexity (Baccarini, 1996, Geraldi and Adlbrecht, 2007, Williams, 2002, Remington and Pollack, 2007). Also there are organizations which are working for the advancement of project management, some of these organizations have developed methods and models to evaluate project complexity or evaluate projects based on complexity, such as,

- The Cooperative Research Centre (CRC) for Construction Research Innovation (CRI) developed a decision support tool, *CRI -Project Profile*

- Defence Material Organization in Australia (DMO) developed methodology of the Acquisition Categorization (ACAT) i.e. *DMO-ACAT : Policy for Categorization*
- Global Alliance for Project Performance Standards (GAPPS) published a framework to categorize projects in terms of their management complexity by using tool known as CIFTER – Crawford-Ishikura Factor Table for Evaluating Roles, shown in Appendix ‘A’.
- International Project Management Association (IPMA) – Developed in conjunction with already developed four level certification (IPMA Level A, B, C & D), and complexity table developed to assess management complexity in a project for level certification.

Out of the above, the IPMA method is more elaborate and has strong focus on both technical and organizational aspects, whereas CIFTER focuses more on the impact a project might have due to its business environments and takes a very broader view. All these methods focus on scoring different aspects presented in a specific model or matrix, and then adding the individual scores to present a holistic picture of project complexity. Ignoring the fact that project complexity has various dimensions to be considered which are liable to change over the project life cycle. Also it has been recognised that both in literature and practice the focus is more on technological complexity and to lesser extent on social and organizational aspects (Bosch-Rekveldt and Moi, 2008).

2.8 A word about Uncertainty

Prior to summarising this chapter it is important to discuss uncertainty as many have used it directly or indirectly, in defining and categorising project complexity. Uncertainty and risk are usually interlinked and is overshadowed by risk as it is well established knowledge area and practice.

Uncertainty has been specifically highlighted by Williams (1999) in the context of project complexity, as the others researchers have reflected the uncertainty indirectly in their understanding of project complexity. Also, the differentiating factor and the dominating difference between complex and complicated project is more related to uncertainty.

It is imperative to draw the distinction between risk and uncertainty, as uncertainty and risk are usually interlinked in the project management context. Analysing the views and definitions for risk and uncertainty, Perminova *et al.* (2008) state that in actual project scenarios, various propensities influence the decision to cope with uncertainties, which are based on the individual's experience and belief. Thus uncertainty is recognised differently by various actors in the project, wheras some may not even recognise it. In their definition of uncertainty, Perminova *et al.* (2008) states uncertainty, '*as a context for risks as events having a negative impact on the project's outcome, or opportunities, as events that have beneficial impact on project performance'*. Uncertainty can arise from both internal and external sources in a project.

It has been generally recognised that traditional project management focuses more on planning, monitoring and control (Perminova et al., 2008, Jaafari, 2001, Atkinson et al., 2006). Although highlighted that the good project management practices can be thought of doing effective uncertainty management, by clearly defining objective and plans and allocating resources, however this planning only works very well if the project is running smooth and no deviations are foreseen and occur. However in reality, projects are affected by multiple factors which change (or require changing) the plans in order achieve the goals and objectives and/or at times the goals and objectives change during the project life cycle, consequently affecting all the initial planning effort done. So there lies an element of uncertainty in projects which directly affects the project and/or its environment.

Uncertainty cannot be managed in a similar way risk is managed in projects, for the traditional project risk management tools are effective for avoiding risks, these methods however are not enough to manage uncertainty especially when uncertainty is considered as both risks and opportunities. To manage uncertainty it is important to look beyond the perceived threats, opportunities and their effects and focus more on the sources giving rise to them, and where and why are they important in the project context (Ward and Chapman, 2003).

The traditional project tends to address uncertainty in a way, but it lacks to identify the sources which give rise to uncertainty. Atkinson *et al* (2006) identifies three sources giving rise to uncertainty,

i. *Uncertainty in Estimates*
ii. *Uncertainty associated with project parties*
iii. *Uncertainty associated with stages of the project life cycle*

Ward and Chapman (2003) also identify five areas which contribute to uncertainties in projects,

i. *The variability associated with estimates to the project parameters*
ii. *The basis of estimates of project parameters*
iii. *Design and logistics*
iv. *Objective and priorities*
v. *Relationship between project parties*

The variability associated with '*estimates of the project parameters'* and '*the relationship between project parties*,' are described in the same context as in the aforementioned reference.

Many traditional definitions view project as a sequence of activities carried out to achieve a set defined goal and objective, depending on how well the goals are defined and how well the methods are known to achieve them, and influencing the planning aspect which is done in the early stages which focuses more on the objectives and methods and the resources required for the execution. But in reality as stated earlier, there are number of unknowns and uncertainties, which makes the project execution a difficult and a challenging task (Turner and Cochrane, 1993).

2.9 Summary

The theoretical and practitioners' perspectives of project complexity have been presented above; commonality in them is the use of the linguistic meaning of the word 'complex' as a basis of describing project complexity. The explanations presented above focus on *'manifoldness'*, *'interrelatedness'* and *'consequential impact of a decision field'*, and a close look at projects reveals the presence of these three terms. Taking into consideration *'manifoldness'* and *'interrelatedness',* it can be said that both complicated and complex projects exhibit these properties, but the factor that differentiates a complex project from a complicated one is the ambiguity or uncertainty in the outcome of the interactions of its multiple elements, which can be related (or interrelated) to ongoing processes in the project, the deliverable product and/or people involved in the project. The project deliverable (end-product) more or less governs the choice of processes and procedures, technologies and groups and the involvement of people (stakeholders).

Looking at the characteristic of complex adaptive systems and the concepts of complexity theory which have been used by researchers to unfold project complexity, it can be seen that the characteristics seemed to be given in terms of inherent behaviours. Whereas more focus of these should be on project *'actuality'* (Cicmil et al., 2006), as it is characterised as taking place within a human and social context (a social process), occurring in a complex dynamic environment characterized by chaos and uncertainty. In this social process people are the 'complex adaptive systems' exhibiting all its characteristics and concepts. People deliver successful projects and not just the application methods and tools. The reason for mentioning this is to highlight, that the human element or the people side in projects can be analysed as complex adaptive systems and/or using complexity theory, and it is their actions/reactions/interactions within a project exhibiting characteristics such as phase transition, adaptiveness, emergence, non-linearity and sensitivity to initial conditions. However, for deliverable product (technology) and project process can be better explained in terms of *manifoldness, interrelationship and uncertainty*, rather using the complexity theory approach.

The above review of project complexity presented focuses more on its typology and somehow fails to identify the factors that contribute to and/or affect project complexity. This is important in order to understand the dynamic nature of projects and to identify the factors which in essence are beneficial for *'people'* who are involved in managing projects and are responsible for its successful outcomes. In this context, Geraldi and Adlbrecht (2007) not only defined the patterns of complexity (minimum manageable context of complexities within a project) but also related the types to the terms well recognised by practitioners. Expanding the well established structural complexity and uncertainty into more practical terms as '*complexity of fact'*, '*complexity of faith'* and '*complexity of interactions'*.

It has been recognised generally that traditional project management focuses more on planning, monitoring and control (Perminova et al., 2008, Jaafari, 2001, Atkinson et al., 2006). Although highlighted that the good project management practices can be thought of doing effective uncertainty management by clearly defining objective and plans and allocating resources, but all this planning works very well if the project running is smooth and no deviations are foreseen or occur. However in the practical scenario, projects are faced with multiple factors which change (or requires changing) the plans in order achieve the goals and objectives and/or at times the goals and objectives change in the project life cycle, consequently affecting all the initial planning effort done. So there lies an element of uncertainty and complexity in the projects which directly affects the project and its environment and as stated earlier identifying the sources of this uncertainty and complexity and managing it an effective and productive way to ensure project and project management success.

Academic research resulting in theories and findings is beneficial in enhancing the theoretical data base which is useful in revealing the underlying patterns to give a better understanding of a phenomenon(s) and gaining knowledge about the system. With the increase in recognition and understanding of projects and specifically project complexity, current project management research still attracts criticism for its lack of relevance to practice as it focuses on hard aspects, based on linear, analytic and rational approaches, emphasizing planning and control.

Viewing the literature presented on project complexity, it tries to explain the complexities in project using different platform to give a satisfactory explanation, but seems to lack to point out the source of complexities in a project, which can be easily identifiable and presented in the terminology familiar with the practitioners. The important thing is to know about the cause, and only then the consequences can be addressed in an appropriate and effective manner. So it is imperative for the practitioners to understand the factors that contribute to project complexity and to identify its sources.

The next section presents the part of the literature review that focuses on key project management processes and project critical success factors.

Chapter 3

Literature Review – Part II

3.0 Introduction

This chapter is the continuation of the literature review, as the previous chapter focused on complexity and project complexity in particular. In this chapter other topics related to this research i.e., project management processes and project critical success factors are presented.

The focus of this chapter is to highlight the project management processes presented in various professional body of knowledge and the views of researchers on their applicability and usefulness in the actual project settings. The first part of this chapter discusses in brief the existing bodies of knowledge and frameworks e.g., International Project Management Association (IPMA) / Association of Project Management (APM), Project Management Institute (PMI), and Australian Institute of Project Management (AIPM) – Body of Knowledge (BoK)) which support project management in practice. This is followed by section on hard and soft skills as these terms are frequently used in theory and practice.

Although PMI's PMBoK is the most recognised of the existing BoKs (Ofer, 2009), however for the purpose of this research purpose the processes and terminologies of APM BoK were used due to the fact the practitioners involved in this research were more familiar with its terminologies and also for the reason that APM BoK recognises and highlights the importance of soft skills, as discussed in the section on hard and soft skills, as these terms are frequently used in theory and practice.

The last part of this chapter presents the literature review on project success and project critical success factors. For projects are undertaken to achieve a specific objective, it is both natural and justified to seek and assess the extent to which the purpose or objective has been achieved. Success criteria are the measures against which the success or failure of the projects are judged and success factors are those characteristics, conditions or variables that tend to lead directly to the project success (Cooke-Davies, 2004). However, success is an interesting word, as it conveys different meaning to different people, for the contextual factor dominates in defining it (Jugdev and Muller, 2005). So its imperative to understand what is meant by the term project success. The ultimate objective of the people and organizations who are involved in projects is its successful outcome, and this section aims to elaborate on what is meant by this term. Lastly, in conjunction with success, project critical success factors are discussed in the last sections of this chapter, highlighting and reviewing the work in this area. The use of project critical success factors perhaps are the best known approach for tackling human and organizational aspects of projects but although the approach has very many champions it is not without its critics (Fortune and White, 2006).

3.1 Key Management Processes

Project management has been well developed and well accepted as a domain for the exercise of professional expertise and areas for academic research. There are numerous methods and techniques in place covering all aspects of managing projects, and they have been disseminated widely in books and journal and through the work of professional bodies. However, project management still remains a highly problematic endeavour, with many projects either exceeding their budgets, running late and/or failing to meet their objectives (White and Fortune, 2002). As project management research continues to grow, there is still limited research evidence that links adherence to these project standards to better project performance (Mullaly and Thomas, 2007).

BoKs initiative was initially for certification purposes, however, the APM Body of Knowledge, along with PMBoK and P2M, still remains one of the most influential publications, constituting the knowledge base of the profession Morris . Several papers published on project management practices highlight the use of project management tools and techniques, which are in reference and/or are based on the existing BoKs (Besner and Hobbs, 2008a). While many aspects of project management practice are common to most projects in most contexts, others differ significantly in different types of projects and contexts (Besner and Hobbs, 2008b). These variations in projects have made researchers to criticise *'one size fits all'* philosophy which is based on the assumption that all projects are fundamentally similar in nature (Shenhar, 2001), and to research into the aspect as to what extent these standards are used in practice and their impact on project performance (Papke-Shields et al., 2009 in Press). This aspect is also highlighted in the introduction of PMBoK as,

'*The primary purpose of the PMBOK® Guide is to identify that subset of the Project Management Body of Knowledge that is generally recognized as good practice... ....Good practice does not mean that the knowledge described should always be applied uniformly on all projects; the project management team is responsible for determining what is appropriate for any given project'* (PMI 2004, p 3)

There are many standards/BoKs that have been developed and disseminated by various professional project management bodies such as Project Management Institute USA, the Association for Project Management UK, the Australian Institute of Project Management and the International Project Management Association (IPMA, 2009). However, PMI's PMBoK is considered to be the leading, most recognised and the most influential book in the field of project management (Pender, 2001, Pant and Baroudi, 2008, Ofer, 2009, Morris, Morris et al., 2006b, Reich and Wee, 2006).

The PMI's PMBok and APM's Body of Knowledge are discussed briefly in the next sections, highlighting their structure and approach.

3.1.1 PMI's PMBoK

Project Management Institute (PMI), the largest by membership, is a U.S. based project management association founded in 1969. The most popular and the most recognised body of knowledge worldwide is the PMI's '*A Guide to the Project Management Body of Knowledge'*-PMBOK® Guide (2008a). There are nine knowledge areas identified in PMBOK that a project manager should focus in the course of the project life cycle which are generally recognised as '*good practice*'. (PMI 2008, Pant and Baroudi, 2008).

"The Project Management Body of Knowledge is an inclusive term that describes the sum of knowledge within the profession of PM. As with other professions such as law, medicine, and accounting, the body of knowledge rests with the practitioners and academics that apply and advance it. It identifies and defines the elements of PM in which competent PM professionals should be knowledgeable. The complete PMBoK includes knowledge of proven traditional practices that are widely applied, as well as innovative and advanced practices that are emerging in the profession, including published and unpublished material. As a result, the PMBoK is constantly evolving" (2008a).

PMBoK comprises of nine Knowledge Areas as shown below as given in PMI (2004),

1). Project Integration Management - *the processes and activities that integrate the various elements of project management, which are identified, defined, combined, unified and coordinated within the Project Management Process Groups.*

2). Project Scope Management - *the processes involved in ascertaining that the project includes all the work required, and only the work required, to complete the project successfully*

3). Project Time Management - *the processes concerning the timely completion of the project.*

4). Project Cost Management - *the processes involved in planning, estimating, budgeting, and controlling costs so that the project is completed within the approved budget.*

5). Project Quality Management - *the processes involved in assuring that the project will satisfy the objectives for which it was undertaken.*

6). Project Human Resource Management - *the processes that organize and manage the project team.*

7). Project Communications Management - *the processes concerning the timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information.*

8). Project Risk Management - *the processes concerned with conducting risk management on a project.*

9). Project Procurement Management - *the processes that purchase or acquire products, services or results, as well as contract management processes.*

Projects are composed of processes, namely project management processes and product oriented processes, these processes are performed by people. The former describe, organize and complete the work of the project, the latter specify and create the project product e.g. the scope of the project cannot be defined without the basic understanding of how the product is made.

PMBoK expects a project manager to perform 44 processes within these knowledge areas, which include 21 planning processes about 48% of all processes, emphasizing and highlighting the importance of planning during the project life cycle.

The processes are defined specifically for the nine knowledge areas (Ofer, 2009) as shown below in Table 3-1,

Process Groups / Knowledge Area	**Initiating** *(authorising the project or phase)*	**Planning** *(Defining & refining objectives and selecting the best of the alternative courses of action to attain the objectives)*	**Executing** *(Coordinating people and other resources to carry out the plan)*	**Controlling** *(Ensuring that project objectives are met by monitoring and measuring progress regularly to identify variance to plan)*	**Closing** *(Formally acceptance of phase or bringing it to an end)*
1. Project Integration Management	1.1 ***Develop Project Charter*** 1.2 ***Develop Preliminary*** 1.3 ***Project Scope Statement***	1.4 ***Develop Project Management Plan***	1.5 ***Direct and Management Project Plan Execution***	1.6 ***Monitor and Control Project Work*** 1.6 ***Integrated Change Control***	1.7 ***Close Project***
2. Project Scope Management		2.1 ***Scope planning*** 2.2 ***Scope Definition*** 2.3 ***Create WBS***		2.4 ***Scope Verification*** 2.5 ***Scope Control***	
3. Project Time Management		3.1 ***Activity definition*** 3.2 ***Activity sequencing*** 3.3 ***Activity Resource Estimating*** 3.4 ***Activity Duration Estimating*** 3.5 ***Schedule Development***		3.6 ***Schedule Control***	
4. Project Cost Management		4.1 ***Cost Estimating*** 4.2 ***Cost Budgeting***		4.3 ***Cost Control***	
5. Project Quality Management		5.1 ***Quality Planning***	5.2 ***Perform Quality Assurance***	5.3 ***Perform Quality Control***	
6. Project Human Resource Management		6.1 ***Human Resource Planning***	6.2 ***Acquire Project Team*** 6.3 ***Develop Project Team***	6.4 ***Manage Project Team***	
7. Project Communications Management		7.1 ***Communications Planning***	7.2 ***Information Distribution***	7.3 ***Performance Reporting*** 7.4 ***Manage Stakeholders***	
8. Project Risk Management		8.1 ***Risk Management Planning*** 8.2 ***Risk Identification*** 8.3 ***Qualitative Risk Analysis*** 8.4 ***Quantitative Risk Analysis*** 8.5 ***Risk Response Planning***		8.6 ***Risk Monitoring and Control***	
9. Project Procurement Management		9.1 ***Plan Purchases and Acquisitions*** ***9.2 Plan Contracting***	9.3 ***Request Seller Responses*** 9.4 ***Select Sellers***	9.5 ***Contract Administration***	9.6 ***Contract Closeout***

Table 3-1: PMBoK Processes and Knowledge Areas (PMI, 2004)

Although the PMBoK is a well recognised body of knowledge, however it has been criticised by many such as,

- Besner and Hobbs (2006) highlight the lack and the need of specifying the importance as to which particular tools/process sets are more useful and valuable in different project contexts and phases,

- Pant and Baroudi (2008) and Morris *et al* (2006) criticised the PMI BoK for focusing more on the hard skills than the soft skills compared to other BoKs, and

- Winter *et al* (2006), and Cicmil *et al* (2006) highlighted the limitations in addressing the dynamic, social and complex contexts and their lack of relevance to practice.

The lack of focus on soft skills is further highlighted by Pant and Baroudi (2008) as,

'The strong influence that PMBOK has, and continues to have, in project management education in Australian universities and around the world, warrants that its authors takes amore balanced approach in dealing with the soft and hard skills required for success in the profession'.

The lack of relevance to practice, mentioned earlier was one of the motives behind the development of the APM's Body of Knowledge (Morris et al., 2006b), which is discussed in the next section.

3.1.2 APM Body of Knowledge

Association of Project Management (APM) is a UK based project management association. APM Body of Knowledge (BoK) represents topics which are considered important by practitioners and experts and are considered important for the professionals in project management to be knowledgeable and competent in them. APM BoK has a more practical approach, encompassing the broad range of knowledge base of project management. However it is not an exhaustive set of competencies and also it does not cover much about the behavioural characteristics that are considered important in project management (APM, 2000).

It was realised by APM in the early 90s at the time of launch of its certification programs that PMI BoK did not adequately reflect the knowledge base that project management professionals needed. Hence APM developed its own BoK which differed markedly from PMI's BoK (Morris, 1999). As highlighted in the introduction of APM BoK that, '*APM Body of Knowledge 5th Edition has been written by practising project managers for practising project managers' (APM, 2006a).* APM thus developed more comprehensive view of the knowledge required to accomplish projects adopting a broader, more discursive and less method oriented approach as compared to PMBOK guide (Morris et al., 2006b).

The APM Body of Knowledge is a well-established collection of project management knowledge and is currently in its fifth edition. The sections and topics in it provide introductions and common guides to the areas which are considered essential to the discipline of managing projects. This information directly assists all those interested in project management in their work, studies and learning (APM, 2006b). The 5th Edition has a total of 52 topics divided amongst seven sections. as shown below in Table 3-2,

<table>
<tr><td colspan="5">1.0 Project Management in Context
1.1 Project Management
1.2 Programme Management
1.3 Portfolio Management
1.4 Project context
1.5 Project Sponsorship
1.6 Project Office</td></tr>
<tr><td colspan="5">2.0 Planning the Strategy
2.1 Project Success and Benefits Management
2.2 Stakeholder Management
2.3 Value Management
2.4 Project Management Plan
2.5 Project Risk Management
2.6 Project Quality Management
2.7 Safety, Health & Environmental Management</td></tr>
<tr>
<td>3.0 Control/Executing the Strategy
3.1 Scope Management
3.2 Scheduling
3.3 Resource Management
3.4 Budgeting & Cost Management
3.5 Change Control
3.6 EVM
3.7 Information Management
3.8 Issue Management</td>
<td>4.0 Techniques
4.1 Requirements Management
4.2 Development
4.3 Estimating
4.4 Technology Management
4.5 Value Engineering
4.6 Modelling & Testing
4.7 Configuration Management</td>
<td>5.0 Business and Commercial
5.1 Business Case
5.2 Marketing & Sales
5.3 Project Financing and Funding
5.4 Procurement
5.5 Legal Awareness</td>
<td>6.0 Organisational and Governance
6.1 Project Life Cycles
6.2 Concept
6.3 Definition
6.4 Implementation
6.5 Handover and Close-out
6.6 Project Reviews
6.7 Organisational Structure
6.8 Organisational Roles
6.9 Methods and Procedures
6.10 Governance of Project Management</td>
<td>7.0 People and the Profession
7.1 Communication
7.2 Teamwork
7.3 Leadership
7.4 Conflict Management
7.5 Negotiating
7.6 Human Resource Management
7.7 Behavioural characteristics
7.8 Learning and Development
7.9 Professionalism and Ethics</td>
</tr>
</table>

Table 3-2: APM BoK Sections and Topics (APM, 2006a)

These sections are closely linked with each other but have been presented separately due to their significance and to aid the simplicity of their presentation. APM BoK does not propose a mechanistic set of rules/practices which must be followed to guarantee success; in reality its a difficult proposition, that is why APM BoK is discursive, stressing more on the importance of context (Morris et al., 2006). APM BoK also has specific section on 'people' which focuses on behavioural and human relation as opposed to PMBoK which instead emphasizes more on tools and processes (Pant and Baroudi, 2008). The importance of soft skills is highlighted by the following statement,

'Projects begin and end, arguably, with people, yet the project management BOKs do not deal in detail with this as a knowledge area, generally spending less space on it than on the other topics' (Morris et al., 2006b).

The two well recognised and established bodies of knowledge have been discussed in brief, highlighting their structure and contents. In the observations about the BoKs by researchers, invariably the terms hard and soft skills were mentioned, as they are more commonly used in practice to represent the management processes and human issues respectively. The next section highlights the 'Hard' and the 'Soft' Skill continuum.

3.2 Hard and Soft Skills

The terms ‘hard’ and ‘soft’ are being used in the project management context in a loose and ambiguous way, referring to projects, programs, approaches, methodologies, etc. (Crawford and Pollack, 2004).

However, ‘hard’ skills in the project management context generally refer to project management processes, procedures, tools and techniques, such as given in project management Body of Knowledge (specially in PMBoK), where as the ‘soft’ skills refer to dealing with human issues i.e. the ‘people’ part of the project, which is now gaining more and more recognition. Winter et al (2006) highlight the fact that project management thinking is based on a ‘hard’ systems model focusing more on planning and control and not sufficiently accounting for the human issues (soft), which at times are the most significant (Crawford and Pollack, 2004). PMBoK in particular has been criticised for focusing on the hard skills more than the soft skills as compared to the other BoKs (Pant and Baroudi, 2008, Morris et al., 2006a). As Gale and Brown (2003) state , *‘there are some obvious gaps in all the BoKs, particularly in the area of people and culture’* (p. 417).

The realisation of importance of soft skills is on the rise, as the research and reviews on various aspects of project management, from evaluation of BoKs; project manager competencies (Ireland, 2004); leadership styles (Turner and Muller, 2005) to project critical success factors, reveal the importance of soft skills in one way or the other. As the importance of soft skills in the application project management is becoming more recognized, it still remains under represented in the project management literature e.g BoKs, which focuses on hard aspects, based on linear, analytic and rational approaches, emphasizing planning and control.

Project management practice is seen as a social conduct and interaction occurring between people working together to accomplish an objective (Cicmil and Marshall, 2005). The importance of soft skills has been highlighted by many researchers as imperative for project success. As contended by Halstead (1999),

'Whist a project manager must focus on the task, real success comes from knowing how to get things done through others. Whilst some may see managing the human issues within a project, as a soft option. It is neither soft, nor an option, if a project manager wants the project to succeed' (Halstead, 1999, p 4).

People deliver successful projects and not just the application of methods and tools. People need the ability to adapt and engage intelligently with aspects of project complexity to ensure project objectives are successfully met. Effective management of people in the dynamic project setting, and to execute well chalked-out plan catering for the continuous changing requirements and environments, is the key to the success. 'Effective team leaders are social architects who understand the interaction of organizational and behavioural variables and can foster a climate of active participation, accountability and result-orientation'(Thamhain, 2004).

As mentioned earlier, the APM BoK realising this importance of soft skills has a dedicated section focusing on this aspect. The factors related to people given in *section 7- People and the profession* of APMBoK 5th Edition are shown in Table 3-2 which are similar to the ones given in the ICB Competence Baseline shown in Table 3-3 below, under the technical, behavioural and contextual competence range used in the definition of project management competency, thus highlighting the importance of soft skills in managing projects which in turn is managing people. Although the traditional project management competencies are critical for project success, but soft skills are vital not only to understand people but the environment, and also using the interpersonal abilities, technical competencies and cognitive aptitude to manage them (Pant and Baroudi, 2008).

1. Communication
Communication is the giving, receiving, processing and interpretation of information. Information can be conveyed verbally, non-verbally, actively, passively, formally, informally, consciously or unconsciously.
2. Teamwork
Teamwork is when people work collaboratively towards a common goal as distinct from other ways that individuals can work within a group.
3. Leadership
Leadership is the ability to establish vision and direction, to influence and align others towards a common purpose, and to empower and inspire people to achieve project success. It enables the project to proceed in an environment of change and uncertainty.
4. Conflict management
Conflict management is the process of identifying and addressing differences that if unmanaged would affect project objectives. Effective conflict management prevents differences becoming destructive elements in a project.
5. Negotiation
Negotiation is a search for agreement, seeking acceptance, consensus and alignment of views. Negotiation in a project can take place on an informal basis throughout the project life cycle, or on a formal basis such as during procurement, and between signatories to a contract.
6. Human resource management
Human resource management (HRM) is the understanding and application of the policy and procedures that directly affect the people working within the project team and working group. These policies include recruitment, retention, reward, personal development, training and career development.
7. Behavioural characteristics
Behavioural characteristics are the elements that separate and describe a person's preferred way of acting, interacting and reacting in a variety of situations. Behaviours complement knowledge and experience and are a function of values, beliefs and identity. They can be used in assessment, engagement and career advice.
8. Learning and development
Learning and development involves the continual improvement of competencies in the organisation. The identification and application of learning within projects develops the organisation's capability to undertake current and future projects.
9. Professionalism and ethics
Professionalism and ethics both relate to proper conduct. Professionalism is demonstrable awareness and application of qualities and competencies covering knowledge, appropriate skills and behaviours. Ethics covers the conduct and moral principles recognised as appropriate within the project management profession.

Table 3-3: ICB Competences and Soft Skills (Adapted from IPMA (2006))

Loo (2002) describes best practices as optimum ways of performing work processes to achieve high performance, citing the best practices examined by Toney and Powers (1997) as *'they identified some 19 key success factors....'*", and continues to discuss best practices linking them to project manager competencies, PM processes and important of all soft skills covering most of the aspects given in the table above. It can be observed from the aforementioned premise that the success factors and best practices are interlinked and support each other, as best practices make use of optimal process where as the success factors would be '*those characteristics, conditions or variables that, when properly sustained, maintained, or managed, can have a significant impact on the success of a firm competing in particular industry'* (Leidecker and Bruno, 1984).

The next section highlights the critical success factors, as they are considered an important set of parameters / factors influencing both project and project management success.

3.3 Project Critical Success Factors

Project critical success factors have been discussed by various researchers in the context of different project types in various industrial sectors. This area is of interest to both academicians and practitioners, the former interested to enhance the knowledge base and the latter in the practical terms to understand the important aspects to achieve the end objectives, beneficial for the company and its stakeholders. However, this achievement of end objectives, in other words termed as *'success'*, has been interpreted by many, and that too with different perspectives (Baccarini, 1999, Cooke-Davies, 2004, de Wit, 1988, Dvir et al., 1998, Morris and Hough, 1987, Pinto and Mantel, 1990).

Success is an interesting word, and it conveys different meaning to different people, for the contextual factor dominates in defining it. So the understanding of different dimensions of success is important, for success for one may not be the same for other. However, getting consensus on project success, is similar to getting consensus from a group of people on the definition of what is 'good art' (Jugdev and Muller, 2005). Traditional project success criteria focuses on the *'Iron Triangle'* - cost, time and quality (Kerzner, 2003, Jha and Iyer, 2007, Atkinson, 1999, Cooke-Davies, 2004, Lim and Mohamed, 1999, Bryde, 2008), although there is a general recognition in the project management community that defining project success is not that simple. However, looking at time, cost and quality may identify immediate contributions to profit but will not identify how the project was managed (Kerzner, 2003). There are examples of projects which have not been managed well but are still viewed as to be successful, e.g. the Sydney Opera House, which was although behind schedule and over budget, yet it is proudly displayed as an engineering masterpiece.

Westerveld (2003) states that the issue of project success has to be seen beyond the iron triangle as there are more criterion that can highlighted.

"*Perceiving project success simply as the compliance with the time, cost and quality constraints can be qualified as a more 'narrow' view in this respect"(Westerveld, 2003)* .

The measurement of progress, cost and quality are no doubt the essential elements of project control but this activity should not be confused with project success, as highlighted by *de* Wit (1988) as,

"In any discussion on success, it is essential that a distinction is made between project success and the success of the project management effort, bearing in mind that good management can contribute towards project success but is unlikely to be able to prevent failure".

3.4 Project and Project Management Success

Success criteria are the measures against which the outcome of the project is judged whether it is a success or failure (Cooke-Davies, 2004). Success criteria differ and vary from project to project due to various factors such as size, uniqueness and complexity, thus making it difficult to generate a universal checklist of project success criteria (Westerveld, 2003).

Different researchers' understanding of project success is based on either around the *'iron triangle'* or beyond it is briefly discussed below.

Morris and Hughes (1987) and Jugdev and Muller (2005) grouped project success as follows,

- Project Functionality – *does the project meet the financial and technical requirements*
- Project Management – *did the project cost, time and quality specifications are achieved*
- Contractor's commercial performance – *did the contractor's commercial benefit achieved*
- Project termination – *in this event was the decision made on a rationale and was it efficiently achieved*

Pinto and Mantel (1990), categorised project success into 3 dimensions

- ***The implementation process;*** *The success or failure of the implementation process itself is an internally-oriented measure of the performance of the project team, including such criteria as staying on schedule, on budget, meeting the technical goals of the project, and maintaining smooth working relationships within the team and parent organisation. The key issue for the implementation process is efficiency.*
- ***The perceived value of the project;*** *The project team's perceptions of the value and usefulness of the project's deliverables. This assessment places emphasis on the project's potential impact on users. This is the project team's judgment about how good a job they did for the client. The project team's assessment of the project may or may not agree with the client's assessment.*
- ***The Client's Satisfaction,*** *Client satisfaction, the third aspect of project performance, is an external measure of effectiveness, made by the client.*

Baccarini (1999), identified the two distinct component of project success,

- ***Project Management Success,*** focuses on the process and how it is implemented. Focusing in particular to the successful accomplishment of cost, time and quality objectives.
- ***Product Success,*** deals with the effects of the projects final outcome in terms of its product

Terry Cooke-Davies (Cooke-Davies, 2004), defined success criteria in terms of three levels,

- ***Project Management Success – was the project done right?***
  Covers the generally accepted measure of success, which is cost, time and quality, however in reality the project objectives are not this simple, other factors such as profit, business case, technical specifications and goals are to be accomplished.
- ***Project Success – was the right project done?***
  Covers the interest of the owner or sponsor of the project, in the broadest sense is the measure of value of money. The assumption of success here is that it delivers to the expectation and satisfaction of the stakeholders. Project success is not a better level to establish success criteria, both project management success and project success is important to each other.
- ***Consistent project success – were the right project done right, time after time?***
  Covers the criteria to ensure consistent project success, related to the whole organisation and is inevitably influenced by the chosen strategy. A consistent project success assumes an increasing strategic importance. It is basically the overall level of project management success.

The three criteria indicate that there are different organisational levels involved in the assessment of project success and satisfying all three levels are necessary for achieving project success.(Cooke-Davies, 2004)

Looking at the above classifications, it can be seen that the classification of project success has been done on the basis of two aspects i.e., the 'project management process' and 'stakeholder satisfaction'. Jugdev and Muller (2005) state that the views of project success have changed over the years, from the definition which only focused on the implementation phase to the definition which now covers the whole project and product life cycles. How effectively and efficiently the project is carried out, and how the project's product and services add to the business value, both of these give strategic value to project management. By restricting to time, cost and quality variables, project management is providing tactical (operational) value and not the strategic value. Projects are about managing and meeting expectations, and expectations are tied up with the perception on success. Project success is complex and ambiguous concept and it changes over the project and product life cycle. (Jugdev and Muller, 2005).

The next section looks into critical success factors and their importance.

3.5 Critical Success Factors

The concept of success factors was first introduced by Daniel, however the concept became popular when Rockart unpacked the term 'critical success factor' (Amberg, 2005, Fortune and White, 2006, Zwikael and Globerson, 2006, Randall Byers and Blume, 1994, Leidecker and Bruno, 1984).

'Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization.................As a result, the critical success factors are areas of activity that should receive constant and careful attention from management'. (Rockart, 1979)

Based on the above definition by Rockart, many researchers such as Boynton and Zmud (1984), Leidecker and Bruno (1984), Zwikael and Globerson (2006) have given similar definitions of critical success factors linking them to specific areas critical to successful project outcome, and areas that need special and continuous managerial and enterprise attention to achieve and ensure the organization's successful competitive performance. Critical success factors include issues vital to an organisation's current operating activities and to its future success.

The research on Critical Success Factors (CSF) for project management has been done by many authors who have compiled and published a list of factors, some relating to a specific problem area and the associated activities, and others at times stressing the applicability of the factors to all projects types (Fortune and White, 2006). The aim of their research into project success factors concentrated on identifying those critical key areas that increases the likelihood of successful project outcome. Initially the focus of the researchers on the critical success factors was on the control aspects of the projects, which proved to be a narrow approach as it aimed only on developing standard tools and techniques for project management. The result of later studies, especially on large projects, highlighted the importance of other factors which needed to be taken into account in order to successfully manage projects and its outcomes.(Westerveld, 2003, Morris and Hough, 1987, Pinto and Prescott, 1988, Munns and Bjeirmi, 1996).

Pinto and Slevin (1989) published a major research study in this area which focused specifically on the project oriented environment. The factors from their study are listed below in Table 3-4,

Pinto & Slevin (1989)	
Top Management Support	Communication
Client Consultation	Trouble-shooting
Personnel Recruitment	Characteristic of the project team leader
Technical Task	Power & Politics
Client Acceptance	Environment events
Monitoring & Feedback	Urgency

Table 3-4: Critical Success Factors by Pinto & Slevin (1989)

Belassi and Tukel (1996) instead of listing the factors individually in a tabular form adapted another approach and presented a new frame work for determining the critical success factors by grouping the factors according to a criterion. The purpose of the framework was to identify the group to which the factor belongs and then determine the combined effects of these factors on the project success or failure. The framework is shown below in Figure 3-1,

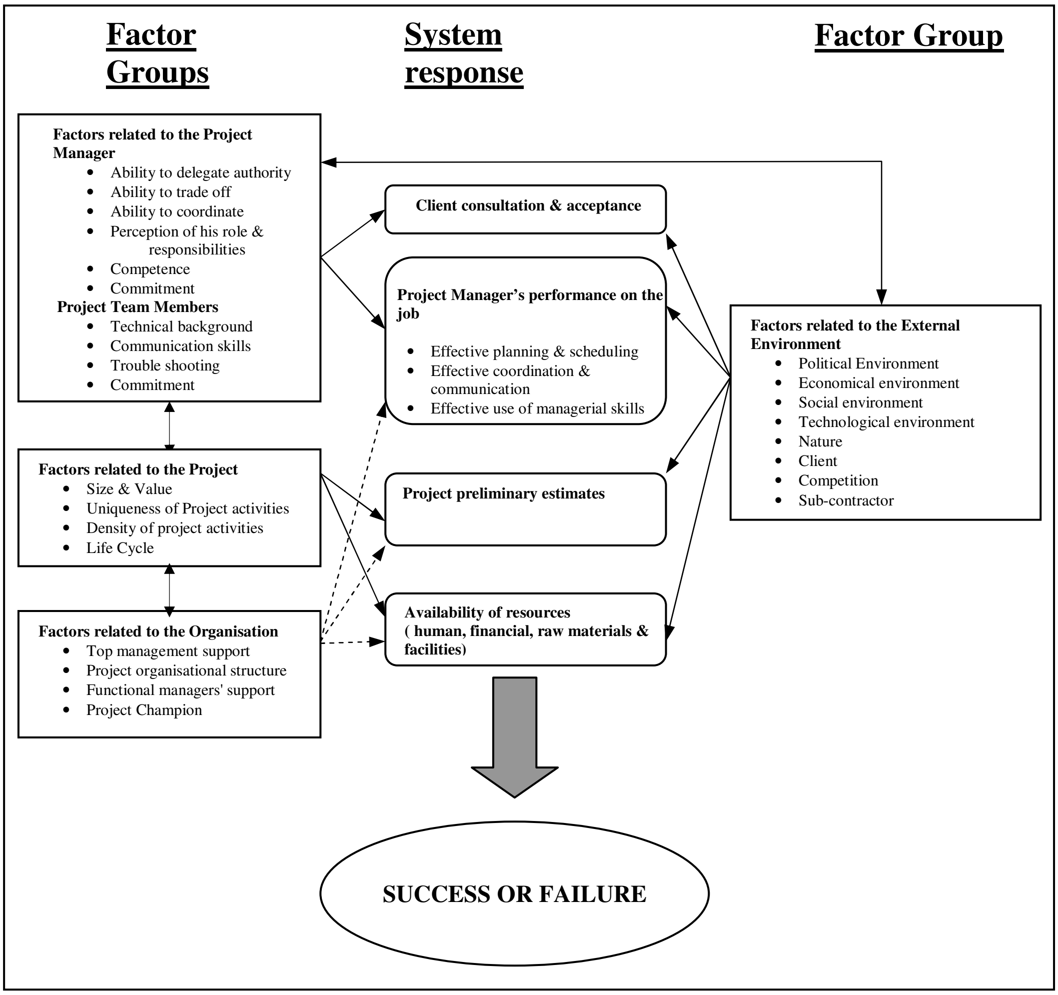

Figure 3-1: CSF Framework (Belassi and Tukel, 1996)

The advantage of putting the success factors in groups is that it makes it easier to identify to which group the critical success factor belongs and also to assess the affect of the intra-relationship of the factors within the groups. The importance of the inter-relationship of the critical success factors is also highlighted by Clarke (1999) stating that all the factors are interdependent and a single factor on its own cannot ensure project success. Although it is important to recognise a critical success factor and its impact, but for optimised results it should considered in the context of other factors. This means that a holistic view of the total system has to be taken to assess, optimise and utilize the impact of the critical success factors. Fortune and White (2006), based on the review of 63 publications, compiled and listed the critical success factors in the decreasing order of occurrence which are shown in the Table 3-5 below,

Critical Factor	***Counts of Citations***
Support from senior management	39
Clear realistic objectives	31
Strong/detailed plan kept to date	29
Good communication & feedback	27
User/client involvement	24
Skilled/suitably qualified/sufficient staff/team	20
Competent project manager	19
Strong business case/sound basis for project	19
Sufficient/well allocated resources	16
Good Leadership	16
Proven/familiar technology	15
Realistic schedule	14
Risk addressed/assessed/managed	14
Project sponsor/champion	13
Effective monitoring / control	12
Adequate budget	12
Organisational adaptation/culture/structure	11
Good performance by suppliers/contractors/consultants	10
Planned close down/review/acceptance of possible failure	10
Training provision	9
Political stability	7
Correct choice/past experience of project management methodology/tools	6
Environmental Influences	6
Past experience (learning from)	5
Project size (large)/level of complexity (high)/number of people involved (too many)/duration (over 3 years)	4
Different view points (appreciating)	3

Table 3-5: CSF indentified across 63 publications (Adpated from (Fortune and White, 2006))

However, Fortune and White (2006) highlighted the following aspects in regards to the critical success factors given in the above table,

- The above ranking does not hold true or represent all the studies, there is a variation in the ranking between the studies, so the top ranking given in the above table does not mean to be the top in the others.
- Lack of showing the importance of their inter-relationship (Wateridge, 1995)
- Lack to show the dynamic nature of the factor and ignores the potential for a factor to have varying levels of importance at different stages of the implementation process. (Larsen and Myers, 1999)

Looking at the above Table 3-5, it can be seen that the most of the factors are either related to the project management soft skills, which focus more on the aspects of people (stakeholders), and/or project manager and team, however there is a less emphasis on control aspects of the projects, which at times are thought to be an important aspect. The important point to note is that these critical success factors are based on the feed back of the practitioners, which is in turn based on their experience of working in the actual project settings, reflecting the realization of importance of soft skills to manage people and stakeholders.

3.6 Summary

This chapter presented the literature review on the two most important project management aspects, which are to some extent inter-related. These areas have been the focus of researchers in the field of project management, as the proper implementation of the processes and CSFs are envisaged to ensure successful project outcome. Efforts have been done by various project management associations to list down these processes in their respective Body of Knowledge although initially they were compiled for the reason of certification purposes. However in recent years a few associations, realizing their lack of relevance to practice, have started updating their BoKs to cover this gap. Similarly, the project management literature focused more the on hard aspects, based on linear, analytic and rational approaches, emphasizing planning and control dimensions of project management, whereas in *"actuality"*, projects are characterised as taking place within a human and social context (a social process), occurring in a dynamic environment continually changing. This continuously changing environment entails project managers not only to use the hard skills but also the soft skills to manage people and manage change. Relying only on the linear approaches seemed not to be enough to manage the project actuality as it requires more flexible and soft approaches and this is why the importance of soft skills in the application project management is becoming more recognized. Although soft skills are still under-represented in the project management literature, it is important to realise the fact that people deliver successful projects and not just the application methods and tools and its people need the ability to adapt and engage intelligently with aspects of project complexity to ensure project objectives are successfully met.

All efforts and processes given above are to ensure the successful outcome of projects, whether it is project success and/or project management success. Moving away from the linear approach and understanding the dynamic and changing environment, practitioners in addition to hard and soft skills, rely and focus on project critical success factors. Project critical success factors are factors, which the practitioners based on their knowledge and experience rely on and use a particular factor according to a situation i.e. the right critical success factor at the right time and the timing is based on the practitioner's judgement. It is like the use of trump cards in the card game.

This research with the main focus on a better understanding of project complexity also looked into this area of key project management practices and project critical success factors in relation to complex projects. Experienced practitioners working on complex products and in complex project settings were asked to identify key project management processes and project critical success factor. The objective was to draw comparison with the theoretical perspective and previous research; not only to enhance the current knowledge base and also to find the differentiating key processes and CSFs for complex projects.

In the next chapters, the four studies carried have been presented in detail, analysing the responses of practitioners focusing on project complexity, and key project management process and critical success factors for managing complex projects.

Chapter 4

Research Design and Methodology.

4.0 Introduction

This chapter presents in detail the research philosophy, approach, strategy and design, and methods used to address the research problem outlined in Chapter 1. Both research methodology and research methods have been discussed in this chapter, as method and methodology are completely different concepts and should not be used interchangeably. Method is a tool and technique used to model of make sense of a problem, whereas methodology is a framework in which methods are positioned as part of the broader research strategy (Saunders et al., 2003, p 2).

This whole research process is captured in the *'research process onion'* shown below in Figure 4-1,

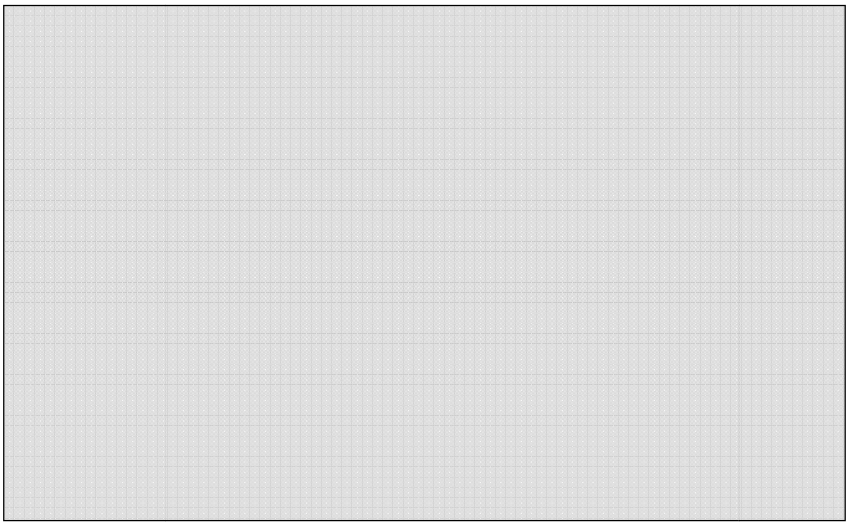

Figure 4-1 The research process 'onion' (Saunders et al., 2000)

This chapter elucidates the research philosophy, research approaches and research design and strategy adopted in this study. The overall purpose of the chapter is to provide a robust rationale for the selection of the appropriate methods and methodology in context of the aims, objectives and limitations of the study.

4.1 Research Aim and Objectives

It is important to briefly reflect back on the research aims and objectives presented in Chapter 1 before going into the details of research methodology and methods. The aim of this research is to investigate the practitioners' perception of project complexity and its contributing factors, and to highlight key project management processes and project critical success factors based on practitioners' experience of working in actual project settings. The purpose is to have a better understanding of the '*actuality*' of projects and to compare it with the theoretical perspective, which entails an in-depth knowledge of the theoretical perspective and a candid and detailed view of the practitioners engaged in complex, dynamic and social project setting. This increased understanding of project actuality would help to bridge the perceived gap between PM theory and practice by highlighting PM aspects to be deliberated. The aforementioned premise is an important consideration in selecting suitable research methodology and methods.

The next sections present the details on the research methods and methodology which have been discussed in the context of the research aim by examining the techniques the most appropriate for this research.

4.2 Research Process

This section highlights the rationale for the research and presents the sequence of the studies which have been conducted, as shown in Figure 4-2. The research is divided into two phases, the first phase, an exploratory phase, in which a survey approach was adopted comprising of research instruments, namely semi-structured interviews and questionnaire survey. The objectives of the first phase studies were to establish a basis for the pragmatic perception of project complexity and also to further explore the perceived gap between theory and practice. The two studies along with the key outcomes from the literature review formed the basis for investigating further and suggest further directions for study. The second phase of the study which consisted of a case study approach was designed to provide more meaningful insights into the notion of *project actuality*. In this phase, the defence business sector of a leading UK aerospace company was selected to explore the manifestation of project complexity in situ; it is suggested in this work that defence projects usually exhibit the properties of *Complex Product Systems (CoPS)* (Hobday and Rush, 1999).

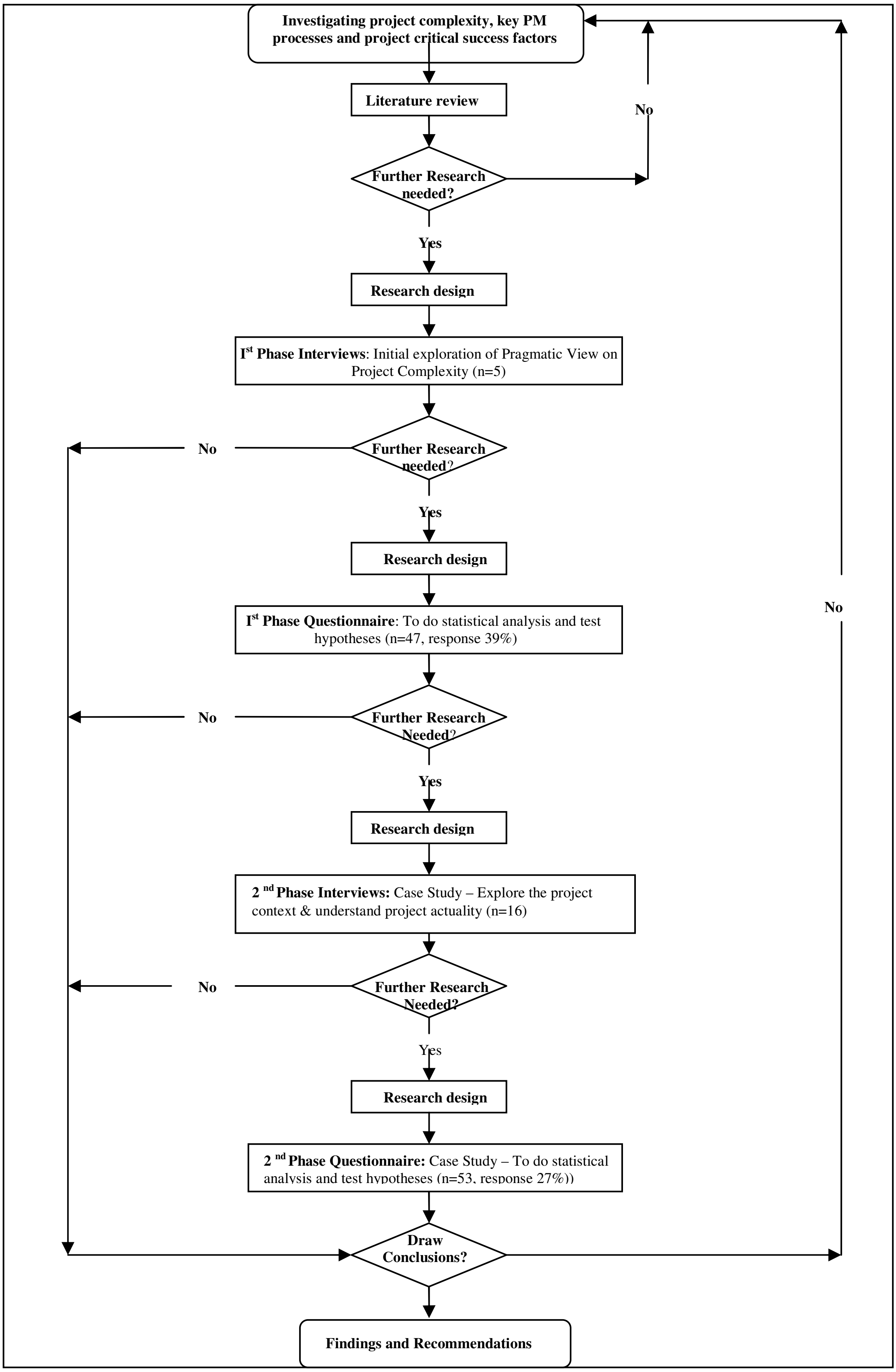

Figure 4-2 :: Research Process Flowchart

4.3 Research Philosophy

In the existing literature, positivism and phenomenology appear to be the research paradigms that are applied to explore the truth and facts about the world by researchers. These two stances that dominate epistemology. The alternative terms used for these two terminologies are shown below (Mangan et al., 2004),

- Positivist paradigm**:**
  Quantitative, Objectivist, Scientific, Experimentalist, Traditionalist, Hypothetico deductive, Social constructionism.
- Phenomenological paradigm:
  Qualitative, Subjectivist, Humanistic, Interpretivist / hermeneutic, Inductive

Positivism**,** is 'an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond' (Bryman and Bell, 2003, p 14). Positivistic approaches to research are based on highly structured research methodologies commonly used in science to facilitate replication and on quantifiable observations that lend themselves to statistical analysis. Positivism uses experimental and quantitative methods to test hypothetical-deductive generalizations. However, as Saunders (2003, p 84) highlights, 'the rich insights into the complex world are lost if such complexity is reduced to mere law-like generalisations'. Phenomenological approaches are particularly concerned with understanding behaviours from the participants' own subjective frames of reference. Research methods in this case are chosen therefore, to try and describe, translate and explain, and to interpret events from the perspectives of the people who are the subject of the research.

The positivist approach is often underpinned by deductive reasoning and the phenomenological approach leans towards inductive research The key features of the two philosophy paradigms have been summarised by Easterby-Smith *et al.* (1991, p 27) in the Table 4-1 shown below.

	Positivist paradigm	Phenomenological paradigm
Basic beliefs	The world is external and objective	The world is socially constructed and subjective
	Observer is independent	Observer is part of what observed
	Science is value-free	Science is driven by human interests
Researcher should	Focus on facts	Focus on meanings
	Look for causality and fundamental laws	Try to understand what is happening
	Reduce phenomenon to simplest elements	Look at the totality of each situation
	Formulate hypotheses and then test them	Develop ideas through induction from data
Preferred methods include	Operationalising concepts so that they can be measured	Using multiple methods to establish different views of phenomena
	Taking large samples	Small samples investigated in depth or over time

Table 4-1: Comparison of Positivist and Phenomenological paradigm (Easterby-Smith et al. (1991)

As Saunder's (2003) points out the practical reality is that the research rarely falls into only one philosophical domain, and management research in particular is often a mixture between positivist and phenomenological strategies. This is not due to an inability to decide between the various merits and demerits of the various alternatives but due to the reason that all methods are valuable if used appropriately, the bifurcation of techniques is therefore unhelpful in this work. Research can include elements of both approaches, if managed carefully.

Looking at the above table and given the research problems outlined in Chapter 1, phenomenological philosophy seems to be the best fit for this research, as the research focuses on the understanding of project complexity in light of project actuality, which falls in the phenomenological paradigm. However, recognising the lack of objectivity sometimes associated with phenomenological research methods, it necessitates the need to adapt a positivist, quantitative approach. The best fit for the research is to use both the philosophies, as there will be hypotheses that will be tested using quantitative methods, and also there will be ideas that shall be developed and explored using inductive approach. This premise will be further deliberated when the justification for the research approaches is presented and explained in the following sections, as the research onion is explored.

4.4 Research Approaches

Authors have used different expressions to define the research approaches, and irrespective of the notion used, these research approaches use a variety of research methods and techniques for data collection (Thomas, 2004). For the empirical approach, the main dimensions considered are,

- Qualitative / Quantitative
- Deductive / Inductive

Although, these do not necessary represent a simple either/or choice, but should be seen as the extent to which the elements of the approach apply. The next sections highlight the above.

4.4.1 Quantitative / Qualitative Approach

Qualitative research is more *subjective* in nature and involves examining and reflecting on the less tangible aspects of a research subject, e.g. values, attitudes, perceptions. Qualitative research is defined as, *'a subjective approach which includes examining and reflecting on perceptions in order to gain understanding of social and human activities'* (Hussey and Hussey, 1997, p 20). Qualitative approach is often adapted when it is required to uncover a person's experience or behaviour, to create an in-depth analysis of a particular process of a single case study or limited number of cases, and to understand a phenomenon about which little is known (Ghauri and Gronhaug, 2001). Qualitative data sources include interviews, questionnaires and surveys(open-ended), documents and texts, observations (field work), focus groups, and researcher's impressions and reactions to understand and explain the social phenomenon (Yin, 2003).

The motivation for doing qualitative research, as opposed to quantitative research, comes from the observation that, if there is one thing which distinguishes humans from the natural world, it is their ability to talk. Qualitative research methods are designed to help researchers to understand people and the social and cultural contexts within which they live (Myers, 1997).

Quantitative research is more *objective* in nature than the qualitative research, and the emphasis of quantitative research is on collecting and analysing numerical data; as it concentrates on measuring such as the scale, range, frequency of a phenomenon. This type of research, although initially harder to design, is usually highly detailed and structured, and results can be easily collated and presented statistically. Quantitative research methods were originally developed in the natural sciences to study natural phenomena. Examples of quantitative methods well accepted in the social sciences include survey methods, laboratory experiments, formal methods (e.g. econometrics) and numerical methods such as mathematical modelling, and then submitting the data to scientific techniques for appropriate analysis to test the hypothesis (Myers, 1997, Yin, 2003).

Both approaches have their strengths and weaknesses, which have been listed by various researchers (Hackley, 2003, Gable, 1994, Easterby-Smith et al., 1991, Hussey and Hussey, 1997, Saunders et al., 2003). Quantitative approach with its “closed” questions may limit the breadth of the responses thus keeping the researcher objectively separated from the subject matter. On the other hand in the qualitative approach researchers tend to become subjectively immersed in the subject matter, exploring motivations between factors (Hackley, 2003, Remenyi et al., 1998, Marczyk et al., 2005). Qualitative research can be very useful in defining patterns of associations between factors on the ground, as confronted with abstract interrelations received from investigation of large scale surveys and combined data.

Both, qualitative and quantitative approaches can be used in different research strategies and are employed by both positivist and phenomenological researchers (Oates, 2006). A mixed research approach takes advantage of the strengths of the both qualitative and quantitative approaches. Although most researchers do either quantitative or qualitative research work, but some researchers have suggested combining one or more research methods in the one study, also called *'triangulation'* (Yin, 2003, Ghauri and Gronhaug, 2001, Marczyk et al., 2005, Thomas, 2004). Triangulation refers to the use of more than one approach to investigate a research question(s) in order to enhance confidence in the findings.

In the light of the above discussion, keeping in view the strengths and weaknesses of qualitative and quantitative approach, a multi-method triangulation (methodological triangulation), which refers to the use of more than one method for gathering data (Denzin, 1970) was deemed suitable for this research. As it will be seen from the research process Figure 4-2, that qualitative approach has been used to explore the views of the practitioners and to understand their motives behind the reasoning, whereas quantitative approach has been used to focus on particular area(s) and to investigate relationships and/or differences using statistical techniques. One of the main reasons for using mutli-methods is to validate results through triangulation, as it is one way of determining whether the findings from different studies converge to common grounds.

In a web article, Trochim (2006) attempts to clarify the difference in two types of approaches as the terminologies seem to be interchangeably used,

'First, let's do away with the most common myths about the differences between qualitative and quantitative research. Many people believe the following:

- *Quantitative research is confirmatory and deductive in nature.*
- *Qualitative research is exploratory and inductive in nature.*

I think that while there's a shred of truth in each of these statements, they are not exactly correct. In general, a lot of quantitative research tends to be confirmatory and deductive. But there's lots of quantitative research that can be classified as exploratory as well. And while much qualitative research does tend to be exploratory, it can also be used to confirm very specific deductive hypotheses. The problem I have with these kinds of statements is that they don't *acknowledge the richness of both traditions. They don't recognize that both qualitative and quantitative research can be used to address almost any kind of research question'.*

4.4.2 Deductive / Inductive

As mentioned earlier that the two broad methods of reasoning are also referred to as the deductive and inductive approaches. The extent about the clarity of theory at the beginning of the research raises the question about the design of the research, whether deductive, inductive and/or combination of the both be used.

Deductive approach is one in which a theory and hypotheses are developed and then a strategy is designed to test the hypotheses, whereas in the inductive approach data is collected and theory is developed as the result of the data analysis (Saunders et al., 2003). Deductive approach works from the more general to the more specific, informally called a "top-down" approach, beginning with a theory, narrowing down into specific hypotheses and finally testing them. Inductive approach works the other way, moving from specific observations to broader generalizations and theories, informally called a "bottom up" approach, beginning with specific observations and measures, detecting patterns and regularities, formulating some tentative hypotheses to be explored, and finally ending up developing some general conclusions or theories, as shown in Figure 4-3

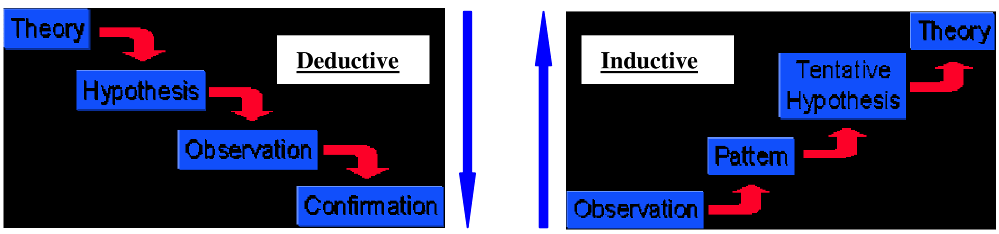

Figure 4-3 : Deductive and Inductive Approach (Adpated from (Trochim, 2006))

The difference between two approaches have been summarised below in Table 4-2,

Deduction Emphasis	Induction Emphasis
• Scientific Principles • Moving from theory to data • The need to explain casual relationship between variables • The collection of quantitative data • The application of controls to ensure validity of data • The operationalisation of concepts to ensure clarity of definition • A highly structured approach • Researcher independence of what is being researched • The necessity to select samples of sufficient size in order to generalise conclusions	• Gaining an understanding of the meaning human attach to events • A close understanding of the research context • The collection of qualitative data • A more flexible structure to permit changes of research emphasis as the research progresses • A realization that the researcher is part of the research • Less concern with the need to generalise

Table 4-2: Comparison between Deductive and Inductive approaches (Saunders et al., 2003)

'*Not only it is perfectly possible to combine approaches within the same research, but in our experience it often advantageous too'* (Saunders et al., 2003).

As in the case for the justification of using both qualitative and quantitative approaches, similar justification holds true in this case. Different methods can be used for different purpose in a study, as in this research initially interviews (inductive) were done to know the key issues, followed by questionnaire (deductive) to test the hypotheses. This was followed by both the interviews and questionnaires used in the case study to get the in-depth view and motives, and to test hypotheses based on these. This is summarised in the research process flow chart shown in Figure 4-2. The next section briefly discusses the various research strategies/methods along with the details of the research strategy adopted for this research.

4.5 Research Strategy / Methodology

There are various alternatives to design strategies/methodologies that can be employed, apparently belonging to qualitative (deductive) approach and quantitative (inductive) approach, but it is unduly simplistic to allocate the strategies to either one of these approaches. The important thing is the applicability and suitability of the strategy to the research questions and objectives (Thomas, 2004). A number of research strategies have been listed by various authors (Hussey and Hussey, 1997, Ghauri and Gronhaug, 2001, Hackley, 2003) such as,

- Experiment – *(more common to natural sciences; also in social sciences particularly psychology)*
- Survey – *(associated with deductive approach; e.g. questionnaires, structured observations, structured interviews)*
- Case Study – *(investigation of a particular contemporary phenomenon within its real life context)*
- Grounded Theory – *(inductive approach; theory developed from data generated by a series of observations)*
- Ethnography – *(inductive approach; an in-depth, descriptive study of a culture; part of the subfield of socio-cultural anthropology)*
- Action Research – *(research undertaken by teams that is flexible and iterative; the aim is to problem-solve in order to improve the way processes are performed and services are delivered*)
- Time horizons
  - Cross-sectional – *(snapshot approach; study of particular phenomenon at a particular time)*
  - Longitudinal studies – *(Diary approach; the same group of individuals are examined at regular intervals throughout a given time period)*
- Exploratory, descriptive and explanatory studies
  - Exploratory – (*a valuable means of finding out what is happening; to seek new insights; to ask questions and to assess phenomenon in a new light)*

- Descriptive – *(to portray an accurate profile of persons, events or situations; used to explore and describe; asks "what exists?" ; answers the questions who, what, where, when and how)*

The various strategies have been highlighted along with a brief description of each. The strategies adopted for this research are discussed in detail in the next sections along with their relevance to this research. This research uses a multi-method approach (Saunders et al., 2003), i.e. starting with a survey strategy followed by a case study.

4.5.1 Survey

A survey strategy is normally associated with the deductive approach and is a common and a popular strategy in business and management research. As it allows the collection of a large amount of data from a sizeable population in an economical way, whereby a sample of subjects is drawn from a population and studied to make inferences about it (Hussey and Hussey, 1997). The word survey normally indicates human respondents and the basic data are gathered by talking to people, either face to face, by means of telephone, over the internet or by written questionnaire (Jankowicz, 2005).

The most important and critical stage of the survey is the selection of sample, ensuring that it is not biased and is representative of the population. The next critical thing is the mode to conduct the survey; most common ones are interviews or questionnaires, as efforts are done to ask the same questions to all participants in the same circumstances (Hussey and Hussey, 1997). However, the data collected using the survey methods have limitations, as in the case of questionnaires, it may not be wide ranging/rich as collected by other strategies owing to the fact that they are basically exploratory in nature and one may make inferences without really going into the details of the cause-and effects. In the case of interviews, there is also a risk of interviewer bias, while in postal surveys, problem with high rates of 'non-response' is identified (Ghauri and Gronhaug, 2001).

In the first phase of this research, a survey approach was adopted, including both semi-structured interviews and questionnaire. As the nature of this research focused on exploring the actuality of projects, understanding the context and developing it based on the practitioner's point of view, semi-structured interviews seemed to be a suitable approach especially when it is important to know the reason for the respondent's response and understand the attitudes, motive and opinions behind it (Saunders et al., 2003) and also to develop an understanding of the respondent's 'world' (Hussey and Hussey, 1997). As a starting step, semi-structured interviews were conducted with experienced practitioners (involved with academics also) to get the overview about project complexity which helped in establishing the foundation for the pragmatic perspective; the details of these interviews are presented in Chapter 5. This was followed by a questionnaire, which was designed based on the findings of the earlier interviews and literature review, with the aim to test a few hypotheses and rank order the level of impact of factors contributing to project complexity. As questionnaire was found suitable for the reason stated earlier as, 'a questionnaire is list of carefully structured and well thought and well tested questions, administered to gather reliable responses from a chosen sample with the aim is to find out what a selected group of participants do, think and feel about the subject addressed in the questionnaire'. And also it enables to identify the variability in different phenomena and examine and explain relationship between variables (Saunders et al., 2003).

The details on the concept of interviews and questionnaire are presented in section 4.6 which highlights the data collecting method / techniques.

4.5.2 Case Study

A case study, an example of a phenomenological methodology, is an extensive examination of single instance of a phenomenon of interest which involves its empirical investigation within its real life context using multiple sources of evidence (Hackley, 2003, Saunders et al., 2003, Yin, 2003, Thomas, 2004) 'The case study is a research strategy which focuses on understanding the dynamics present within a single settings' (Eisenhardt, 1989). Generally, a case study method is used when the focus of the research is on a set of issues in a single organization and the objective is to identify the factors involved in an in-depth study of the organization or a single department within it (Jankowicz, 2005).

Yin (2003) identifies the following characteristics of a case study research,

i. The aim of the research is not only to explore certain phenomenon but also to understand it within a particular context

ii. The research does not commence with rigid questions and notions

iii. Multiple methods are used for the collection of data.

However, the definition which captures the essence of this research is given by Stake (1995), stating that, *'a case study is expected to catch the complexity of a single case - a study of the particularity and complexity of single case, coming to understand its activity within important circumstances'*.

The various options for data collection techniques employed in case studies may include questionnaires, interviews, observation, and documentary analysis (Hussey and Hussey, 1997, Saunders et al., 2003, Yin, 2003). However, these authors do not restrict to one technique rather suggest multi-technique approach, allowing broader and often complimentary view on the research problem or issue.

Keeping in view the definition of a case that is understanding a particular phenomenon in a particular setting, this is inline to research objectives i.e., exploring the *project actuality* to understand the social and dynamic processes in projects and to gain a better understanding of project complexity. In this regard, a leading European aerospace company was selected engaged in complex projects delivering complex products, thus providing an opportunity to interact with practitioners who have worked in multiple projects and project settings. The other reason for the selection of this company was the 'ease of access of data', as the University of Manchester had good collaboration with the company on various research projects. Initially semi-structured interviews were conducted, the details of which are presented in Chapter 7. This was followed by a questionnaire administered to a larger population in the same and different business units to validate the overall findings; this is discussed in Chapter 8.

Continuing with the layers of the *'research onion'* shown in Figure 4-1, the next section covers a brief discussion on *'time horizons'* followed by section on *'data collection techniques'*, that is the inner most core of the *research onion*.

4.5.3 Time Horizon

- Depending on the research question(s), the research could be a *'snapshot'* taken at a particular time or could be more akin to a *'diary'*, representing events over a longer period. The snapshot response is called *'cross-sectional'* while the diary perspective is called *'longitudinal'* (Saunders et al., 2003, Easterby-Smith et al., 1991).

- **Cross-sectional Studies**: These are conducted when there are constraints of time and / or resources and the data is collected over a short period of time, before its analysed and reported, basically taking a snapshot of an ongoing situation. Cross sectional studies often employ survey strategy. (Thomas, 2004)

- **Longitudinal Studies**: These are conducted over time, of a group or variable with the aim to research the dynamics of the problem by investigating the same situation or people several times or continuously over a specified period. Repeated observations are taken with the objective to reveal the relative stability of the phenomenon under study and to observe changes if any. Even with time constraints it is also possible to conduct such a research if need arise.

Looking at the aforementioned brief definitions of the two study types, this research falls into the category of a snapshot / cross-sectional study, one reason is the time constraints and secondly this study is not concentrating on investigate a change but rather to get a snapshot observation and understanding based on a case study, presenting a starting point for further research.

4.6 Data Collection Methods / Techniques

Generally researchers start focusing on the data collection techniques, the inner core of the research onion (Figure 4-1), without giving enough consideration to its outer layers. Especially in the case of qualitative research, there is a tendency to start focusing on questionnaires and/or interviews without taking into consideration the whole research process and its objectives and without considering the pros and cons of research methodologies and methods.

The main data collection methods / techniques listed by Hussey and Hussey (1997) are discussed briefly,

- Critical Incident technique – *(procedure for gathering certain important facts concerning behaviour in defined situations)*
- Diaries – *(are a method of collecting data and is a daily record of events or thoughts and is typically used to capture and record what people do, think & feel)*
- Focus Groups – *(normally associated with phenomenological methodology, are used to gather data relating to the feelings and opinions of a group of people who are involved in a common situation)*
- Interviews – *(associated with both methodologies, are a method of collecting data in which participants are asked questions in order to find out what they do, think or feel; Types: structured, semi-structured & unstructured/in-depth interviews)*
- Observations – *(associated with both methodologies, take place in laboratory or natural setting; non-participant: observe and record only - isolated & participant type: fully involved)*
- Protocol Analysis – *(phenomenological; used to identify the mental process and to ascertain how people behave and think*

- Questionnaires – *(associated with both methodologies; types - closed question & open ended questions)*

As mentioned earlier that this research adopts the multi-strategy/method approach consisting of survey and case study, the details of which have been discussed earlier. The data collection techniques used in the two research approaches are interview and questionnaire, which are discussed in the next section in light of this research.

- **Interviews**

According to Saunders *et al* (2003), *structured interviews* use questions which are based on a pre-determined and standardized set, whereas in the *semi-structured / unstructured interviews* there is list of themes and questions to be covered. The list of themes and questions vary within semi-structured interviews depending on the flow of the conversation, and also as the area of interest explored, as the interviewee is given opportunity to talk freely about events, behaviour, views and belief in relation to the topic.

In the first phase, a survey method was adapted, in which the initial data were collected by conducting face-to-face, semi-structured interviews with experienced and knowledgeable practitioners, followed by questionnaire survey. In the second phase, case study method was adopted, initially face-to-face, semi-structured interviews were conducted with project executives and program managers, to understand the project context, and which was followed by a questionnaire survey within the company selected for the case study. The justification for conducting semi-structured interviews in the survey and case study were inline with reasons recommended by Easterby-Smith *et al* (1991) below,

- ➢ To understand the construct that the interviewee uses as a basis for his or her opinion to the research topic – which in this case was to get a pragmatic view on project complexity.

- To develop an understanding of the respondents' world – which in this case was to understand the project actuality in the context of project complexity.
- To conduct discussion not only to reveal but to understand the *'what'* and *'how'* but also to place more emphasis on exploring the *'why'*.

In addition to the above, the advantage to ask follow-up questions gave a higher degree of confidence in the replies as a clear understanding of the meaning and motives is achieved. Therefore, making interviews suitable for this study and since these were done in conjunction with questionnaires that helped in understanding the problem and designing of the interview guides to explore the issue in-depth.

- **Questionnaires**

A questionnaire comprises of a list of clearly and carefully structured questions, which may be based on the previous studies, with a aim to find out what a selected group of participants do, think or feel and/or to test relationship (Hussey and Hussey, 1997). There are two types of questionnaire design, open-ended and closed, in open-ended type respondent can give a personal response or opinion, where as in the closed type the respondent has to select an answer from predetermined alternatives (Saunders et al., 2003). Closed type questionnaires could have a multiple-choice answer format or could use rating scales, of which the most common is the Likert type scale, which allows a numerical value to be given to an opinion (Hussey and Hussey, 1997). A good questionnaire needs a careful designing based on a thorough understanding of the research (Hackley, 2003). However, the type of scale used in the questionnaire is critical and is an important aspect taken into consideration while choosing between the parametric and non-parametric techniques. This aspect is discussed in detail in Chapter 6 and 8, in the section on the rationale for the selection of the statistical tests.

Questionnaires are a popular method of collecting data, owing to the fact that the questionnaire survey is cost effective and less time consuming than the interviews on the other hand they have drawbacks such as of non-response, which can affect their meaningful outcome (Saunders et al., 2003).

Self-administered questionnaires are usually completed by respondents, which can be distributed either by post, done online electronically and distributed individually or to a group, whereas interview-administered questionnaires are recorded by the interviewer, through face to face meeting or through telephonic discussion.

This research combines survey and case study research methods. In both cases the interviews were followed by questionnaire, as it has been recommended by many researchers to use multi-method approach to understand the in-depth nature of the problem. Self administered, closed type questionnaire using ranking scales were used in this research, which were designed based on the findings of the interviews and were administered not only to triangulate, validate the findings but also to test the proposed hypotheses. *'A questionnaire to discover customers' attitudes complemented by in-depth interviews to explore and understand these attitudes'* (Saunders et al., 2003).

The data collection methods / techniques have been discussed along with the rationale for the selection of the particular techniques for this research. The next section focuses on the sampling techniques used in this research.

4.7 Research sampling

Whatever the research questions and objectives are requires collecting data. However collecting and analysing data from every possible case, termed as census, is impossible for many researchers either due to financial constraints and/or paucity of time. Sampling techniques provide a range of methods, enabling to reduce the data to be collected from a subgroup rather than all possible cases. The two techniques available are namely, *probability* or representative sampling; and *non-probability* or judgmental sampling. The full set of cases from which the sample is taken is called the *population* as show in Figure 4-4,

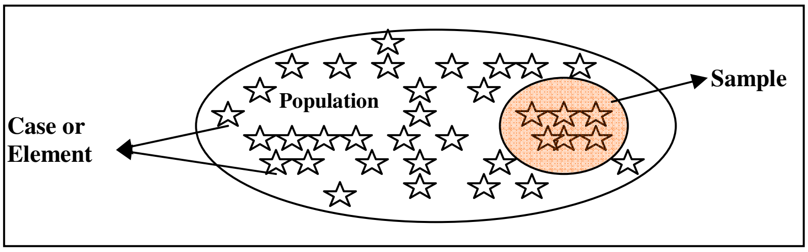

Figure 4-4 : Population, Sample and Case (Adapted from (Saunders et al., 2003)

In *probability* sampling, the chance or probability of each case being selected from the population is known and is usually equal for all cases, whereas in *non-probability*, as the name implies, the probability of each case being selected from the total population is not known. In probability sampling, statistical estimations can be done, and in non-probability it is difficult to do statistical inferences but generalization may be possible (Saunders et al., 2003, Thomas, 2004).

Probability sampling, is most commonly associated with survey based research and the four sample selection techniques associated with it are, *simple random sampling, systematic sampling, stratified random sampling and cluster sampling*.

Non-probability sampling is more useful to gain insights into a phenomenon, particularly in the case of qualitative research. Some of the few techniques identified in non-probability sampling are *natural sampling*, *quota sampling, purposive or judgemental sampling, snowball sampling, self-selecting sampling and convenience sampling*. However, many research project entail the use a variety of sampling techniques at different stages (Ghauri and Gronhaug, 2001, Saunders et al., 2003, Thomas, 2004).

4.7.1 Population

'Unfortunately, the actual population (called the target population) to which a researcher would really like to generalise is rarely available. The population to which a researcher is able to generalise, therefore, is the accessible population' (Fraenkel and Wallen, 2006, p 93). The accessible population for this research would be the PMPDP delegates in the case of 1st phase survey and defence business sectors of the case study aerospace company in the 2nd phase. It is difficult to quantify the exact population in both the cases, however estimations can be done based on data and statistics available.

In the case of 1st phase, the questionnaire was administered to PMPDP delegates, it is difficult to quantify an exact number of people around the globe who have done or are doing a postgraduate course in project management, however, using this conservative approach to estimate for all 83 courses which could possibly be running in the majority of these 42 UK universities for the last 8 years (since 2001), the calculations suggest a rough figure of 8981 individuals in the UK and the working population for the PMPDP in 2009 was 292. (Alam, 2009b).

In the case of 2nd phase, the reported population for the UK Defense Aerospace, according to the report published by SBAC (2009), out of the total 100,740 employees, 36% (approx 36,000) are graduate, engineers and managers, as shown in Figure 4-5.

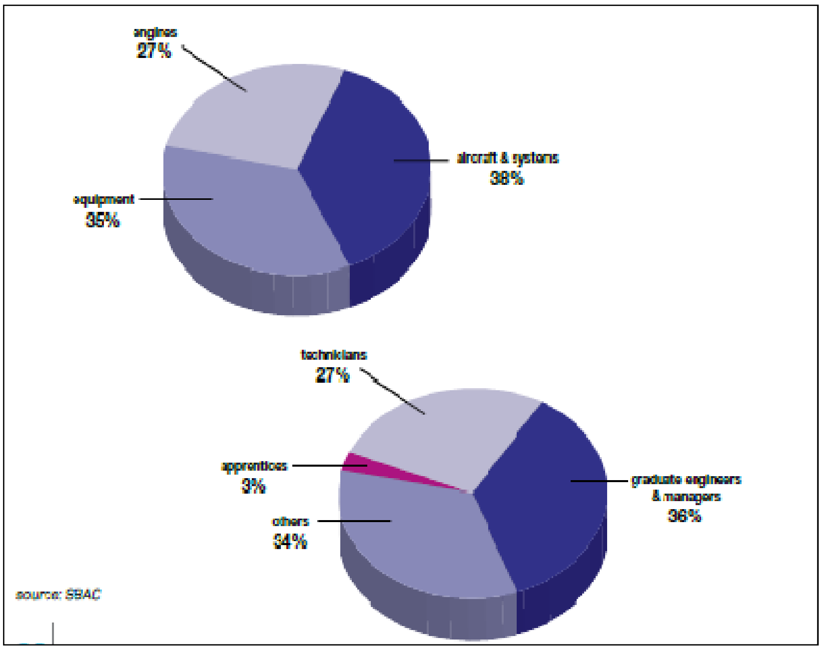

Figure 4-5 : UK Defense Aerospace population (SBAC (2009))

However the target population, in the case study, is the defence business sector/unit in the respective company, although it was difficult to provide the exact number for they were scattered in different projects and location, however the rough estimate obtained for people directly or indirectly related to project / program management is 100 plus in respective business units.

Different sampling techniques have been used for the sample selection, which are described in the next section.

4.7.2 Sampling Techniques

The sampling techniques adopted in this research are discussed below,

- Natural Sampling

  It is fairly common in business and management research, and is used when the researcher has little on the influence on the composition. This is based on either involving a particular group of people available at the time of study or a particular group is involved with the phenomenon being investigated (Hussey and Hussey, 1997).

- Stratified random sampling

  It is a modification of random sampling in which the population is divided into two or more relevant and significant strata based on one or number of attributes, basically the sampling frame is divided into subsets. In stratified sampling, the problem of under or overrepresentation of population associated with a small, random sample, is taken care of as each identifiable strata of the population is taken into account.(Hussey and Hussey, 1997, Saunders et al., 2003).

- Snowball Sampling

  Snowball sampling or networking is commonly used when it is difficult to identify the members of the population and is essential to use people with experience of the phenomenon under study. The initial contact is of prime importance; once it is done these individual(s) further identify further suitable members. For populations that are difficult to identify, snowball sampling may identify the only possibility (Hussey and Hussey, 1997, Saunders et al., 2003).

- Purposive or judgemental sampling

  In purposive or judgemental sampling, the participants are selected by the researcher on the strength of their experience related to the research topic. This form of sample is often selected when working with small samples and when you wish to select cases which are informative (Hussey and Hussey, 1997, Saunders et al., 2003).

- Convenience Sampling

  Convenience sampling involves selecting cases those are easiest to obtain, i.e. a sample population selected because it is readily available and convenient.

The sampling techniques adopted in the four studies of this research are summarised in Table 4-3 below,

Study	Sampling Technique	Remarks / Justification
1st Phase Interview	Convenience & Purposive	Initial informative, exploratory study, to get the feed back from experienced practitioners with academic link / experience and / or formal project management qualification. Purposive sampling technique used to select cases deemed suitable to answer the research questions and convenience sampling to identify samples which can be easily accessible.
1st Phase Questionnaire	Natural & Convenience	Natural sampling technique was adopted, as PMPDP platform was suitable for this research as the respondents had industrial experience as well theoretical PM Knowledge. Also the ease, access and time were also other considerations in the selection.
2 nd Phase Interview	Snowball & Purposive	The head of project management function in the case study company was given the research overview, who then directed to different business units PM heads and who then identified relevant samples keeping in view the research objectives. Also snowball technique was utilised in business sectors which did not identify a group of samples for the interviews.
2 nd Phase Questionnaire	Purposive & Stratified	In the second phase questionnaire, purposive and stratified technique was used, in order to validate the findings of the initial studies and also to get a meaningful response from a stratified sample at different levels in the business units under consideration.

Table 4-3: Summary of sampling techniques used in this research

In the above section the sampling techniques along with the justification for the techniques used for this research has been presented.

4.7.3 Sample Size

There is a temptation particularly in the questionnaire survey to pick as large sample as possible, which is at times not feasible and practical and is not deemed necessary for there is always seem to be an acceptance for a degree of uncertainty in the conclusion (Hussey and Hussey, 1997).

'The question remains, therefore, as to what constitutes an adequate, or sufficient, size for a sample. Unfortunately there is no clear cut answer to this question' (Fraenkel and Wallen, 2006, p 103). However, one of the criteria that is commonly used in interviews is the concept of 'saturation', or the point at which no new information or themes are observed in the data, then a sufficient sample size has been reached (Boyce and Neale, 2006, Guest et al., 2006). Generally between a large number of respondents with less experience related to the problem research area and less number with rich experience, the preference is usually given to the latter, owing to quality and other logistical constraints. In phenomenological research, usually a small sample over a period of time will be examined using different research methods to obtain perception of the phenomenon and seeking to understand the situations (Hussey and Hussey, 1997).

Keeping in view the rationale given for the sampling techniques used, time and logistical constraints, and efforts not to comprise on the quality of the data, the sample selection was done in consultation with the supervisor and also with the heads of program management functions in the concerned business units of the case study. The 1st phase interviews comprised of a small sample size (n=5), but again the practitioners selected had a vast industrial experience and were either involved with project management academically and/or had attained project management certification/degree. The main aim was to explore their theoretical perceptions and practical experience in the light of project complexity. However, sense making patterns and themes emerged out of the initial interviews, which in conjunction with literature reviews provided enough information to design a questionnaire.

Similarly, for the 2nd phase interviews, the sample size (n=16) was selected in consultation of the heads of program management functions in the different business units of the case study. The interviewees represented the senior and middle management level, program executives (8) and program managers (5), of the company working on various projects (12), either with the development and/or production of complex products, identified as Complex Products Systems (CoPS) (Hobday and Rush, 1999). Keeping in view the level and profile of the respondents and their experience on major defence aerospace projects, they were considered suitable for the research, as the emphasis again was on quality. As McCraken (1998) points out, “less is more” i.e. it is better to work more and with greater care with fewer and experienced people than less with more people.

In the case of the questionnaires, 1st phase questionnaires were distributed to 120 PMPDP delegates attending the plenary session in April 2009, the valid response rate was 39% (n=47). Whereas for the 2nd phase questionnaire, the questionnaire were distributed to two defence business sectors which work under financial, management and organizational structure, the response rate from the two sectors was 27% (n=53). The response rate seemed to suitable keeping in view the response rates presented in similar research studies.

The next section discusses about the credibility of research findings, the reliability and validity of the research, as one of the reason for triangulation is to have more reliability and validity of results by obtaining the same from different methods.

4.8 The Credibility of Research Findings

The important aspects under consideration are reliability, validity and generalization. In order to reduce the possibility of getting the wrong answer, it entails the focus on two things, research design reliability and validity (Saunders et al., 2003).

Reliability, is concerned with the findings of the research and are said to be reliable if they are repeatable in another similar research settings (Hussey and Hussey, 1997, Saunders et al., 2003). The following three questions can be used to assess the reliability of the research (Easterby-Smith et al., 1991),

- *Will the measures yield the same results on other occasions?*
- *Will the similar observation be reached by other observers?*
- *Is there a transparency how sense was made from the raw data?*

Validity is concerned with the extent to which the findings accurately represent what is happening in the situation i.e. whether the findings are really about what they appear to be about (Saunders et al., 2003, Hussey and Hussey, 1997). In other words whether the data give the true reflection of what is studied. Even with a very high reliability of the data, if the questions do not measure what you intended to measure, then the validity is low, so therefore the relevance of the questions to the intended topic of study is important. 'The term validity, as used in research, refers to the appropriateness, meaningfulness, correctness, and useful of any inferences a researcher draws based on data obtained through the use of an instrument' (Fraenkel and Wallen, 2006, p 165).

In order to establish the reliability and validity of this research, the most important consideration was the multi-method approach used, which also helped to triangulate the findings of the research. The main focus of all the studies were on the research questions, although done at various stages, however they were interlinked, as one formed the basis of justification for the other. The interviews were also tape recorded allowing concentrating more on the discussion than on taking down notes. This ensured that the maximum time is spent in exploring the research issue and later on also helped in transcribing and understanding the responses. Since the respondents had rich experience on working on multiple projects, so effort was done during the interviews to extract and understand the true motive behind their responses. The questionnaires were designed keeping in view the theoretical perspective and in conjunction with responses from the interviews, ensuring the relevancy of the questions.

Generalisability, is concerned with the applicability of the results to the cases or situations beyond those examined in the study (Hussey and Hussey, 1997). Although, the purpose of this research is not to produce and test a theory which is generalisable to all organisations but efforts were made to obtain generalisability for at least business sectors within the company operating in a similar financial, managerial and organizational constraints. However, the robustness of this research's findings could be tested in the follow-up studies, by exploring other research settings and projects with different and / or similar settings exhibiting different project complexity characteristics and factors, and drawing comparisons between them.

4.9 Summary

This chapter describes the overall research process, and in specific the research methodologies and methods adapted to investigate the research problems. The multi-method approach has been used and the overall research philosophy combines both positivistic (quantitative) and phenomenological (qualitative), using both deductive and inductive approaches. Two research methods used are, survey and case study, i.e. in the initial exploratory study was survey based comprising of semi-structured interviews followed by a questionnaire to test hypotheses. This was followed by a case study (snapshot) approach, which again consisted of in-depth interviews to explore the *project actuality* and followed by questionnaire to do statistical inferences and test the hypotheses.

Different sampling techniques with reference to each study have been discussed along with the justification of it. However, the emphasis of sample selection was basically on two important aspects i.e. PM knowledge and the industrial exposure of the respondents in the light of the research problem and the project context.

The next four chapters of this thesis present and analyse the data collected. The first of these, i.e. Chapter 5 gives the results and findings of 1st phase interviews.

Chapter 5

1st Phase Interviews

5.0 Introduction

This chapter presents the analysis and findings of the initial first phase interviews (Dec ’08 to Jan ’09). These interviews were the starting point for this research and were done to explore the pragmatic perception of project complexity with the aim to investigate the research questions and to obtain an initial response from the practitioners. The primary aim was to obtain an exploratory view based on the actuality of projects, and compare this practitioners’ perspective with the theoretical concepts.

The convenience and purposive sampling strategy, discussed in previous chapter, was adapted for the 1st phase semi-structured interviews. Convenience sampling technique was used keeping in view the research time and logistical constraints, and without compromising on the quality of the data purposive sampling technique was also used to select the most suitable cases to answer the research questions

The interviewees were short-listed after discussion with the supervisors, who then helped in identifying the suitable individuals, based on the criterion taken into consideration, i.e. their industrial background, the extent of theoretical project management knowledge and/or role with project management academia.

5.1 Planning & Designing of the 1st Phase Interviews

The interview guide was designed keeping in view the research questions and objectives, which was further refined in consultation with the supervisors and after conducting pilot interviews with fellow research students. Pilot interviews helped to verify the clarity of questions, assess the length of the interview time and to familiarise with the process. As the practitioners have busy schedule, therefore the interview guide was designed in a way to restrict the duration of the interview under an hour and a half. The interview guide consisted of six sections, the first four sections covered the biographical data, qualifications, company information, job experience / role respectively, and the final two main sections addressed questions related to project complexity and project critical success factors. The interview guide is attached as Appendix 'B' – 1st Phase Interview Guide.

5.2 Sampling & Data

As mentioned earlier, a convenient and purposive sampling technique was used in this case, thereby giving the flexibility to choose the most appropriate sample. Since one of the aims of the study was to investigate the perceived gap between theory and practice, keeping this consideration it was decided to interview individuals who had an academic project management qualification as well as industrial / academic experience. The profile of the interviewees are shown below in the Table 5-1,

Interviewee	Age	Experience		Number of Projects / Sector
		Industrial / Management	Academic (Qualification)	
1	50+	16	25+ (PhD - PM)	6+ Nuclear & Hydro-power
2	35+	6	10+ (PhD - PM)	6 Oil & Gas, Manufacturing
3	50+	36+	5+ (PMPDP) (Masters - PM)	50+ Aerospace
4	30	6	-	15 Construction (D&B)
5	41+	30	(Masters-PM)	10+ Aerospace

Table 5-1: 1st Phase Interviewees' Profile

As it can be seen from the above Table 5-1, the experience range of the interviewees was from 6 to 36 years, with number of projects participated from 6 to 50+, and from different industrial sectors. All of the interviewees except one, either had a degree in the field of Project Management and/or academic experience related to the project management. The respondents with their theoretical concepts and industrial experience were envisaged to reflect on the project complexity based on their experience and knowledge, providing valuable insight to this research.

The same interview guide was used in all the interviews. However, the way the questions were asked was refined as the interviews progressed. All the interviewees gave the permission to voice record the interview session, which assisted in transcribing and post-interview analysis.

As mentioned earlier this phase was the start of the research and efforts were made to select suitable interviewees which could give their view on project complexity based on their experience and theoretical project management knowledge. The first three interviews with experience practitioners (also involved with academics) revealed similarity not only in the responses but also to the logic behind them. In order to further establish the trend, further interviews were done with practitioners who were more involved with the industry, and their responses also highlighted similar trend to the previous initial interviews. Since similar trend was being observed and based on the concept of saturation mentioned in section 4.7.3, it was decided to restrict the number of 1st phase exploratory interviews to 5.

The findings of the 1st phase interviews are presented in the next section, which is divided into two sections, project complexity and, key project management processes and critical success factors respectively.

5.3 Analysis and Discussion

The analysis of the first phase interviews was carried out after all the interviews have been transcribed, analysed and categorised to have meaningful and justified results. The analysis is divided into two sections focusing on,

Section I : Project Complexity
Section II : Key Project Management Processes & Critical Success Factors

It is highlighted that the responses quoted in the coming sections are shown there to explain and support the reasoning behind the analysis presented.

5.3.1 Project Complexity

This section focuses on project complexity and the questions were asked to get the practitioners' view on the following aspects to get a holistic view on it,

- Perception of complex projects or complexity in projects
- Types of project complexity
- Factors contributing to project complexity
- Assessment and variation of project complexity over the Project Life Cycle (PLC)

The responses on each of the above are discussed below and the findings of the first phase interviews are summarised at the end of this chapter.

5.3.1.1 Perception of Complex Projects

The analysis given below is in reference to the following question, to define a complex project or what is meant by a complex project?'

The aim of this question was to get the practitioner's perspective about complex projects. The practitioners were asked to define and give their understanding of a complex project. The main aim of the question was to look beyond the linguistic definition and trying to understand and highlight the underlying characteristics of complex projects based on the practitioners' definition.

It was a difficult question to answer, for the reason that there was not any universally accepted definition that practitioners based on their project management knowledge could have easily cited and also for the reason that there were many dimensions in which it can be looked at. The following response highlights the lack of promptness and the need of defining it,

'That is exactly what I am trying to ask, I don't think the word is helpful, the opposite of complex is simple, so how to define what is not simple……… Probably the answer is 'Yes', that it is complexity of what, the complexity of project does not say anything. Complex in terms of………' [sic]

However, looking at the other responses given by the respondents, complex projects were defined in reference to different project elements. The following responses on the above question highlight the key defining characteristics such as,

'It is the variety of technology rather than the technology; it is the mix between known and unknown, variety is the key word. Regarding people, some experience some inexperience (suppliers-partners), where you use the word complexity is relationship.' [sic]

"Complex project is a project which involves many different people with different skills, perhaps projects where people based in different countries, that always brings complexity"[sic]

"One that has lot of people involved, one that has many layers in WBS, one that is multinational across different time zones and one that is using new technology or highly technical" [sic]

"The old APM thing is multi-disciplinary, multi-company, multi-national, that is a little naïve, but there is not doubt about it, multi is important. I think new is important, its not just new technology, its new everything, so I don't get bogged down with technology, but new." [sic]

"I think it would be a variety of aspects and it would really depend on the project and the mix of the project, you would have technology, you would have how mature the requirements were, time-scales, customer and also I think how many functions you crossover, dealing with less functions so you have got less people to deal with" [sic]

Looking at the above responses, the following project elements / characteristics were used (directly or indirectly) by the practitioners to define the complex projects rather the underlying characteristics of a complex project.

- √ Across different time zones – *multinational*
- √ Multiple Critical Paths – *many layers in the WBS*
- √ Technology – *new technology or highly technical*
- √ Uncertainty – *known-unknown;, how mature the requirements are*
- √ People – *many people with different skills; lots of people; people in different countries; their relation*
- √ Number of functions involved – *how many functions you cross-over*

Analysing the above, it can be seen that the replies revolve around the following three areas,

- People
- Technology
- Project Management Process
- Project Organization

The above elements are common to all projects, so the question is how these elements makes projects complex. The terms like *"New, Variety, Multi"* were invariably used by the practitioners, which not only were used to differentiate but these also highlighted and emphasized the importance and impact of these underlying key characteristics in defining a complex project.

The following response highlights the impact of contextual influence on the definition of a complex project, *"I suppose that really depends upon what you define is complex and it also is from whose perspective of a project, because it would be different between from say project manager or business manager to say a technical perspective or functional manager".*

All the respondents highlighted that their responses were based on their work experience. Although they were in working in different sectors as can be seen in Table 5-1, however all of them were working and/or had worked in multinational, multiple team environments and on technologically challenging bespoke products which is reflected in the responses given earlier on the previous page.

However, one interesting aspect is pointed out by the following response,

'It was not complex, for it was adapting from the previous experience, it was number 14 for the company, it was more of adapting from the previous experience rather than repetition.' [sic]

The above statement raises the question 'complexity in reference to or whose complexity', as highlighted by the above response that the project may not be complex for the organization but it may would be complex for a new project manager joining that organization and working with the new project team.

In this section efforts have been done to highlight the pragmatic perception of a complex project, which will be then compared with the theoretical perspective. The next section presents the discussion on the two terminologies, complex and non-complex projects.

5.3.1.2 Complex and non-complex projects

In addition to the above question, the respondents were asked to differentiate between complex and non-complex projects, with purpose to get the practitioners' view on the two terms and their basis of differentiating. The responses given below to the question to differentiate between complex and non-complex projects are self-explanatory, which seems to focus on the number, i.e. 'the multiple' element and but more to certainty/uncertainty element related directly and indirectly to people, process and product.

"By looking at the pattern of decision making and working patterns, the work stream as some people call it, decision process not just physical activities" [Sic]

"Non complex would be a small modification, my point of view it will be restrict, u can naturally restrict the number of stakeholders, you don't have to deal with so many, if it is kept internal there is more control and as soon as you go external, you got other people to deal with and there more people involved"[sic]

"I would say projects which are short and have simple well defined products, projects which have relatively simple interfaces in an organization, projects with fewer stakeholders, projects in which processes and technology used is well tested and lower cost value" [sic]

"If project is of low complexity I would say is kind of within the office, wholly within the office. Project goes more and more complex when more people are involved" [sic]

The above responses indicate that in a non-complex projects there are,

- *simple interfaces* - less in number and with well-known interactions,
- *well defined products* – more certainty in goals and methods to achieve them
- *well defined process* – well known and well tested
- *where less people are involved* – less people, known relationships

Signifying that in complicated projects the element of newness, the number element and uncertainty is less as compared to complex projects related to people, product and/or process.

The next section highlights the responses to the question regarding the types of complexity, as the theoretical perceptive focusing on project complexity categorises it into three most recognised types, i.e. structural, technical and uncertainty (Geraldi and Adlbrecht, 2007).

5.3.1.3 Types of Project Complexity

As mentioned earlier, the theoretical concepts on project complexity presented in the literature review classify project complexity into three recognised type i.e.

- *Structural,*
- *Technological and*
- *Uncertainty.*

The motive behind this question was to assess whether practitioners are aware of the theoretical construct, and whether their perspectives are similar to the underlying logics behind the theoretical construct. The practitioners' responses to the question pertaining to the types of project complexity are shown below,

'Social Complexity; you have complexity of product and service the actual thing the project is trying to create; you have complexity associated with risk and uncertainty; communication complexity such as different languages.' [sic]

'Technical Complexity; complexity in planning, duration of tasks and scheduling difficulties; complexity due to large teams and also cultural complexity.' [sic]

'Unknown requirements, poorly defined requirements…; Specific requirements that are technological difficult to do…; Customer complexity….' [sic]

Comparing the above response to the theoretical types, it appears that the respondents are conveying the same logic but using more practical terms/terminologies, whereby the underlying logic for the both perspectives seems have the similar basis. Social or customer complexity can be related to structural complexity, in a way it refers to interdependencies and interrelationships between people. Similarly, complexity of product and technical/technological aspects are similar to the theoretical concept of technical complexity; and ambiguity / uncertainty and unknown requirements seem to be similar to uncertainty.

However, the practitioners showed a lack of familiarization with the theoretical types, may be due to the reason that less emphasis is given to understanding project complexity in the project management bodies of knowledge.

The next section focuses on factors contributing to project complexity as it is importance to know/understand the cause/source of an issue or a problem before it can be tackled.

5.3.1.4 Factors Contributing to Project Complexity

This was one of the important research questions focusing on the factors that contribute to project complexity in the actual project settings. The aim of this question was to get the practitioners' view based on their industrial experience and exposure. It is important to know the cause / source of an issue before it can be managed, so in the case of complex projects, it is imperative to know the root cause of complexities in projects.

The respondents were asked to identify the factors based on their experience which affect project complexity and/or contribute to project complexity. The respondents identified the factors based on the projects they have worked on and gave supporting remarks to elaborate them.

The main factors identified by the practitioners are listed below,

- √ Organizational Structure
- √ Number of Disciplines involved
- √ Project Management Process
- √ People (Stakeholders)
- √ Project Duration
- √ Government Legislations
- √ Politics
- √ Culture
- √ Unusual type of design
- √ Unknown / poorly defined requirements
- √ Specific requirements
- √ Customer
- √ Requirements capture
- √ Technology
- √ Skill Base
- √ Bespoke software or hardware
- √ Responsibility & Accountability
- √ Functional role
- √ Project Manager competence
- √ Technical capability of team
- √ Limited resources
- √ Communication

The response to this question highlights that the identification of the factors seems to be very much influenced by the respondents' project experience and context i.e. multinational, multiple team environments and on technologically challenging bespoke products. Reply of a respondent leading a technical design team (functional group) and involved in an overseas project, shows the contextual influence, as factors highlighted are related to multiple teams and organizational structure as,

"I think may be the scale, if something is technically difficult, but you can handle within a small team it will be probably easier to deal with" [sic]

"You need the organization in place so that the team knows who to feedback to and within a team you need to ensure suitable responsibility is allocated to each person. Uncertainty arises within a team when they don't know who to go to with a problem" [sic]

Program manager for highly technical bespoke product highlighted the aspects related to new technology and project organization as follows

'Technology- how mature the technology is… the practical experience is you don't know the system until you throw some hardware on it and try it out. This is the same about technology.'[sic]

"Functional role has much more powerful & influential role on the program than the program manager does, so building up these informal relationships across a formal structure, which is really weird, you got a formal structure but in reality it does not mean diddlysquat, unless you working well with these guys and they realise that you point them in the direction that they need to do and its supporting there functional role"[sic]

"The only problem I have with the project teams is, by definition a business has a limited resource therefore you usually end up with the team that is free and may be not the most optimum one"[sic]

A remark by a very senior practitioner involved in the overall management function sums up the importance of people as one of the factor contributing to project complexity,

"Project management is very easy, its get messed up when you involve people and organizations, that's where the complexity comes in" [sic]

People, in terms of stakeholders, customer etc, have been invariably reported by all of the respondents as one of the factor contributing to project complexity. Whereas complexity associated with technology or technical design has only been highlighted by people involved with high technology projects, especially in a new product development environment. The other reason for this would be less number of respondents, but the important consideration was to assess the holistic views and patterns emerging out of this study. A remark by a functional design group highlights the impact of people, highlighting the importance of influence and relationship, in making projects complex,

"Technology is challenging as long as it is within one group or department, but it gets complex when more people or groups get involved"[sic]

Based on the above and in the view of the theoretical concepts presented in the literature review chapter, it can be said that the factors/characteristics contributing to project complexity are directly or indirectly related to the three main project elements, *People, Product and Process,* externally and internally to the projects. Although not an exhaustive list, but some of the factors in the three categories are shown below in Table 5-2 ,

People	Process	Product
• Team • Number of Disciplines involved • Stakeholders • Culture • Customer • Project Manager competence	• Organizational Structure • Project Management Process • Project Duration • Government Legislations • Unknown requirements • Requirements capture • Responsibility & Accountability	• Number of Disciplines involved • Unusual type of design • Specific requirements that are technological difficult • Technology • Bespoke software or hardware

Table 5-2: People, Product & Product relation to complexity factors

The people, product, and process are an integral part of any project, and it is the underlying characteristics - interactions, interdependencies and uncertainties, that eventually contribute to project complexity or make them complex.

The next section looks into the assessment of project complexity and highlights the importance given to it in practice.

5.3.1.5 Assessment and Variation of Project Complexity over Project Life Cycle (PLC)

The purpose of this question was to investigate the importance/awareness of assessing project complexity and variation of project complexity over the project life cycle.

The responses in regards to the assessment of project complexity were vague, as each respondent looked into this perspective in a very different way or had different set of reference to assess it. Only one respondent, who being the head of program management function, mentioned formally using and/or introducing a tool to assess project complexity, whereas the others had neither assessed project complexity formally or were aware of any such theoretical methods.

However in response to the question, respondents reported assessing project complexity in different ways, relating it in terms of resource requirements and/or in terms of risk assessment based on their own notion and understanding. The self-assessment reported was done based on comparison to the past experience or in reference to similar project, as highlighted by the following responses,

‘At the beginning of the project it is important to understand the complexity, but relative to what - your experience, your standards…’ [sic]

‘Yes partially, If you are deliberately looking at complexity then you will have some way of measuring it, categorising based on different factors.’ [sic]

‘Yes, anticipated it based on experience, however current project was not formally assessed, only the resources required were assesses.’ [sic]

Those who related risk assessment to assessing project complexity, were referring it in consideration to the financial impact,

'Yes, the project I have been on either did a risk assessment at the front end, the majority of the projects don't do risk assessment at the front end, the risk are acknowledged and known at the business end who are making decisions to where to go for it and I suspect its more financial driven than technological.' [sic]

It is apparent from the above responses that the complexity assessment is neither done as a formal process and is apparently not given importance at an organizational level as compared to the other well established project management processes.

Since, the respondents had not formally assessed the complexity of their projects so it was difficult for them to benchmark the variation of complexity over the project life cycle. However, based on their experience they were asked to assess the variation of the recognised theoretical types of complexity over the project life cycle. In this case the four phase project life cycle was used. The responses are shown below Table 5-3,

Interviewee 1 : *Nuclear / Power Plant Projects*			
	Structural	***Technological***	***Uncertainty***
Concept	Low	High	High
Planning	High	High	Low
Execution	High	High	High
Termination	Low	Low	Low
	(Variation of People's Interaction)	*(High tech innovation)*	*(Product / Technology)*
Interviewee 2 : Oil & Gas Sector			
	Structural	***Technological***	***Uncertainty***
Concept	High	Low *(may not know)*	High
Planning	High	High	High
Execution	Low *(if things have gone well in planning)*	High	Medium
Termination	Low	Low	Low
Interviewee 4 : Construction (Structural Design)			
	Social	***Technical- Uncertainty***	***Cultural***
Feasibility	low *(internal)*	lower	low
Concept	Low-medium	Low-medium	low
Scheme	Low	Low-medium	low ***(fewer people)***
Detailed Design	High *(put more man hours, dig deep)*	High	High ***(New People different culture)***
Interviewee 5 : New Product Development (Bespoke)			
	Structural	***Technological***	***Uncertainty***
Concept	Medium-low *(meet & greet)*	High-medium *(past experience)*	High ***(Unknowns)***
Planning	Medium *(starting to understand people's agendas)*	High-medium (prototyping & analysis)	High-Medium
Execution	Medium *(meeting customer demands)*	Medium-low	Medium-low
Termination	Medium *(you are getting people to sign certificates)*	Medium-low *(you don't know what you don't know)*	Medium-low

Table 5-3: Variation of Project Complexity with PLC

It can be observed from the above table the variation of the project complexity (types) has been reported differently by each respondent. The reasons given for this variation seemed to be influenced by the project context, type of project and product. It can be seen from the above table that complexity variation is more linked to uncertainty related to the softer aspects rather than the technical.

The previous sections have covered the different aspects of project complexity, detailing practitioners' views on them. The next section covers the key project management processes and project critical success factors, identified by the practitioners based on their experience of working in complex project settings.

5.3.2 Key Project Management Processes & Project Critical Success Factors

The hard and soft project management aspects and the project critical success factors have been discussed in the literature review section. In this section the practitioners were asked to identify the key management aspects and the project critical success factors, based on their experience of working in complex projects.

5.3.2.1 Key Project Management Processes – Hard and / or Soft Aspect

The purpose of this question was to investigate the significance of hard and soft project management aspects in relation to the management of complex projects. The interviewees were asked to identify the importance of both the hard and soft project management processes based on their experience of managing /working in complex projects. This question was asked in the broader sense without going into detail of identifying the PM processes. Although both hard and soft project management aspects are important but invariably, regardless of experience and job function, the respondents' replies emphasised more on the importance of soft skills.

The following responses highlight the importance of soft skills,

"Its all soft, soft is important! Its about managing stakeholder expectation, there are more stakeholders in complex projects. Soft skills are more dominant, at the end of the day it is of no use having all the knowledge & information, unless it is used to manage the expectations"[sic]

"Both, but certainly/possibly slightly more soft, depending on the type of complexity…" [sic]

"Soft aspects are important & quite often overlooked."[sic]

"I think always the two, you got to have the soft skills to deal with people, to sense changes, to get information; you got to have the hard skills to analyse, predict, extrapolate, I don't think you talk about one you need both"[sic]

"The more complex the more we have to go into the hard aspects of project management……but I think you have to then come down to participative stuff, soft aspect……. I think you need the two, you need the soft ones to make the team work and you need the hard ones to give the team something to work around" [sic]

Regardless of back ground, industrial sectors and experience, all the respondents recognise the significance of soft skills. Emphasising the fact that project is a social setup, which is basically dealing with people, and managing them to achieve the project objectives.

5.3.3 Critical Success Factors (CSF)

In reality there are various factors outside the control of project management which affect the project success and these factors in the literature are referred to as Critical Success Factors (CSF). Project managers have to either focus or rely on these factors to ensure the project is on the desired track.The aim of this question was to get the practitioners' point of view on project critical success factors based on their experience of working in and/or managing complex projects. Practitioners were asked to identify key traits or specific ways, over and above the project management processes, which in their experience played a vital role in achieving the project objectives successfully.

In general, the importance of stakeholder management was highlighted by all. Keeping in view the definition of project success and project management success, the importance of stakeholders is highlighted by the following response,

"Happy Stakeholder, if the stakeholders are happy the project is success in a nutshell" [sic]

However, the respondents were asked to list the factors according to the success factor groups, an approach introduced and used by Belassi and Tukel (1996). The groups indentified are given below,

- Factors related to the Project Manager
- Factors related to Project Team
- Factors related to Project Organisation
- Factors related to External Environment
- Factors related to Project Type
- Factors related to Project Management Processes

The factors reported by the respondents have been consolidated in their respective groups as shown below,

- **Factors related to Project Manager**
  - Under stand the strength and technical ability of the team
  - Understand the culture
  - Technical capability and knowledge
  - Understand priority of clients
  - Experience in Program Management
  - Leadership style
  - Behaviour
  - Strategic ability & agility
  - Tacit knowledge

- **Factors related to Project Team**
  - Technical / knowledge gain,
  - Ownership
  - Motivation
  - Availability of Skill Mix
  - Experience

- **Factors related to Project Organisation**
  - Assess complexity at start,
  - Adequate and effective staffing
  - Organizational structure
  - Clear responsibilities
  - Support from senior management
  - Communication
  - Assign sufficient number of senior management to project
  - Distinct task allocation
  - Good briefing (client, specially multinational mutli-cultural)
  - Need to understand the role and responsibilities
  - Better project awareness
  - The higher level champion

- **Factors related to External Environment**

  - How the customer works there culture and their processes
  - Customer expectations
  - Contract management
  - Economic and political

- **Factors related to Project Type**

  - Requirements for the new product
  - Stakeholder management
  - Good technical links
  - Team willing to work varied hours
  - Activity Brief Sheet

- **Factors related to Project Management Processes**
  - PM Process in place
  - Compliance to PM processes
  - Stakeholder management

The purpose of the question was to identify the critical success factors and to see the trend for the factors reported for complex projects. There were some common factors reported by all the respondents, but some of the factors seem to have strong contextual influence. The project types that respondents discussed or were working in were either multi-national, multi-site and/or new product development (NPD). The multi-national, multi-site projects had a dominance of the factors like cultural, political and legislative issues, working varied hours and the communication protocols, whereas the NPD projects included factors like availability of skill mix, technical experience, knowledge of project manager and team, functional and program manager's relationship and the support from senior management. Also work discipline seems to impact the perception of these factors as can be seen by the replies of the respondents.

The next section concludes the chapter by presenting the summary and findings of the first phase interviews, which acted as a starting point and gave a better understanding and direction into the research.

5.4 Summary and Conclusion

The main objective of the 1st phase interviews was to get a pragmatic view on project complexity and to identify factors that contribute to project complexity. In addition to this, key project management processes and project critical success factors in the context of project complexity were also discussed with the practitioners.

Analysing practitioners' definition and the key characteristics used by the practitioners in differentiating complex and complicated projects, the following can be deduced,

- The key characteristics of complex projects seemed to be associated to the three major elements, people, product and process (internally and externally), and rather it is the interactions and interdependencies between them. In terms of people, the interaction and dependencies is between various departments/teams at organizational levels and also between stakeholders internally and externally. In terms of product, it is the interdependencies and interfaces between the sub-systems. And in terms of process, it is the linkage and affect of once process on the other. In addition to above, uncertainty seemed to be an important defining characteristic of complex projects, which is rather a differentiating factor between complex and complicated projects.

- Practitioner's perception of project complexity seems to have the similar basis as the theoretical perspective, i.e. based on number of interconnected tasks and their interdependencies and also uncertainty. However there seems to be the lack of familiarity with and use of the theoretical construct, although the practitioners' convey the same meaning but in their terminology.

- As far as the factors contributing to project complexity are concerned, they seem to be dependant on the project context and work discipline.

It is more influenced by the type of project and individual's involvement in that project.

- Emphasis on 'Soft' PM skills as compared to 'Hard' PM skills was prominent in the response given by the interviewees. As it can be related to the project success criteria highlighted i.e. 'happy stakeholders'. And for managing stakeholders soft PM skills play a critical and an important role.

The analysis of the initial interviews helped to better understand the pragmatic perspective. Based on the analysis of this perspective and in conjunction with the literature review, it can be proposed that the complexity in projects is related to three main project elements, *'People, Product and Process',* the 3P's of project complexity forming the project 'C*omplexity triangle'* as shown in Figure 5-1 below

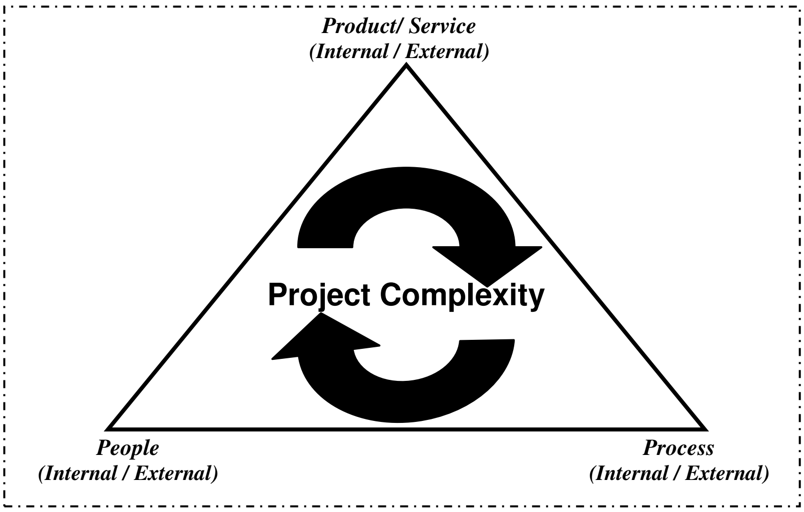

Figure 5-1: Proposed Complexity Triangle

Although the initial interviews gave an overview on the research topic and also highlighted some important aspects to be further investigated, such as,

i. Perception of complexity and its contextual dependency,
ii. Factors contributing to project complexity and their impact.

Keeping in view the research questions and the findings of the initial interviews, a questionnaire survey was designed to address the above findings. The details of the questionnaire along with the statistical analysis of the results are presented and discussed in the next chapter.

Chapter 6

1st Phase Questionnaire

6.0 Introduction

This section details the analysis, results, and findings of the first phase questionnaire survey administered in April - May, 2009. The main purpose of the questionnaire was to evaluate the level of impact of the factors compiled in the proposed 'Project, Product and Process' complexity groups, which was done based on the analysis of the 1st phase interviews and the literature review. The purpose of this questionnaire was to also assess the importance of these complexity groups and their attributes and to statistically assess any difference in the perception of the complexity groups with respondents' age, qualifications, and work experience.

6.1 Research Methodology

6.1.1 Planning and Designing

Literature review and the results of the 1st phase interviews provided the basis and the guidelines for the designing of the questionnaire. Analysis of the 1st phase interviews helped in the realization of the '*complexity triangle*' which was in conjunction with the focus on '*project actuality'* as people, product and process, internally and externally, were envisaged to contribute to project complexity. The attributes in the three project complexity groups were listed after a thorough search of the research papers published in the leading journals which directly or in-directly focused on project complexity.

However there were very few research papers specifically on project complexity which focused on classifying project complexity rather than highlighting the factors contributing to it. However, papers focusing on topics such as complexity linked with technology and new product development, uncertainty and novelty, and complex projects helped in compiling attributes in each of the proposed complexity groups respectively. Analysis of the first phase interviews also helped to compile the attribute list. However, for the process group, APM BoK's (version 5) processes were used in addition to the ones found from the research papers. The factors are listed group wise below,

Complexity Factors - People

- Number of teams / departments involved
- Diversity of teams / departments involved
- Number of Clients / Suppliers
- Diversity of Clients / Suppliers
- Number of stakeholders
- Geographical Location of the team(s)
- Technical knowledge of Project Manager
- Technical knowledge of team(s)
- Team Maturity
- New team
- Project Management skills of Project Manager
- Relationships between team members
- Lack of senior management support
- Lack of leadership
- Lack of team cohesion
- Lack of team motivation
- Lack of communication within the team
- Lack of coordination within the team
- Lack of agreement on objectives between stakeholders
- Inadequate skill base
- Shared resources
- Cultural and Cross-cultural issues
- Company Politics
- Multidisciplinary team(s)

Complexity Factors - Product

- Time to market
- Number of sub-systems
- Variety of technologies
- Newness / novelty of technologies required to deliver the product
- Technical Design Difficulties
- Lack of clear product specifications
- Number of processes
- Variety of resources required
- Variety of technology dependencies
- Variety of methods to achieve product
- Variety of technological
- Skills required
- Technological process dependencies
- Maturity of technology
- Bespoke Product/service
- Impact of design of one assembly on the other
- Concurrency
- Zero rework tolerance
- Number of iterations to refine the product
- Number of product assemblies
- Number of components

Complexity Factors - Process

- Project Success and benefits management
- Stakeholder management
- Value management
- Project management plan
- Project risk management
- Scope management
- Scheduling
- Resource management
- Budgeting and cost management
- Change control
- Earned value management
- Information management & reporting
- Issue management
- Requirements management
- Technology management
- Value engineering
- Project financing and funding
- Procurement strategy
- Legal awareness
- Project life cycles
- Project reviews
- Organization Structure
- Organization roles
- Methods and procedures
- Governance of project management
- Communication
- Team-working
- Leadership
- Conflict management
- Negotiation
- Human resource management
- Behavioural characteristics of team members
- Professionalism and ethics
- Organizational Policies
- Prototyping / Production Process
- Production Technologies

The questionnaire for this study is attached as Appendix 'C' – 1st Phase Questionnaire. The questionnaire is broadly divided into two sections, personal information and factors contributing to project complexity. Personal information section included biographical details, qualification and job experience / work role details. The complexity contributing factors section was further sub-divided into three sections, with the factors in each complexity group listed in each section respectively.

The objective of the questionnaire was to test the significance of the complexity groups and their attributes and secondly to assess the variation in the perception of complexity groups in particular with age, qualification, work discipline, work experience and project type, in order to test the following hypotheses,

Hypothesis 1

H_0: There is no difference in the ranking of **project complexity <u>groups</u>** (proposed people, product and process groups) with practitioners' age, qualification, work discipline, work experience and project type.

H_1: There is difference in the ranking of **project complexity <u>groups</u>** (proposed people, product and process groups) with practitioners' age, qualification, work discipline, work experience and project type.

In addition to the above, the impact levels of the factors in the 'Project, Product and Process' complexity groups were also qualitatively evaluated.

6.2 Sampling and Data Collection

The questionnaire was administered to industrial delegates of the Project Management Professional Development Programme (PMPDP) program run by the University of Manchester, which is developed by The University of Manchester in conjunction with Rolls-Royce, AMEC, Goodrich and EDS. This program is providing postgraduate level project management education to their employees since May 2000. The programme covers most of the topics outlined in the various bodies of knowledge and other standard postgraduate level project management courses offered by various universities, and by July 2009, the programme had circa 159 students (delegates) and 133 MSc graduates. All modules are assessed over the six months study period and during the following plenary event with a two hour written examination where appropriate. The PMPDP plenary sessions are held in April and October every year in Manchester covering lectures, key notes, module introductions and examinations. (Alam, 2009a).

The reason for administering the questionnaire to the PMPDP delegates was the ease of access to the participants and the less time envisaged to get the replies. The other alternate would have been to send the questionnaire to members of the APM branch network. However, keeping in view the aforementioned reasons PMPDP platform was preferred as the plenary session was being held at the University of Manchester.

The questionnaire was administered to 120 industrial delegates attending the PMPDP plenary session April '09. The main reason for using the plenary session as platform to administer the questionnaire was that these delegates were deemed suitable as they had the industrial/practical experience and exposure, and also were aware of theoretical concepts of project management. The other important aspect of using the PMPDP platform was the logistical and time advantage, as the plenary session was taking place at the University of Manchester for a specified duration. The delegates of the PMPDP program were deemed to give a valuable and meaningful feedback for the reason mentioned earlier. The questionnaire was based on the findings of the 1st phase interviews and the understanding of the theoretical construct, as the questionnaire was envisaged to build upon and to enhance the knowledge base.

Hard-copies of the questionnaire were handed over to the PMPDP program administrator, who then distributed the questionnaire to the delegates. The delegates were asked to return questionnaire in person or by post later.

Questionnaires were distributed to 120 delegates, 47 questionnaires were received during the PMPDP session and no questionnaire was received by mail. Thus, making a total response rate of 39%, which was achieved due to the reason that the questionnaire were distributed during the teaching sessions and the participants were given time at the end of the session to fill up the questionnaire. After receiving the hard copies of the questionnaires, they were coded and recorded in Microsoft Excel and also in the statistical analysis software 'Statistical Package for the Social Sciences' (SPSS)-16.

Another important aspect that needs to be discussed and highlighted prior to presenting the descriptive and inferential statistics is the rationale for the selection of statistical tests. There are various statistical tests available and there are multiple views on the selection criteria of the suitable and relevant test. So it is important to highlight the reason for selection of type of tests for this research.

6.3 Rationale for the selection of statistical test

There is no such thing as a universal decision tree that will directly help researcher to choose the right statistical test (Kinnear and Gray, 2000).

There are a number of philosophical positions adopted by researchers involved in statistical analysis, and it is not the purpose here to explore this in great depth. However, it is important to reflect upon the important distinction between *'parametric' and 'non-parametric'* methods since this does have implications for the research described in this thesis.

A parametric test requires that the data used with the study does not violate certain classical assumptions. It is therefore of great importance to validate these assumptions before selecting the appropriate statistical test (Field, 2003).

The choice of a statistical test depends on the understanding of the research questions, the type of items and the nature and level of measurement of each variable (Pallant, 2005b). In order to ensure that the correct philosophical approach is adopted, common aspects that have been cited by researchers to be taken into consideration while choosing between parametric and non-parametric tests are the shape of the population distribution, sample size and the type of measurement.

The normal distribution can be checked observing the histograms, by checking the ratio of skewness and standard error, or by ratio of kurtosis and standard and error, and also by performing the test of normality. There are numerous test of normality which include those which involve a measure (i.e. Shapiro-Wilk and those that use a visual representation (P-P and Q-Q) plots.

The histograms for the three groups are shown below in Figure 6-1 along with the results of the normality test shown in Table 6-1.

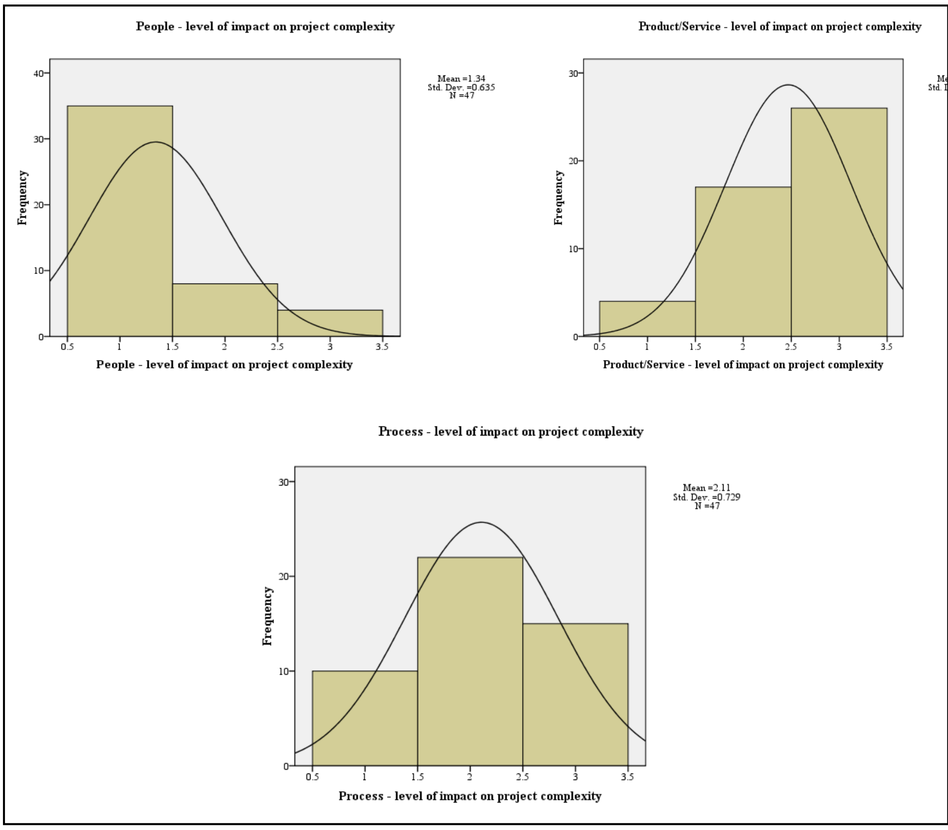

Figure 6-1: – Histograms for 3 groups

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
People - level of impact on project complexity	.449	47	.000	.578	47	.000
Product/Service - level of impact on project complexity	.345	47	.000	.726	47	.000
Process - level of impact on project complexity	.239	47	.000	.806	47	.000
a. Lilliefors Significance Correction						

Table 6-1: Test of Normality for 3 groups

It can be observed from the histograms that the data are not normally distributed which is also confirmed by the test of normality, for the convention is that a Sig. value greater than 0.05 indicates normality of distribution, which in this case is violated as can be seen from Table 6-1.

The scale of measurement used in this case is an ordinal scale, for which the non-parametric techniques have been generally recommended, as the analysis based on means or standard deviations cannot be performed as meaningful calculation of mean and standard deviation cannot be done. Although by ranking data some information about the magnitude of difference between scores is lost and because of this non-parametric techniques are less powerful than the parametric counterparts (Field, 2003, Pallant, 2005b)

Non-parametric techniques are used for the analysis due to the aforementioned reasons.

6.4 Data Analysis

The data analysis is presented in two parts, the first details the descriptive and qualitative analysis of the attributes showing there level of impact, whereas the Inferential statistics are presented in the second part.

6.4.1 Descriptive Statistics

This section summarises the sample using statistical measures such as frequency, median, standard deviation etc to show the details about the data. In addition to this qualitative analysis of the factors contributing to project complexity has also been shown and discussed.

The first part of the section focuses on the following personal information about the respondents,

i. Gender
ii. Age
iii. Academic Qualifications
iv. Formal Project Management Qualifications/Certification
v. Company
vi. Work Discipline
vii. Total Work Experience
viii. Organizational Context Experience
ix. Experience in different Project Types

6.4.1.1 Biographical Details

The biographical details include information about respondents' gender and age.

Table 6-2 shows that there are 36 males (76.6%) and 11 females (13.2%) in the sample out of a total of 47 respondents.

Gender				
		Frequency	Percent	Valid Percent
Valid	Male	36	76.6	76.6
	Female	11	23.4	23.4
	Total	47	100.0	100.0

Table 6-2: Gender Distribution

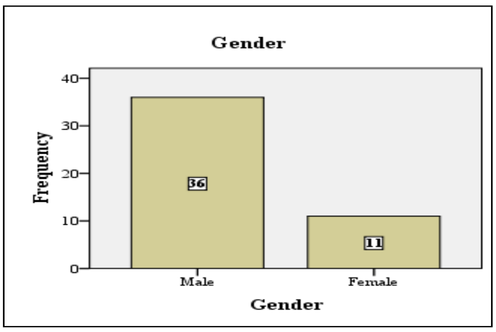

Figure 6-2: Gender Frequency

Table 6-3 shows the age ranges of the respondents, 64% of the respondents are in the range of 30-50 years and 34% of the respondents in 41-50 yrs bracket.

Age				
		Frequency	Percent	Valid Percent
Valid	Under 30 yrs	16	34.0	34.0
	30-40 yrs	16	34.0	34.0
	41-50 yrs	14	29.8	29.8
	Above 50 yrs	1	2.1	2.1
	Total	47	100.0	100.0

Table 6-3: Age Distribution

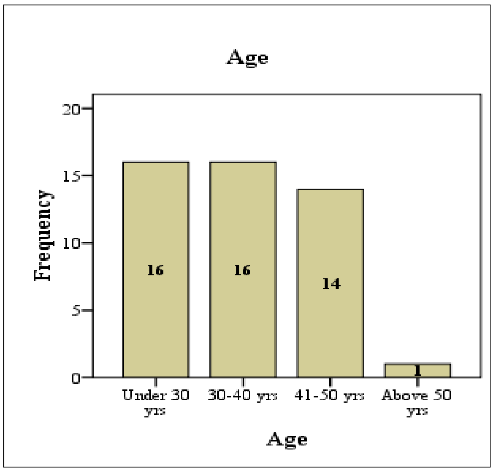

Figure 6-3 Age Frequency

As can be seen from the above table there is only one respondent in the 'above 50 yrs' category, while doing the inferential statistics, this category is merged into '41-50 yrs' category to have a meaningful value.

6.4.1.2 Qualifications

This section focuses on the academic qualifications and in addition to the project management qualifications/certifications with aim to assess whether there is any influence of these on the perception of project complexity groups.

Academic Qualification				
		Frequency	Percent	Valid Percent
Valid	Bachelor	22	46.8	47.8
	Master	15	31.9	32.6
	Other	9	19.1	19.6
	Total	46	97.9	100.0
Missing	System	1	2.1	
Total		47	100.0	

Table 6-4: Academic Qualification Distribution

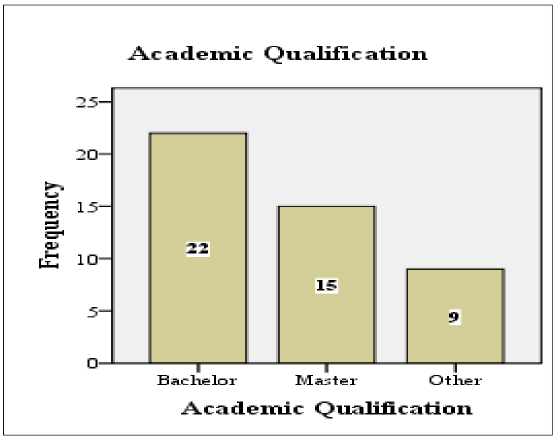

Figure 6-4 Academic Qualification Frequency

The above Table 6-4 and Figure 6-4 shows the distribution of the academic qualification of the respondents. 47% holds a bachelors degree whereas 32% hold a masters degree, whereas 19% hold degrees other than the two specified.

In terms of Project Management formal qualifications / certifications, the respondents were asked to identify whether they have any of the APM and/or PMI's certifications or they hold a formal degree in the field of management of projects. The Table 6-5 and Figure 6-5 shows the distribution of the Project Management formal qualifications/certifications among the delegates. It can be seen from the table below that only one respondents holds a formal PMI qualification, so in the inferential statistical analysis it was merged with the APM qualifications, so making 11 respondents with some sort of PM certifications, 4 with academic PM degree and 32 with no formal certification or qualification.

Project Management Qualifications/Certifications				
		Frequency	Percent	Valid Percent
Valid	APM Level	10	21.3	21.3
	PMI Level	1	2.1	2.1
	Academic/ Other	4	8.5	8.5
	None	32	68.1	68.1
	Total	47	100.0	100.0

Table 6-5: PM Qualification

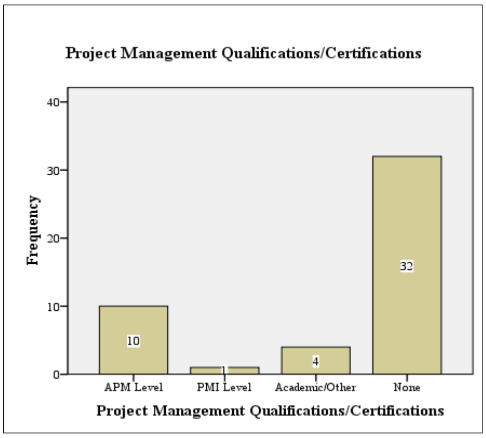

Figure 6-5 : PM Qualification Frequency

6.4.1.3 Job Experience / Role

The details under this heading included company the respondents belong to, their work discipline, total work experience, type of project and project organizational structure.

As mentioned earlier that the Project Management Professional Development Programme (PMPDP) developed by The University of Manchester in conjunction with Rolls-Royce, AMEC, Goodrich and EDS, is providing postgraduate level project management education to their employees.

Company				
		Frequency	Percent	Valid Percent
Valid	Rolls Royce	28	59.6	59.6
	Amec	10	21.3	21.3
	Others	9	19.1	19.1
	Total	47	100.0	100.0

Table 6-6 Company wise Distribution

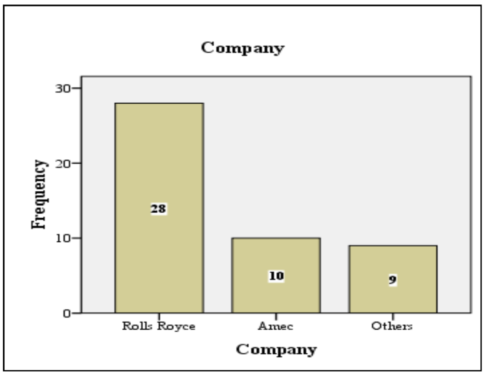

Figure 6-6 Company wise frequency

So there were 60% (n=28) delegates belonging to Rolls Royce, 21% (n=10) and 20 % (n=9) from other companies as shown in Figure 6-6 and Table 6-6.

The respondents were asked to describe their work discipline, 32% (n=15) of the respondents selected engineering, 57% (n=27) management and there was one from finance and 4 selected others categotry. One delegate from finance was merged with the 'others group'. This is shown in the Figure 6-7 and Table 6-7 below.

Work Discipline				
		Frequency	Percent	Valid Percent
Valid	Engineering	15	31.9	31.9
	Management	27	57.4	57.4
	Other	5	10.6	10.6
	Total	47	100.0	100.0

Table 6-7: Work Discipline Distribution

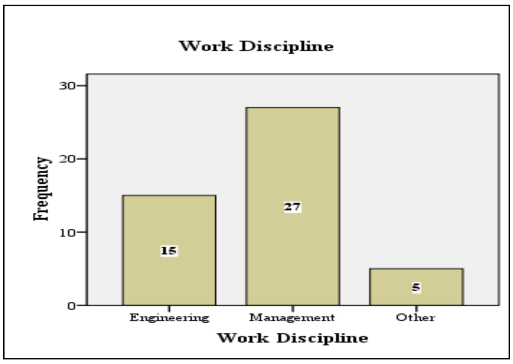

Figure 6-7 : Work Discipline Frequency

In the PMPDP program there were delegates with a very diversified total work experience range, delegates with under 3yrs of experience to ones with over 20 years of work experience as show in Table 6-8 and Figure 6-8 below,

Total Work Experience				
		Frequency	Percent	Valid Percent
Valid	Under 3 yrs	5	10.6	10.6
	3 - 6 yrs	8	17.0	17.0
	7-10 yrs	7	14.9	14.9
	11-15 yrs	7	14.9	14.9
	16-20 yrs	6	12.8	12.8
	Over 20 yrs	14	29.8	29.8
	Total	47	100.0	100.0

Table 6-8: Total Work Experience Distribution

Figure 6-8 : Total Work Experience Frequency

Similarly delegates had the experience of working in different types of organizational structures as show below in Figure 6-9 to Figure 6-11 and Table 6-9 to Table 6-11,

Functional Organizational Structure				
		Frequency	Percent	Valid Percent
Valid	No Experience	16	34.0	36.4
	Under 3 yrs	8	17.0	18.2
	3 - 6 yrs	10	21.3	22.7
	7-10 yrs	4	8.5	9.1
	11-15 yrs	5	10.6	11.4
	16-20 yrs	1	2.1	2.3
	Total	44	93.6	100.0
Missing	System	3	6.4	
Total		47	100.0	

Table 6-9: Functional Organization Structure Distribution

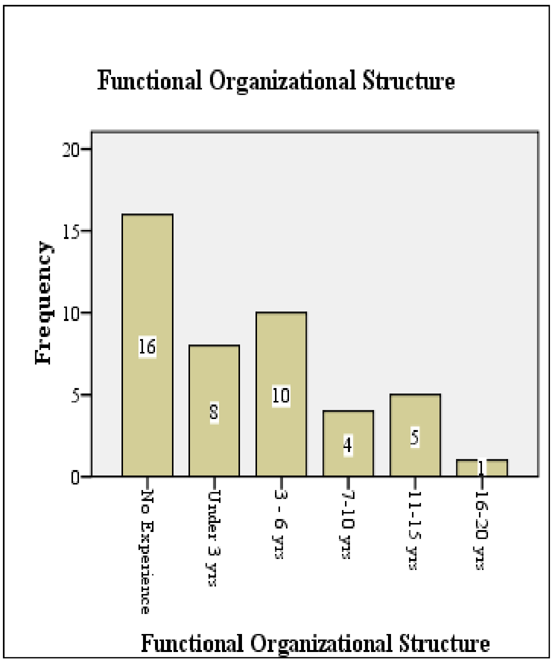

Figure 6-9 : Functional Organization Structure Frequency

Matrix Organizational Structure				
		Frequency	Percent	Valid Percent
Valid	No Experience	16	34.0	35.6
	Under 3 yrs	7	14.9	15.6
	3 - 6 yrs	10	21.3	22.2
	7-10 yrs	8	17.0	17.8
	11-15 yrs	3	6.4	6.7
	16-20 yrs	1	2.1	2.2
	Total	45	95.7	100.0
Missing	System	2	4.3	
Total		47	100.0	

Table 6-10: Matrix Organization Structure Distribution

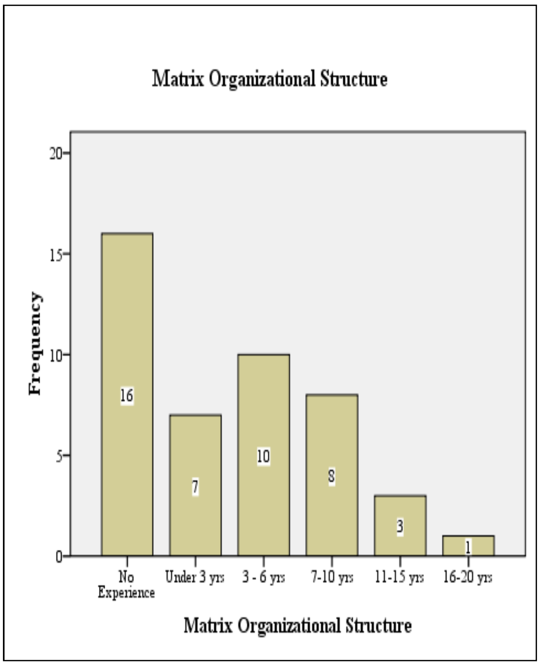

Figure 6-10 : Matrix Organization Structure Frequency

Project Organizational Structure				
		Freq.	Percent	Valid Percent
0	Total			
Valid	No Experience	8	17.0	17.4
	Under 3 yrs	6	12.8	13.0
	3 - 6 yrs	14	29.8	30.4
	7-10 yrs	9	19.1	19.6
	11-15 yrs	4	8.5	8.7
	16-20 yrs	3	6.4	6.5
	Over 20 yrs	2	4.3	4.3
	Total	46	97.9	100.0
Missing	System	1	2.1	
Total		47	100.0	

Table 6-11: Project Organizational Structure Distribution

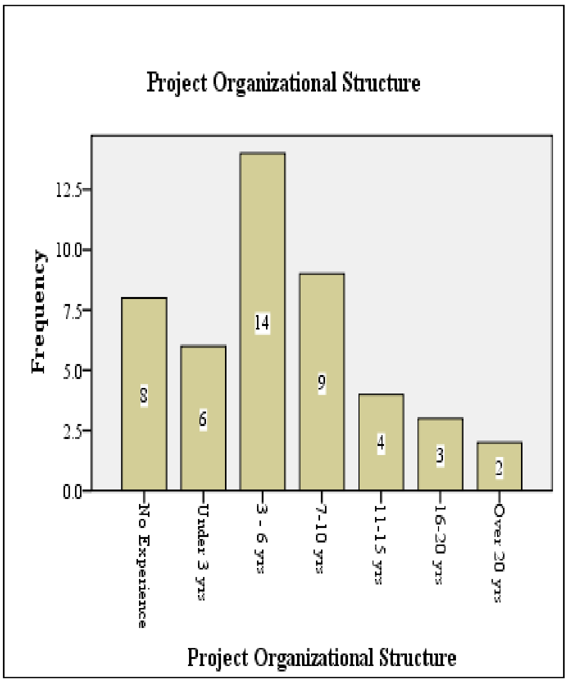

Figure 6-11 : Project Organizational Structure Frequency

Lastly, the type of project the delegates have worked in, these categories were based on Turner's (1993) goal and method matrix (shown in Figure 2-4). The distribution of respondents' project wise experience is shown below,

Type1 Goals & Method Well Defined				
		Frequency	Percent	Valid Percent
Valid	Yes	22	46.8	46.8
	No	25	53.2	53.2
	Total	47	100.0	100.0

Table 6-12: Project Type 1 Distribution

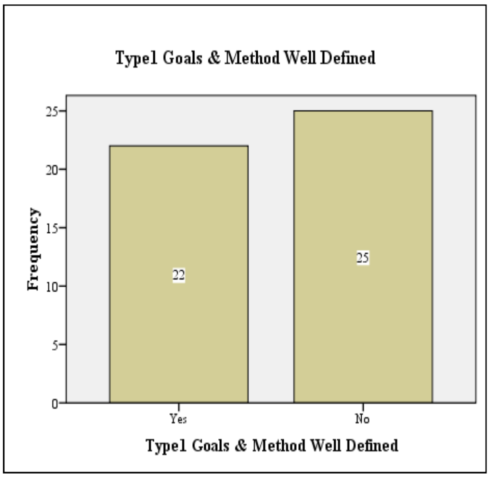

Figure 6-12: Project Type 1 Frequency

Type2 Goals well defined, Methods not well defined				
		Frequency	Percent	Valid Percent
Valid	Yes	39	83.0	83.0
	No	8	17.0	17.0
	Total	47	100.0	100.0

Table 6-13: Project Type 2 Distribution

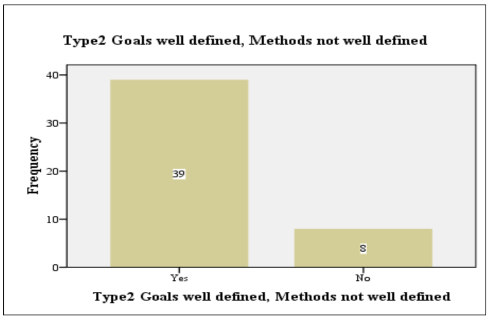

Figure 6-13 : Project Type 2 Frequency

Type3 Methods well defined, Goals not well defined				
		Frequency	Percent	Valid Percent
Valid	Yes	24	51.1	51.1
	No	23	48.9	48.9
	Total	47	100.0	100.0

Table 6-14: Project Type 3 Distribution

Figure 6-14 : Project Type 3 Frequency

Type4 Goals & Methods not well defined				
		Frequency	Percent	Valid Percent
Valid	Yes	26	55.3	55.3
	No	21	44.7	44.7
	Total	47	100.0	100.0

Table 6-15: Project Type4 Distribution

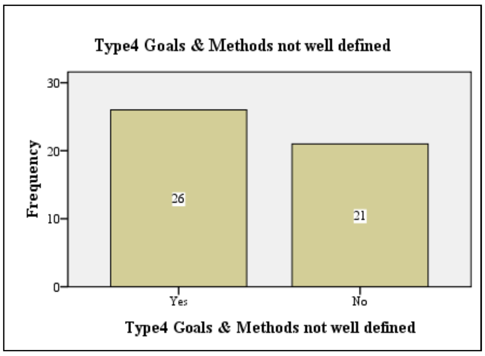

Figure 6-15 : Project Type 4 Frequency

As can it can be seen from the above Table 6-12 to Table 6-15 and Figure 6-12 to Figure 6-15, there are respondents in all the categories, with 83% (n=39) experience of working in project which have goals defined but the methods to achieve them are not clear which have been categorised as Type 2 projects in Turner and Cochrane's Goals and Method Matrix shown in Figure 2-4 i.e. projects with an element of uncertainty in them, which is also in the projects of Type 3 and Type 4 projects, 51% in the former and 55% in the latter respectively. It can be seen that most of the respondents have experience of working in projects which have to some element of ambiguity and uncertainty prevailing in them.

6.4.1.4 Project Complexity Groups

The respondents were asked to indentify based on their experience the importance in which the groups-*people, product and process,* affect and / or contribute to project complexity. The scale on which it was ranked was '1' denoting most significant, '2' - significant and '3' - least significant.

People as area contributing to Project Complexity				
		Frequency	Percent	Valid Percent
Valid	Least Significant	4	8.5	8.5
	Significant	8	17.0	17.0
	Most Significant	35	74.5	74.5
	Total	47	100.0	100.0

Table 6-16: People as area contributing to Project Complexity Distribution

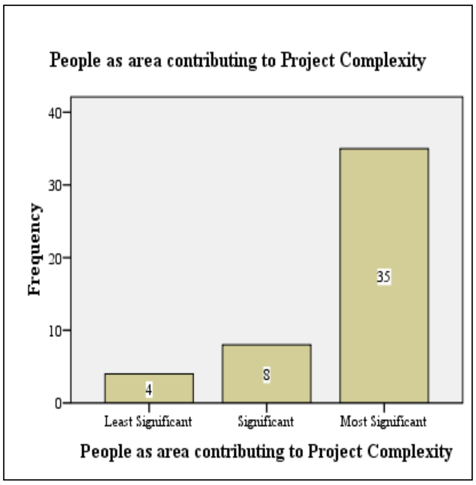

Figure 6-16 : People as area contributing to Project Complexity Frequeny

Product/Service as area contributing to Project Complexity				
		Frequency	Percent	Valid Percent
Valid	Least Significant	26	55.3	55.3
	Significant	17	36.2	36.2
	Most Significant	4	8.5	8.5
	Total	47	100.0	100.0

Table 6-17: Product/Service as area contributing to Project Complexity Distribution

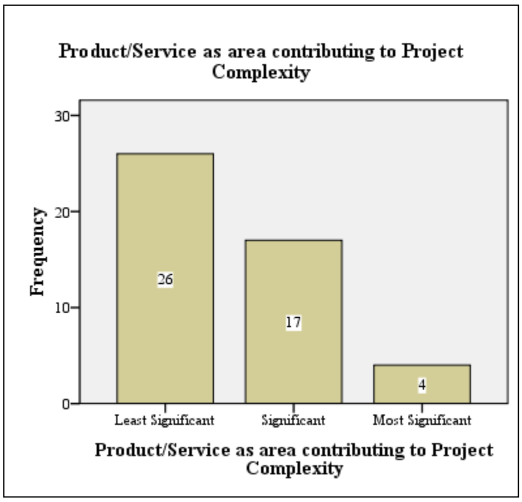

Figure 6-17 : Product/Service as area contributing to Project Complexity Distribution

Process as area contributing to Project Complexity				
		Frequency	Percent	Valid Percent
Valid	Least Significant	14	29.8	29.8
	Significant	22	46.8	46.8
	Most Significant	11	23.4	23.4
	Total	47	100.0	100.0

Table 6-18: Process as area contributing to Project Complexity Distribution

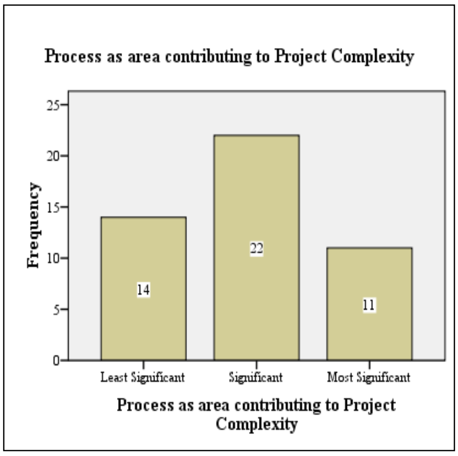

Figure 6-18 : Process as area contributing to Project Complexity Distribution

The above Table 6-16 to Table 6-18 and Figure 6-16 to Figure 6-18 highlight the responses in each category. Comparing the 'most significant' response it can be seen that 75% respondents rated 'people' group as most significant, followed by process 23% and product 9% respectively, which can also be seen by comparing the medians of the three groups as show in Table 6-19 below,

Statistics				
		People as area contributing to Project Complexity	**Product/Service as area contributing to Project Complexity**	**Process as area contributing to Project Complexity**
N	Valid	47	47	47
	Missing	0	0	0
	Median	**3.00**	**1.00**	**2.00**

Table 6-19: Comparison of People, Product & Process groups

'People' as group was considered as the most significant followed by 'process' and then 'product'. In project actuality, it is the interaction of people and their interdependencies which is perceived to have a high level of impact on project complexity. Processes are important to plan and then to manage that plan and to effectively reduce deviations and ambiguities which have an impact on project complexity. Product has impact on complexity, either due to its novelty or lack of its specifications and/or due to the novelty of methods to achieve it, which is shown in the next section.

6.4.1.5 Level of Impact of Factors in the Project Complexity Groups

The respondents were asked to highlight the level of impact of attributes in each of the project complexity groups. The Table 6-20 below shows in each group the factors which have the highest level of impacts in each group.

High level of Impact on Project Complexity - Product			
	Valid	Missing	Median
Newness/Novelty of Technologies required to deliver the product	46	1	3.00
Technical Design Difficulty	46	1	3.00
Lack of Product Specifications	46	1	3.00
High level of Impact on Project Complexity - Process			
	Valid	Missing	Median
Scope Management	47	0	3.00
Change Control	46	1	3.00
Communication	46	1	3.00
Leadership	46	1	3.00
High level of Impact on Project Complexity - People			
	Valid	Missing	Median
Number of Teams/Departments Involved	47	0	3.00
Diversity of Teams/Departments Involved	47	0	3.00
Number of Clients/Suppliers	47	0	3.00
Number of Stakeholders	46	1	3.00
Technical Knowledge of Team(s)	47	0	3.00
Lack of senior management support	47	0	3.00
Lack of Leadership	47	0	3.00
Lack of communication within the team	47	0	3.00
Lack of coordination within the team	47	0	3.00
Lack of agreement on objectives between stakeholders	47	0	3.00

Table 6-20: Level of Impact on Project Complexity based on Medians
(Product, Process & People)

As mentioned earlier the factors related to product group are mostly related to newness/novelty of product in terms of the technologies required to deliver and/or difficulties associated with its design and/or an element of ambiguity created by lack of product specifications, which seems to have high level of impact on project complexity.

Process related attributes that have a high impact on project complexity include processes which are important to manage deviations and changes and in turn reduce uncertainties and it is the lack of effectively utilising these processes which contribute to project complexity. And in order to implement these processes, effective and timely communication and leadership qualities are required which is also highlighted in the above Table 6-20.

‘People group’ attributes include the ones related to their diversity and number, which signifies the subsequent impact on interactions and interdependencies. The other factors are the ones which give rise uncertainties, while others which are useful in managing uncertainties. The factors which have been reported high in the three groups are shown in Figure 6-19 to Figure 6-21 below,

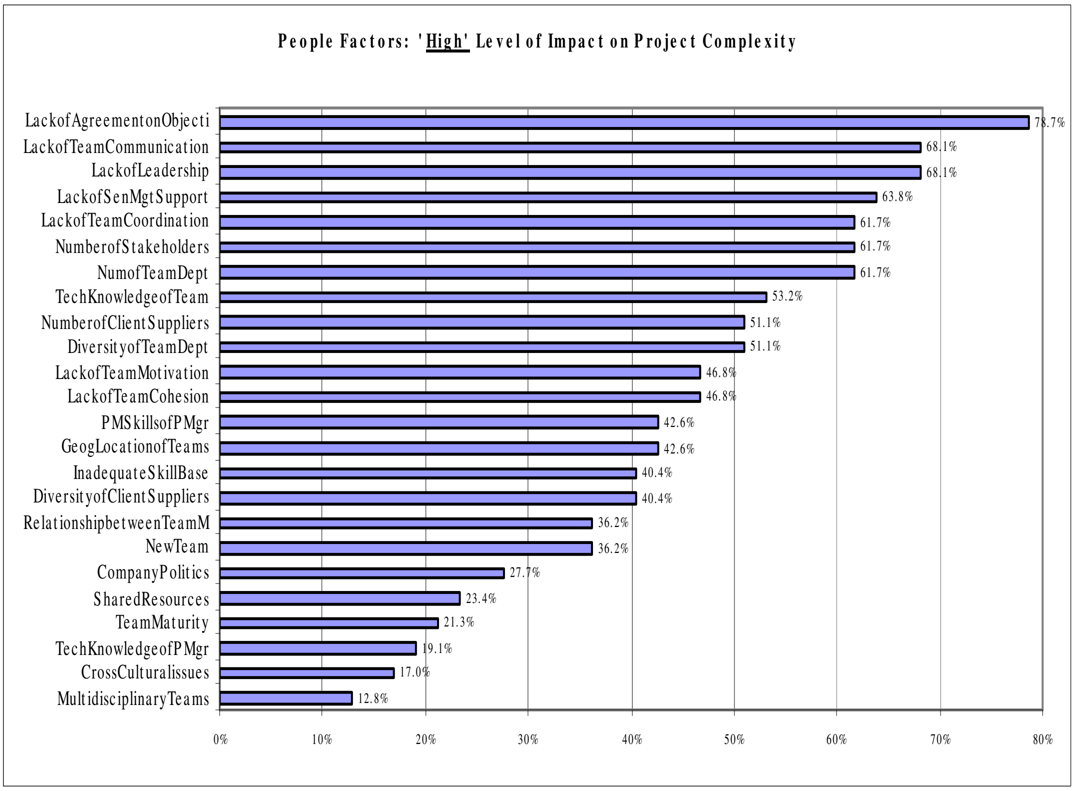

Figure 6-19 : People Factors (High Level of Impact) based on frequency

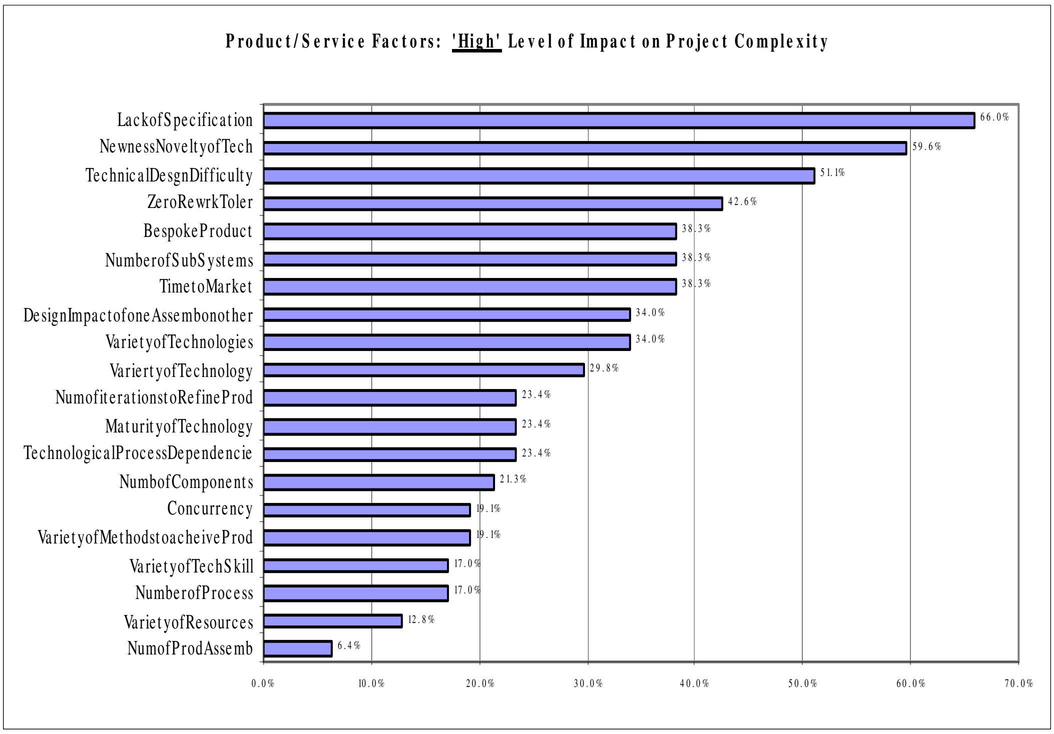

Figure 6-20 : Product Factors (High Level of Impact) based on frequency

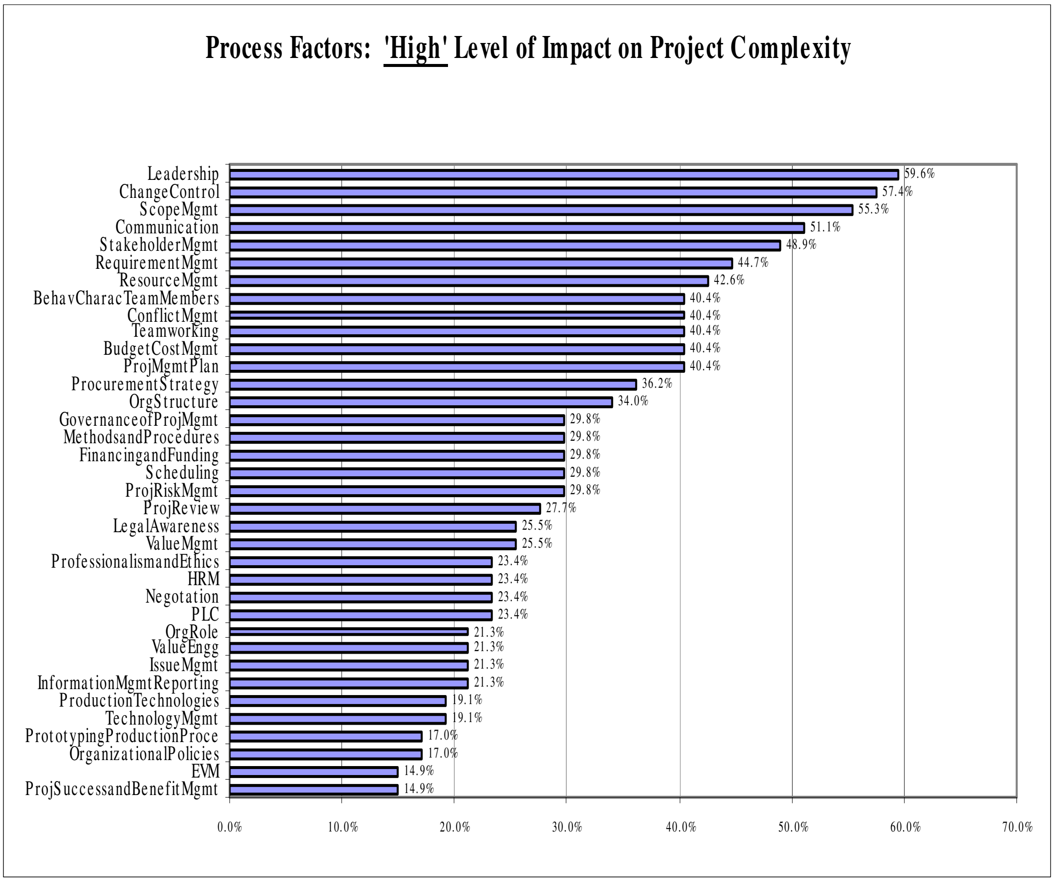

Figure 6-21: Process Factors (High Level of Impact) based on frequency

6.4.2 Inferential Statistics

This section presents the statistical tests performed to explore the differences and/or relationships if any in the data in order to test the hypotheses given below,

Hypothesis 1

H_0: There is no difference in the ranking of **project complexity <u>groups</u>** (proposed people, product and process groups) with practitioners' age, qualification, work discipline, work experience and project type.
H_1: There is difference in the ranking of **project complexity <u>groups</u>** (proposed people, product and process groups) with practitioners' age, qualification, work discipline, work experience and project type.

The results for the non-parametric tests performed, 'Mann-Whitney U' and 'Kruskal Wallis' are given below. *The requisite tests were done for all of the above-mentioned variables, however the data/results for the test of differences is shown below only for the variables for which there was statistical significance found i.e. '<u>PM qualifications' and 'work discipline'</u>.* The results are considered to be significant at significance value of $p < 0.05$.

6.4.2.1 Kruskal Wallis Test

Table 6-21 below shows the results of Kruskal Wallis Test carried out to find any difference in the perception of project complexity groups with the independent variables given in the questionnaire attached in Appendix 'C'. It can be seen from the statistical test Table 6-21 shown below, that for independent variable 'PM Qualifications', the 'process group' group has a p-value of 0.037, which is less than 0.05, so for this **H_0** is rejected and **H_1** is accepted, that means that there is a difference in the ranking of process group based on 'PM Qualification', comparing the ranks it shows that respondents with academic qualifications give more importance to process group in terms of level of impact on project complexity as compared to one with PM certifications and no project management qualification. This is in supported by the argument made about the

‘BoKs’ and PM theoretical base, that they are process dominated and focus more on hard skills.

Kruskal Wallis Test Ranks			
	Project Management Qualifications/Certifications	**N**	**Mean Rank**
People as area contributing to Project Complexity	APM Level	11	28.05
	Academic/Other	4	13.88
	None	32	23.88
	Total	47	
Product/Service as area contributing to Project Complexity	APM Level	11	23.27
	Academic/Other	4	13.50
	None	32	25.56
	Total	47	
Process as area contributing to Project Complexity	APM Level	11	18.82
	Academic/Other	4	37.88
	None	32	24.05
	Total	47	

Kruskal Wallis Test Statistics[a,b]			
	Chi-Square	**df**	**Asymp. Sig.**
People as area contributing to Project Complexity	5.400	2	.067
Product/Service as area contributing to Project Complexity	3.566	2	.168
Process as area contributing to Project Complexity	6.601	2	**.037**
a. Kruskal Wallis Test			
b. **Grouping Variable: Project Management Qualifications/Certifications**			

Table 6-21: Significance of Project Complexity Groups with PM Qual/Cert.

The next Kruskal Wallis Test (Table 6-22) between ‘work disciplines’ and ‘project complexity groups’, was done to find out any statistical significance. It can be observed from the table below for project complexity groups ‘Product/Service’ and ‘Process’ the has a significance p-value of 0.035 and 0.003 respectively, so for these groups $\mathbf{H_0}$ is rejected and $\mathbf{H_1}$ is accepted, which means that respondents from ‘other work disciplines’ give more importance to ‘Product group’ in terms of its level of impact on project complexity as compared to engineering and management, and similarly the respondents in engineering discipline give more importance to 'Process group' in terms of level of impact on project complexity as oppose to the rest.

Kruskal Wallis Test Ranks			
	Work Discipline	**N**	**Mean Rank**
People as area contributing to Project Complexity	Engineering	15	18.77
	Management	27	26.59
	Other	5	25.70
	Total	47	
Product/Service as area contributing to Project Complexity	Engineering	15	23.50
	Management	27	21.85
	Other	5	37.10
	Total	47	
Process as area contributing to Project Complexity	Engineering	15	29.70
	Management	27	23.89
	Other	5	7.50
	Total	47	

Kruskal Wallis Test Statistics[a,b]			
	Chi-Square	df	Asymp. Sig.
People as area contributing to Project Complexity	5.548	2	.062
Product/Service as area contributing to Project Complexity	6.700	2	**.035**
Process as area contributing to Project Complexity	11.455	2	**.003**
a. Kruskal Wallis Test			
b. **Grouping Variable: Work Discipline**			

Table 6-22: Significance of Project Complexity Groups with Work Discipline

However, in the above test which is between 'work disciplines' and project complexity groups, since the number of respondents were only 5 in the 'other discipline group', another test (Mann-Whitney U) was done between 'engineering and management disciplines' which revealed different results as shown below. T

6.4.2.2 Mann-Whitney U Test

Man-Whitney U Test was performed, as it is non-parametric test for 2 independent samples, which in this case was ‘engineering’ and ‘management’ work disciplines.

Mann-Whitney U Test Ranks				
	Work Discipline	**N**	**Mean Rank**	**Sum of Ranks**
People as area contributing to Project Complexity	Engineering	15	17.03	255.50
	Management	27	23.98	647.50
	Total	42		
Product/Service as area contributing to Project Complexity	Engineering	15	22.37	335.50
	Management	27	21.02	567.50
	Total	42		
Process as area contributing to Project Complexity	Engineering	15	25.03	375.50
	Management	27	19.54	527.50
	Total	42		

Mann-Whitney U Test Statistics[a]				
	Mann-Whitney U	**Wilcoxon W**	**Z**	**Asymp. Sig. (2-tailed)**
People as area contributing to Project Complexity	135.500	255.500	-2.284	**.022**
Product/Service as area contributing to Project Complexity	189.500	567.500	-.399	.690
Process as area contributing to Project Complexity	149.500	527.500	-1.528	.126
a. **Grouping Variable: Work Discipline**				

Table 6-23: Significance of Project Complexity Groups with Work Discipline - Engineering & Management

It can be observed from the Table 6-23 that for project complexity group ‘People’ has a significance p-value of 0.022, so for this group $\mathbf{H_0}$ is rejected and $\mathbf{H_1}$ is accepted, which means that respondents from ‘management work discipline’ give more importance to ‘People group’ in terms of its level of impact on project complexity as compared to ‘engineering’ for the reason that in project actuality project management is about managing stakeholders (people) as they have significance impact on project outcome.

6.5 Summary and Conclusion

The main objective of the 1st phase questionnaire was to build upon and validate the findings of the 1st phase interviews and the literature review, and to further enhance the perspective by focusing on the factors contributing to project complexity. The reason for focusing on the factors was due to the lack of consolidated project complexity factors in the existing literature and highlighting their relevancy to practice.

The proposed 'complexity triangle' was further explored through this questionnaire by investigating the impact levels of the project complexity groups and their attributes. The questionnaire was designed to address the objectives mentioned earlier.

Since one of the aims of the study was to investigate the perceived gap between theory and practice, therefore in order to research the 'project actuality' and to get the pragmatic view, it was necessitated that the questionnaire to be distributed to practitioners with experience and understanding of project management theory and practice. Keep in view the aforementioned premise; the questionnaire was administered to the delegates of the PMPDP plenary session as they were seemed to be suitable to fit in the criteria mentioned, as they had experience of working with reputable companies working on complex products and in complex project settings. In addition to their work experience, these delegates were in the process of enhancing their theoretical project management base through the PMPDP program. Thus they were deemed suitable to give a valuable and meaningful response.

The questionnaire focused on assessing the perceived level of impact of the proposed project complexity groups in per se' and also their attributes. The qualitative and statistical analysis focused on reporting the level of impact of these groups and the factors as reported significant by the respondents. Inferential statistics was done to assess the variation of the perception of the project complexity groups with the respondents' biographical details, qualifications and work experience / role.

The analysis of the questionnaire is summarised as follows,

- ***'Complexity Triangle'* – People, Product and Process their impact level on project complexity**

The response on the level of impact of people, product and process groups per se on project complexity indicates that three groups have an impact on project complexity, with 'people' group reported to have the highest, followed by 'process' and 'product' respectively. 'People' was reported by 75% of the respondents and the median of the responses also indicate the same. This is also reflected from the analysis of the first phase interviews which indirectly indicated the same in terms of highlighting 'soft' PM skills and the importance of people in all project dimensions.

- **Significance of the factors in the project complexity groups**

The previous study and this one highlighted the importance of the complexity groups in terms of their level of impact on project complexity, however the underlying attributes which collectively or individually impact project complexity were explored in this study. This was done in order to indentify the root cause so that their effect can be understood and better managed. In regards to 'People' and 'Product' groups the factors rated with high level of impact in this study were also reflected in the analysis of the 1st phase interviews, however in the 'process' factors there was a variation, the reason for this could be the project context, as majority of the respondents in the questionnaire were from the aerospace industry as compared to diversified context in the previous study. The analysis however helped in ranking the factors belonging to each category in terms of their level of impact.

- **Context dependency of the factors/ groups contributing to project complexity**

The results of inferential statistics highlighted two aspects, the variation in perception of complexity groups with ‘PM Qualifications/Certifications’ and ‘Work discipline’. The latter was also depicted in the results of the first phase interview analysis. Thus highlighting that the perception of the project complexity groups differs with different work discipline, as highlighted that in the case of engineering, management and ‘others’ categories. However when considering the two groups ‘engineering’ and ‘management’, it was established that respondents from ‘management work discipline’ give more importance to ‘People group’ in terms of its level of impact on project complexity as compared to ‘engineering group’. Thus highlighting the influence of context on the perception of project complexity. This was also reflected in the in the broader sense from the results of 1st phase interviews.

Keeping in view the findings of this questionnaire and the previous interviews, the results were discussed with the supervisors and industrial advisors and a case study approach was agreed upon to further investigate the following,

- Perception of complexity and its context dependency,
- Factors contributing to project complexity and their impact.
- Key project management skills
- Project critical success factors

The details of the interviews and the questionnaire survey carried out in the case study organization, which in this case was a leading European aerospace company, are presented in the following chapters respectively.

Chapter 7

2nd Phase In-depth Interviews

7.0 Introduction

This chapter presents the results and analysis of second phase in-depth interviews (July – October 2009). The purpose of these interviews was to further investigate and to validate the findings of the previous studies, i.e. the first phase interviews and the questionnaires, which have been discussed in detail in the previous chapters. The interviews were conducted with project management personnel of a leading European aerospace company, engaged in the development and production of number of state of the art and novel products, involving multiple high end technologies and processes. The selection of the company was done in consultation with the supervisors, with the purpose to focus on a specific industry which is characterised as complex not only due to the nature of its products i.e. falling under the Complex Product Systems (CoPS) category (Hobday and Rush, 1999), but also in terms of its organizational and business characteristics. The other reason for the selection of the company was the 'ease of access of data', as the University of Manchester and the supervisor had good collaboration with the company on various research projects.

The interview questions focused on the following research areas with the aim to get a pragmatic view from the practitioners engaged in the *project actuality*,

i. Perception of Project Complexity / Complex Project.
ii. Factors contributing to project complexity.
iii. Key Project Management Aspects in managing complex project
iv. Project Critical Success Factors for complex projects.

The results and analysis of these interviews are presented in the next sections in the above order, with the summary of each section presented at the end of the section and the overall summary and conclusion of this chapter given at the end this chapter.

7.1 Rationale for the 2nd Phase Interviews

The analysis and results of the 1st phase interviews and questionnaire presented in the previous chapters highlighted,

- The relevance of Project Complexity Groups
- The level of impact of the project complexity factors
- The influence of context in the perception of these factors

Based on the above, it was necessary to explore these findings through in depth interviews, firstly for the reason of a mutli-method research approach adopted to validate the findings of the previous studies and secondly to get a comprehensive viewpoint of the practitioners, with the detail of logic and reasoning for their responses. A case study approach was adapted with the aim to understand project complexity in a particular setting by exploring the *project actuality* embedded with the social and dynamic processes taking place in projects.

7.2 Planning & Designing of the 2nd Phase Interviews

The decision to proceed for the second phase interviews was done after deliberating the results of the previous studies with the supervisors. The interview guide for the first phase interviews was used as a reference to keep the consistency of the questions. However based on the experience of 1st phase interviews, certain questions were modified and/or omitted to keep the focus and relevancy and to improve on their clarity. After refining and finalizing the interview guide, pilot interviews were conducted with the supervisors and peers to rule out any ambiguity, to check the flow of the questions and to assess the duration of the interview.

The interview questions focused specifically on the following,

a. Project Complexity – a general view
   - *Perception of a complex project*
   - *Difference between complex and complicated projects*
   - *Assessment of project complexity*

b. Project Complexity – project specific
   - *Factors making it complex*
   - *Key Project Management aspects to manage that project*
   - *Critical Success Factors for the reported for the project*

The respondents were given a flexibility to choose a project for discussion. They were asked to choose from projects they have worked on which they deem to be complex, either a past project or the current one, to discuss its project complexity in detail. This flexibility in choosing a project gave the researcher an opportunity to assess how practitioners perceive project complexity and what is the influencing factor and logic behind this understanding. The interview guide is given in Appendix 'D' – 2nd Phase Interview Guide.

7.3 Sampling and Data Collection

A brief on the research areas and the theme of the interviews was prepared in consultation with the supervisors and was forwarded to the industrial advisors, which in this case were the heads of project/program management functions in different business units of the company. These executives were already in collaboration with the University of Manchester for ongoing research. A group of individuals within different company's business units/divisions was forwarded the brief about the research topic area. The individuals, who volunteered for the interview based on their interest in the topic, were then provided with a brief on the areas to be covered in the interviews. This gave them an opportunity to reflect back and think about the subject prior to the interview.

A total of 16 interviews were conducted from September – October 2009. Most of the interviewees had experience of working in multiple projects and were at a senior level in the business unit/company and had been working in the same company for an average of more than 10 years. The interviews were carried out two different business units at Site ‘B’ and Site ‘D’ respectively, with 11 interviews done at the former and 5 interviews at the latter site. Table 7-1 below stratifies the sample in terms of their age, job title, current job function, work experience in years and the number of major projects participated. The interviewees were asked to give the number of projects participated, reporting only those projects in which they have worked either through the complete project life cycle or through phase(s) which lead to a deliverable, prototype or the final product/service. In other words, they have worked in a project through the phases which are considered critical and important and have a significant impact on the project’s deliverable(s).

Age	Job Title	Experience Job Function wise	Work Experience (years)	Number of Major Projects:
41-50	Program Director	Management	20	5
41-50	Head of Commercial & Program Management	Functional / Management	24	A lot
41	Program Executive	Functional / Management	24	3
38	Program Executive	Functional / Management	17	12
41	Program Executive	Functional / Management	19	5
50+	Program Executive	Functional / Management	32	10
42	Program Executive	Functional / Management	22	10
52	Program Executive	Functional / Management	30	A lot
36	Program Manager	Functional / Management	15	6
36	Program Manager	Functional / Management	5	3
45	Program Manager	Functional / Management	29	4
30-40	Program Manager	Functional / Management	17	4
34	Program Manager	Functional / Management	13	6
46	Program Lead	Functional / Management	20	5
37	Program Lead	Functional / Management	14	3
Under 30	Program Controller	Graduate Rotations	2	6 project rotations

Table 7-1: Interviewees' Profile

As seen from the above table, participants were from different management levels within the organizational structure, with the age range from 20s to 50s, and most of them had experience of both management and technical functions. Although less in number, the respondents had rich experience of working in various complex projects which fall under the CoPs category (Hobday and Rush, 1999), the preference was given to the quality of responses rather than the number of interviews. Another reason for the relatively less number of interviews was the availability and time issues with the practitioners due to their project commitments. However, all the respondents had experience of working in multiple projects and the flexibility given to them to choose a project for the discussion gave a better understanding of their logic and basis of the project considered by them to be complex. Interviews were preferred over focus group for the reason that in the interviews each individual was able to give his point view in detail providing clarity to their responses which would have not been achieved in that detail in focus group.

Keeping in view the research objectives, one-to-one semi-structured interviews spanning over one to two hours were conducted. All of the interviews were digitally recorded with the prior consent of the interviewee. In addition to the recordings, notes were also taken during the interviews, which assisted in asking further questions based on their replies, and also to get clarity on their views and understanding the motives behind their replies. Recordings of the interviews later on helped in transcribing and also gave the flexibility to listen to the interviews multiple times to get the full understanding of the context. In depth analysis was conducted once all the interviews were completed and transcribed.

The analysis of the interviews is presented in the following order,

- Perception of Project Complexity / Complex Project.
- Factors contributing to project complexity.
- Key Project Management Aspects
- Project Critical Success Factors

7.4 Complex Project / Project Complexity

The analysis in this section is based on the replies to the questions pertaining to,

- Definition of a complex project
- Difference between a complex and complicated project
- Assessment of project complexity

The main purpose of these questions was to get an overview of practitioners on the above based on their working in actual project settings.

7.4.1. Definition of Complex Project

The respondents were asked to give their general overview and understanding of the term ‘complex project’. The purpose, as highlighted earlier, was to compare the theoretical perspective with the practitioners’ response and to observe any difference, if any. Participants were asked to respond to the question, as to how they define a complex project and/or what they think is meant by the term complex project. The purpose of this question was to focus on the terms or the key aspects/characteristics reported by the practitioners to identify the underlying phenomenon/process/condition which makes a project complex. Respondents were asked to avoid defining it in terms of the contributing factors, rather give their perception/understanding of the underlying philosophy which makes a project complex.

The key characteristics highlighted in the respondent responses representing/describing their perception of complex projects are summarised in the Table 7-2 below.

Job Title	Underlying aspects in the perception of a Complex Project
Program Director	• Number of contradictory factors • Uncertainty • Novelty
Head of Commercial & Program Management	• Uncertainty • Novelty • Number of stakeholders • Number of interfaces and dependencies
Program Executive	• Novelty • Number of Stakeholders • Number of inter-relationship / interdependencies
Program Executive	• Number of variables • Number of interdependencies
Program Executive	• Novelty • Degree of Interdependencies • Concurrency
Program Executive	• Unpredictable Stakeholders / Objectives • Uncertainty
Program Executive	• No Clue I haven't worried or spent anytime whether the program I am running, how I would categorise it.
Program Executive	• High level of interfaces • High level of stakeholder and their interaction
Program Manager	• Uncertainty of outcomes • Number & Relationship between stakeholders
Program Manager	• Number of people, customers (stakeholders)
Program Manager	• High degree of dependency and inter-relationship • Uncertainty • Novelty
Program Manager	• Wide ranging number of elements (mixed skills & disciplines)
Program Manager	• Number of stakeholders
Program Lead	• Number of stakeholders • Technical Complexity
Program Lead	• Number of partners • External interfaces • Technical interfaces
Program Controller	• Number of interfaces • Different people, location, cultures, functions

Table 7-2: Response Summary - Complex Project

Looking at the responses given in the above table, the following common characteristics were used by the practitioners in describing complex project,

- Stakeholders
- Interfaces
- Interdependencies
- Uncertainty
- Novelty
- Technology

Figure 7-1 shows the response rate of the key characteristics used in defining complex projects, as these were repeatedly expressed by the respondents.

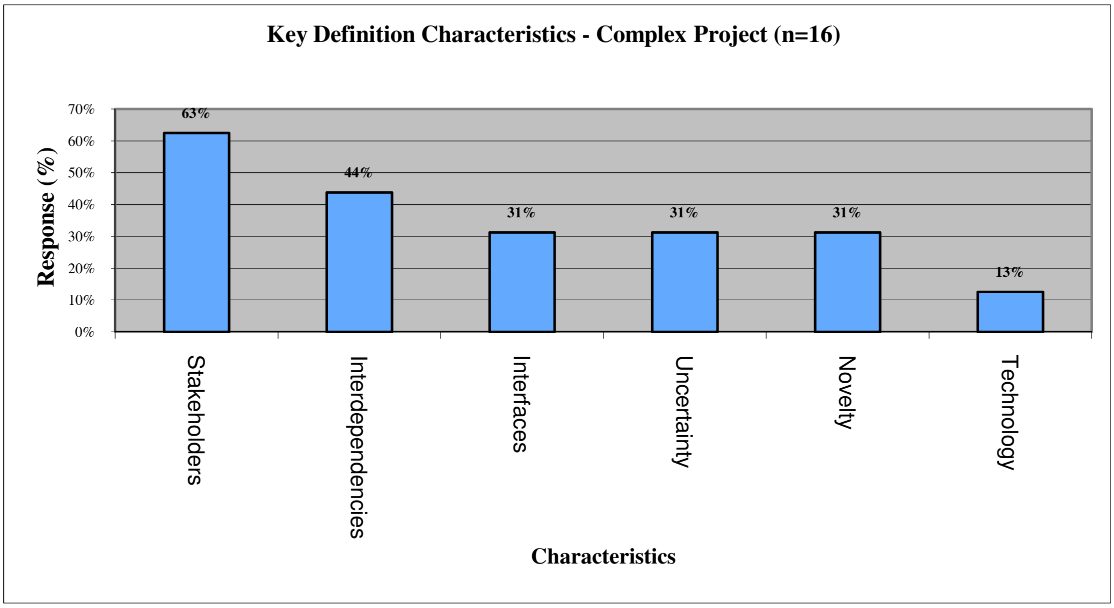

Figure 7-1 : Complex projects key definition characteristics

In this section the key definition characteristics are discussed as reported by the practitioners, however these key characteristics in conjunction with the factors contributing to project complexity, key management processes and critical success factors are discussed in detail in order to better understand their relationship to the '*complexity triangle'* (Azim et al., 2010).

The key characteristics are summarised below along with supporting remarks given by the respondents.

Stakeholders

As seen from Figure 7-1 above, 62.5% of the respondents invariably mentioned stakeholders in their definition of complex project. Although it can be argued, that stakeholder can be categorised as a factor rather than underlying process/characteristic that makes the project complex, but later it will be seen that it is the case, because it is not just simply the stakeholders itself that give rise to complexity but its their interactions and interferences.

The importance of *'stakeholders'* in projects and its impact on the project complexity is highlighted by the following statement by a respondent,

'Projects become more complex when you have more people involved, function of number of people, customer and number of contracts you have with them It is a function of number of partners.' [sic]

The attributes related to stakeholders (both external and internal) that emerge out of the responses, are their number and the most important aspect their inter-relationship/interactions. As highlighted by one of the program manager,

'Then there is something about the number of different stakeholders and particularly external bodies involved. I would particularly say its not just the number of external stakeholders, its also the relationship between the stakeholders, sometimes in project one can lead into very complex inter-relationships and I think that is where you do produce a great deal of complexity.' [sic]

The same aspect is highlighted by one of the program executive,

'In which you have got high level of interfaces, high level of stakeholder and their interactions and interdependencies.' [sic]

The above responses highlight the importance of people in projects and their role in making projects complex.

Interdependencies

As seen from Figure 7-1, 43.8% of the respondents highlighted interdependencies as one of the key characteristics of complex projects. Interdependency may be between project teams internally and externally within the project organization and/or it could be between the sub-systems, technology related to product etc and/or between the processes to manage and achieve the product/service.

Although variables (anything that's subject to change) in a project makes it complex but if there are interdependencies in them, it makes it more difficult to manage, as highlighted by the respondents' responses, *'In general, for me, my experience is that the higher the number of variables and the higher the number of interdependencies the more complex the project is.'[sic]*

'Complex project to me would be something where there is high degree of dependency and inter-relationship between various different aspects to the program.' [sic]

Interdependency related to process is highlighted by the following response,

'I guess it is number of milestones, number of deliverables, and number of inter-relationship / interdependencies in those milestones.' [sic]

Similarly, in terms of people, it is the interdependency that makes the project complex,

'I would particularly say its not just the number of external stakeholders, its also the relationship between the stakeholders, sometimes in project one can lead into very complex inter-relationships and I think that is where you do produce a great deal of complexity.'[Sic]

So interdependency is one of the characteristics of complex projects, whether its between people, product and/or process, complexity can arise from various aspects and in different forms. However, this aspect of interdependency and the way it affects will be better presented and explained later in conjunction with the factors contributing to project complexity.

Interface

As seen from Figure 7-1, 31.5% of the respondents highlighted interface as a key characteristic in defining a complex project. There could be number of interfaces which may contribute in making a project complex but it is their interdependencies /inter-relationships that becomes critical. Invariably, whenever respondents reported interfaces it was in conjunction with interaction and interdependency. The following responses highlight the above, *'My main thought what makes things complex is external interfaces, technical interfaces, number of partners. I think these are the big things to me which add complexity.' [Sic]*

'In which you got high level of interfaces or high level of stakeholder and their interactions and interdependencies.' [Sic]

'Tools/processes – number of interfaces, various disciplines, dependencies, number of technical processes.' [Sic]

Interface can be related to product, process and / or people as highlighted by the above responses. In project environment the more the number of interfaces, there will probably be more interdependencies and interactions, thus making it complex, as there would be a rare case where various interfaces work independently.

Uncertainty

As seen from the Figure 7-1, 31.5% of the respondents highlighted uncertainty as a key characteristic in defining a complex project. Whether uncertainty is a factor contributing to project complexity arising from various aspects and situations, or it is an inherent characteristic or an underlying condition of a complex project, this issue is contentious. Uncertainties either make a project complex, or complex projects have uncertainties in it, in any case they are related to product, process and people. However, the following responses highlight it to be a consequence rather than a cause,

'Something where there is a large number of factors, but its either the large number of factors, because they can be relatively simple factors, so large factors involved which are either contradictory or not aligned and there is a level of uncertainty. I don't think so it is got anything to do with size or money.' [sic]

'Then I think there is something about uncertainty of outcome, so if a project is very well defined at the onset it probably won't fall into the complex bracket.' [sic]
'What is not complex is an established, repeater kind of thing, whereas for instance development program you are not quite sure where you going, lack of clarity.' [sic]

However, in projects in which uncertainties arise from various situations can be categorised as complex, for they will give rise to vagueness, ambiguity and unpredictability of the outcomes, thus bringing in them complexity.

Novelty

Novelty was reported by 31.3% of the respondents as one of the key characteristic in defining a complex project. Novelty, in general can be related to people, product and process. However, novelty reported by the respondents is mainly related to the product and/or technologies required to develop the product. One reason for this could be contextual, due to the nature of the projects the practitioners are involved in, as highlighted by the following responses,

'The degree of Novelty, where I sit today Novelty is the biggest driver.'

'The obvious thing is technical complexity in defence, at least the stuff I have worked tends to be technically complex because its not the development of an existing product, its like Novelty, which brings a lot of challenge.' [sic]

Looking at novelty and uncertainty, it can be said that novelty is the cause and may give rise to uncertainty, which is the consequence. Novelty, can be one aspect in a project which makes it complex, however not all complex projects have novelty in them. Novelty can be taken as one of the underlying characteristics of a complex project rather than a factor making a project complex.

Technology

Technology was reported by 12.5% of the respondents as one of the key characteristic in defining a complex project. However, technology was not directly reported but it was in conjunction with novelty aspect related to it and/or to its interfaces. So in terms of technology, the technical complexity was either due to novelty of the technology; in other instance was due to the concurrency element; and/or also due to the number of technical interfaces. The following responses highlight the above, *'The obvious thing is technical complexity, in defence, at least the stuff I have worked tends to be technically complex.' [sic]*

'I guess three factors, requirement capture, number of stakeholders / stakeholder management and the technical complexity.' [sic]

'My main thought what makes things complex is technical interfaces.' [sic]

'Technical Considerations – Novelty, development phase, technical requirements stability; Tools/processes – number of interfaces, various disciplines, dependencies, number of technical processes, Concurrency, change.' [sic]

The novelty aspect was the main reason in highlighting technology as a characteristic of a complex project.

So in terms of defining a complex project, the main characteristics which emerged were interdependencies, interfaces and novelty, as the rest of the characteristics were defined directly or indirectly in relation to them.

The next section discusses the respondents' views on complex and complicated projects.

7.4.2. Complex and Complicated projects

As highlighted earlier in the literature review section, the terms complex and complicated are interchangeably used. The respondents were asked to explain how they would differentiate between a complex project and a complicated project. The purpose of this question was to explore the key differentiating factors in the classification of complex and complicated projects.

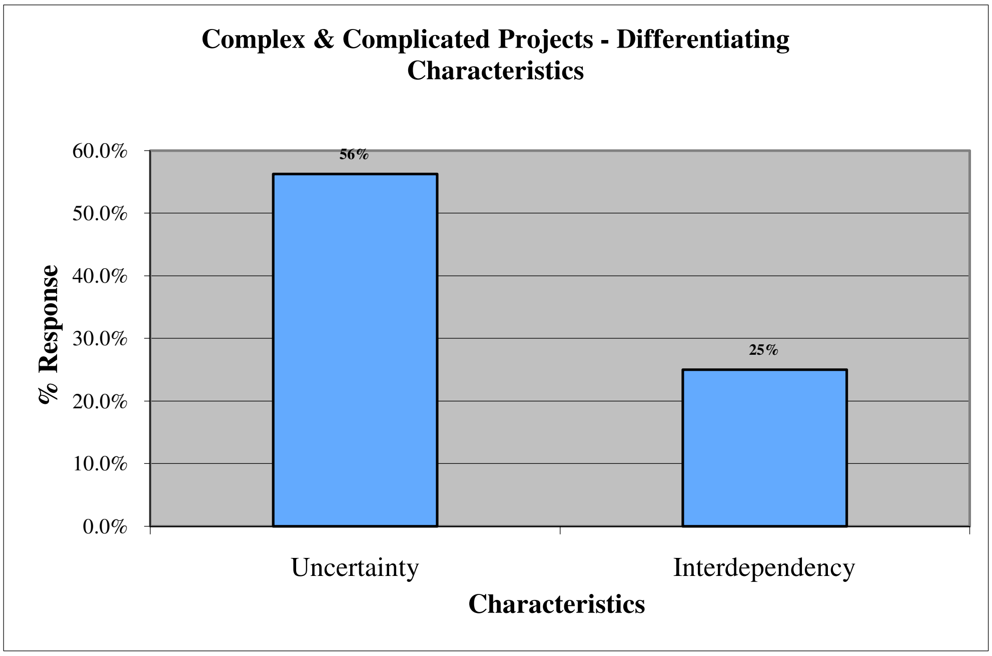

Figure 7-2 : Differentiating characteristics between complex and complicated projects

From Figure 7-2, it can be seen that the two main differentiating characteristics, uncertainty and interdependency, were used by the practitioners in explaining their understanding of complex project and complicated project.

Uncertainty

Uncertainty has also been highlighted as characteristic in the definition of complex project and has also been reported here as the key differentiating factor between a complex and a complicated project. It is the lack of clarity, novelty and the ambiguity about the outcomes, which forms the basis for the differentiating factors between complex and complicated projects, as can be seen in the responses given below, *'Lack of clear direction as opposed to clear direction.' [sic]*

'I would say to me complicated is probably a lot of it but the basic elements are relatively simple. The complicated nature is trying them all together because there are so many bits of them but relatively simple to manage. You know that they are not going to trip you up. Complex is reverse, you may be got fewer activities but they are all quite new, novel, a lot of uncertainty, things could quite easily go wrong. You are managing unknown uncertainties and you don't know what is going to come up.' [sic]

'Complicated is stuff that is difficult, stuff that is challenging, testing the limit of your technical capabilities and knowledge, but there is much more certainty around it. Once you get to that certainty and understanding, it can be managed; for you can focus it into an understanding of exactly what you need. Complicated is much more scientific and technical and can be grasped, defined and eventually solved.' [sic]

Interdependency

However, in some responses, interdependency and interfaces have been used to characterise the difference between complex and complicated projects.

'In complicated projects there are dependencies but in complex they are multiple. I guess it is the number of milestones, number of deliverables, number of inter-relationship & inter-dependencies in those milestones.' [sic]

'Complexity you start to get into where I would call the real sort of environmental things, the Vagueness of world economic situations. Partnership brings complexity - Different objectives, stakeholders' network and their behaviours which are unpredictable.' [sic]

Before moving on to the next section, there were few interesting comments from the practitioners on the aforementioned context.

'No Clue, I haven't worried or spent anytime whether the program I am running how I would categorise it. I really don't know the academic definition of simple complex & complicated.'[sic]

'I am not sure I can give you an easy distinction of that, and I think as a practitioner that is I really do not think about at the moment, may be there is a

gap and something that is addressed as the science of project management progresses.'[sic]

7.4.3. Assessment of Project Complexity

The purpose of this question was to investigate the importance of assessing project complexity in practice.

Based on the responses, 81 % respondents reported that project complexity was not assessed formally or otherwise, whereas 19% reported to assess project complexity individually based on their interest but not as a formal process.

'As far as I am involved we don't assess complexity per say, the element of it are picked up as part of the risk assessment that are conducted and there are obvious things there around stakeholders, scope & specification, site & geographical location.' [sic]

'Yes, as a program executive I have to assess complexity of the project in order to resource it properly, skill set and head count point of view. I assess from risk side, from the program scope side. Do I use a robust formula to assess complexity, No; it is based on experience.' [sic]

'I don't know how you assess it, apart from having a judgemental view. Probably you can assess it by how many stakeholders involved, what locations you working in, and you look at the size, type of project and compare it with another, but its very judgemental.' [sic]

'I think something in our business, knowingly we don't do it in according to any particular process or structured tool.' [sic]

As seen from the above responses, it shows that there is a realization of importance of assessing project complexity but it seems that there is a lack of importance in adapting it as a formal organizational process. One of the reasons seems to be an absence of a robust tool to assess project complexity in a way which is more meaningful to the practitioners. However, in terms of the existing tools in the literature, a few respondents (25%) were aware of the existing methods/tools to assess project complexity and reported an informal use of them, that too at their own capacity and in their own interest. These respondents reported the use of *'Crawford-Ishikura Factor Table for Evaluating Roles'* (CIFTER) model to assess project complexity.

The respondents who were aware of the CIFTER tools, had reservations regarding its subjectivity or its end result,

'CIFTER – the inevitable problem is its fine if one single individual using this tool, as soon as you get more people to use it, it falls down because of the subjectivity issue. CIFTER is good to set you thinking about some of the right things, I think what isn't good is absolute measurement of these things. It is for me was an educational tool in many ways, some of the things underlying complexity.' [sic]

'CIFTER: they are not interested, the don't see it as value adding there view is I tell CIFTER tool about the project based on what I know about it and it tells me how complex it, it tell me a number so what! It just told what I already knew. I already knew how complex it was as far as I know about it and it tells you a number, so what. What do I do with that, it does not tell how to particularly setup a project, project team, and manage it given the degree of complexity.' [sic]

Practitioners using CIFTER, besides the subjectivity issues, reported that it was more useful in highlighting the key areas to be focused in terms of complexity and was helpful in giving the awareness about these areas. For the respondents the awareness aspect was more important to them than the end result, i.e. a numerical value.

'I vet every CIFTER score, I will sit down with you and evaluate / discuss. So I am effectively normalise the score at the end of the day to give my consistency. It forces you to think about the things which you don't have experience. The more I get to make understand people about the consideration of the parameters, the more consistency I get. I am not going away from number for the number gives me very quickly an ability to visually assess and make a decision where particular project sits.' [sic]

'CIFTER is a good tool, it will give you an idea of interfaces you have it in different area, the size of the budget, how well the requirements are known. I use CIFTER analysis to help at the onset of the project to find just the areas that I need to consider, areas where the project seems to be more complex.' [sic]

The details of the practitioners' response on project complexity and its assessment has been presented in the above section. The summary and analysis of the above are presented in the next section.

7.4.4. Summary and Analysis –Project Complexity

The results discussed in this section are based on the responses that have been presented in the previous sections. The analysis is presented in terms of the comparison of the above responses with the theoretical perspective on the perception of complexity.

7.4.4.1 Comparison between theoretical and practical perspective

Theoretical perspective of a complex project or project complexity has been presented in detail in Chapter 2. However, for the ease of discussion the views of different authors on project complexity have been summarised Table 7-3 for a quick overview

As seen from the Table 7-3, researchers have tried to explain project complexity /complex projects using the simplest dictionary definition –*'consisting of many interconnected parts'* which is in terms of its physical elements and their *interdependencies*; *uncertainty,* whereas the others have tried to explain it using *complexity theory*.

However, looking at the pragmatic view i.e. the practitioners' responses, they only focus on these terms,

- Stakeholders,
- Interfaces,
- Interdependencies,
- Uncertainty,
- Novelty
- Technology

Authors	Project Complexity Characteristics	Related to
Turner and Cochrane (1993)	Uncertainty	Goals and Methods Matrix – Well defined, Well known
Baccarini (1996)	Interfaces, Interactions and Interdependencies	Organizational and Technological elements
Williams (1999)	Structural (Differentiation & Interdependencies) and Uncertainty	Organizational and Technological elements. Uncertainty related Goals and Methods Matrix
Geraldi and Adlbrecht (2007)	Interfaces, Interactions, Interdependencies & Novelty	People, product, process, and methods
Remington & Pollack, (2007)	Interfaces, Interactions, Novelty, Uncertainty, Ambiguity	People, product, process, and methods
Cooke-Davies et al. (2007)	Complexity Theory and Complex Responsive Process of Relating (CRPR); Interaction and relationships	Human interactions more in focus
Vidal and Marle (2008)	Size, variety, interdependence, context,	Organizational, Technological and Uncertainty
Maylor et al (2008)	Structural and Dynamic	MODeST dimensions
Cicmil et al (2009)	Complexity theory ; Interactions, Interdependencies and relationships	People and organizational, focusing on human relationships

Table 7-3: Theoretical Perspective on Project complexity

The comparison of the two perspectives, theoretical and practical, indicates a commonality and to some extent a convergence on the view of a complex project. Practitioners tend to highlight the underlying characteristics of project complexity relating them to the project elements - people, product and process. Whereas the academicians either try to link them to existing theories or in an effort to come up with a theory or are trying to show these characteristics under different headings categorising them as types of project complexities. However, whatever the approach and motive is, the underlying characteristics of project complexity remain the same for both the groups.

The main underlying characteristics which can be seen common and forms the basis of the two perspectives are,

- Interdependencies
- Interaction
- Uncertainty / Novelty

Relating the above characteristics to the complexity triangle, it can be seen that it is the interaction, interdependency and uncertainty related to people, process and product, both externally and internally to the project organization, which makes the project complex or give rise to project complexity.

Based on the analysis presented it can be stated that in complex projects, there are interdependencies and interactions in terms of people, product and process, however the differentiating factor (i.e. differentiator between complex and complicated projects) is the novelty element. It is the novelty associated with the relationships between people (stakeholders, suppliers, partners, i.e. human elements), novelty associated with technology and novelty associated with the methods and processes required to achieve the product. This aspect is shown in the Figure 7-3 below,

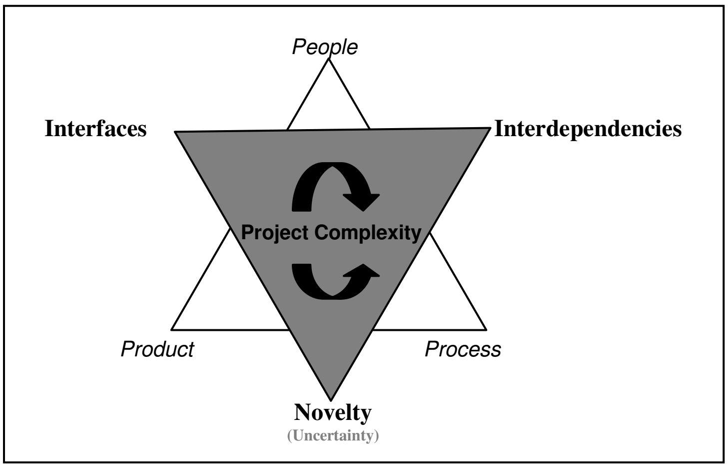

Figure 7-3 : Project Complexity Triangle (Modified)

Another interesting point that emerges out of this analysis is that none of the practitioners used the characteristics such as budget value, time, number of people etc to define a complex project, which at times are commonly perceived to be the defining characteristics of complex project.

7.4.4.2 Perception of complexity

As highlighted in the literature review, the perception of project complexity is idiosyncratic, that it is based on individual's perspective. In the light of this statement, Table 7-4 is expanded to show the respondents' age, work experience and number of projects actively involved in, in order to discuss this aspect.

Age	Job Title	Work Experience (years)	Number of Major Projects:	Underlying aspects in the perception of a Complex Project
41-50	Program Director	20	5	• Number of contradictory factors • Uncertainty • Novelty
41-50	Head of Commercial & Program Management	24	A lot	• Uncertainty • Novelty • Number of stakeholders • Number of interfaces and dependencies
41	Program Executive	24	3	• Novelty • Number of Stakeholders • Number of inter-relationship / interdependencies
38	Program Executive	17	12	• Number of variables • Number of interdependencies
41	Program Executive	19	5	• Novelty • Degree of Interdependencies • Concurrency
50+	Program Executive	32	10	• Unpredictable Stakeholders / Objectives • Uncertainty
42	Program Executive	22	10	• No Clue I haven't worried or spent anytime whether the program I am running, how I would categorise it.
52	Program Executive	30	A lot	• High level of interfaces • High level of stakeholder and their interaction
36	Program Manager	15	6	• Uncertainty of outcomes • Number & Relationship between stakeholders
36	Program Manager	5	3	• Number of people, customers (stakeholders)
45	Program Manager	29	4	• High degree of dependency and inter-relationship • Uncertainty • Novelty
30-40	Program Manager	17	4	• Wide ranging number of elements (mixed skills & disciplines)
34	Program Manager	13	6	• Number of stakeholders
46	Program Lead	20	5	• Number of stakeholders • Technical Complexity
37	Program Lead	14	3	• Number of partners • External interfaces • Technical interfaces
Under 30	Program Controller	2	6 project rotations	• Number of interfaces • Different people, location, cultures, functions

Table 7-4: Perception of complexity summary

Looking at the above table, it can be seen that there is negligible difference in the perception of characteristics of complexity among the respondents, which shows no variation of it with age and/or experience. One of the reasons for this observation could be that all the respondents are from the same industry and similar project environment, facing the same project actuality, which could be the reason for the commonality in the responses.

The next section focuses on the factors contributing to project complexity, which is an important aspect to be looked at, as it is imperative to find the cause and only then the effect can be managed.

7.5 Factors contributing to project complexity

This section focuses on the most important aspect of the interview questions, i.e. *factors contributing to project complexity*. The respondents were given a flexibility to choose a project of their choice they have worked in, either their current project or a past project, giving them a flexibility in choosing a project and thus giving the researcher an opportunity to explore and understand the logic behind their choices.

The factors that emerged from the practitioners' responses can be categorized as,

- Partnerships
- Novelty
- Project Organization
- Geographical Location / Multiple Sites
- Stakeholders (Internal & External)
- Requirement Capture
- Time Constraints / Duration
- Product System Level Issues
- Financial / Budget

These factors are graphically presented in the Figure 7-4 below, ranked according to the percentage response, as reported by the respondents,

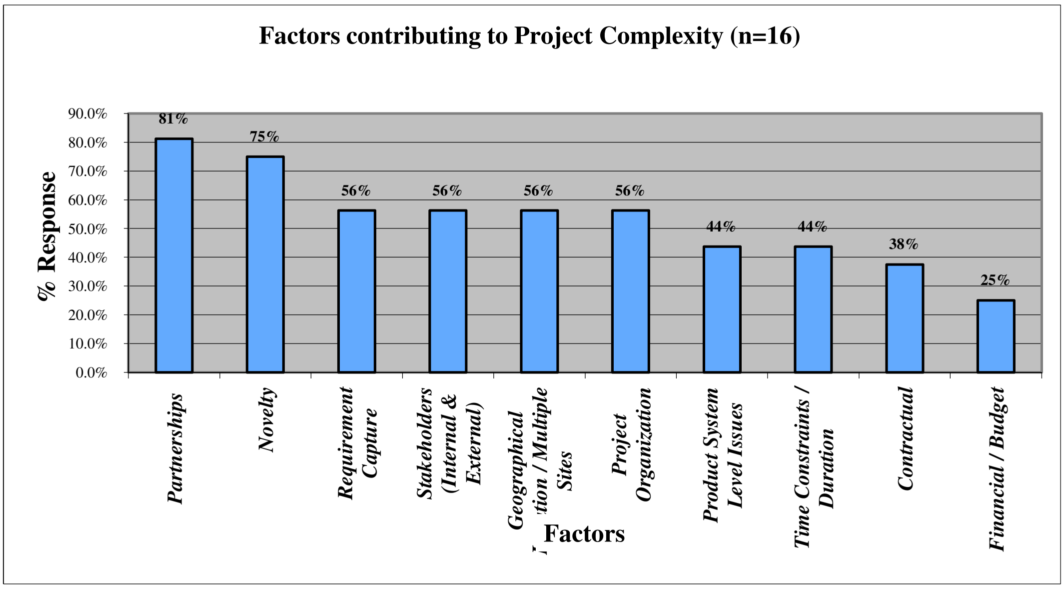

Figure 7-4 : Response on factors contributing to project complexity

The key factors highlighted above in Figure 7-4 are discussed in detail along with the supporting respondents' remarks to highlight the underlying aspects of these factors. These factors are discussed in the context of people, product and process.

Partnership

Partnership, between different companies, either national or multi-national, has been reported as the most significant factor. Partnership was reported by 81% of the respondents and in certain cases it was highlighted as the main factor. The overall project management process in a partnership is a big challenge and it adds to project complexity as there are many activities happening in different time and space and at times which are not in the direct control of project/program manager.

'I think it is the management process that makes the program complex, because you are trying to manage across 4 different partners across national boundaries, the product itself is not that complex, alright yes you have got different partners making different parts, its not a new technology. What makes it complex, in fact is when you got to integrate the four partner nations to produce a single product.' [sic]

However, the underlying attributes of partnerships reported by the respondents, which makes them complex are given below and are invariably associated with people, process and / or product.

In terms of people, the following aspects of partnerships were used in highlighting its effect on project complexity,

- √ Cross Cultural Issues
- √ Motivation
- √ Objectives
- √ Element of Trust
- √ Prior Experience
- √ Level of Agreement
- √ Hidden Agendas

Cross cultural issues was one of the main factors highlighted specially in the case of international partnerships. Issues included such as language problems and cultural differences in the case of multi-national ventures.

'There is the obvious cultural difference and also you have got language problems.' [sic]

'Because international partners, language differences, interpretation issues.' [sic]

Similarly, the mindsets and behaviours seemed to be influenced by the culture, which sometimes effects or hinders cross culture working.

'I think there are certainly cultural differences, partly driven by national European differences and driven by different mindsets.' [sic]

'Cultural aspect was very different; it made our job very different, it made out job very difficult. You could always tell the difference in locations.' [sic]

The other attributes that were highlighted in the partnerships were related to the motives, hidden agendas, trust between the partners and the prior relationships of the parties/people working in the partnerships.

'Different partners have not worked together, some not use to each other and some competitors. So I think the biggest challenge is working in a different way.' [sic]

'The most significant in my point of view, is the fact the motivations were different, looking at the 4 nations variably for some it was job creation, for others it was technology acquisition, develop local capability, with us it was repute.' [sic]

'They didn't trust each other, although the same company, they are different sectors or part of the companies that are at arms length. So what was good for one guy was not good for the other, they had bad experiences working together in the past, they don't have trust on one another.' [sic]

'Its trust at all levels, but trust that we are not exploiting each other for individual financial gains against the wider interest of JV program.' [sic]

The past working relationships between the companies were also reported to contribute to project complexity or in other words it was the novelty of the relationships, *'Different partners have not worked together before, now they are in a JV, some of the companies are not use to each other and some have been competitors.' [sic]*

'Partnership nature of the program is, it is performed with our bitter rivals.' [sic]

Although there is interaction of people in projects, however it becomes more complex in a partnership environment as oppose to that in a single organization, as in terms of 'processes', both management and technical, seems to affected by partnerships. The difference in processes across the partnerships, both management and technical, seems to affect complexity as reported by practitioners,

'Different partner companies trying to deliver the specifications given by multiple customers.' [sic]

'The understanding of processes is different, they have the same process but different emphasis. You think you are going the same way you are not.'[sic]

'There are different bunch of processes. We use a different bunch of process & criteria and complexity comes from trying to have an integrated sense across.'[sic]

'These different companies were operating in their company's own process set , so the things they were being driven by their process requirement didn't necessary align to each of the other partners are expecting.' [sic]

'Different reporting formats, in order to have conformity of format within the consortium which at times was different from our normal formats.' [sic]

'Different organization (internationally) had different processes and standards, which can be very important in engineering, we don't have tools that talk to each other very well, we can do design at one place and its not immediately transferred (different software etc).' [sic]

The other aspect highlighted in terms of partnership was related to the work share between the partners that is assigning work according to company's capabilities, expertise and profile. As highlighted by the following response, *'They formed this company in Spain and left everything to it, because it was such a small company they weren't capable of managing four big companies to deliver what they need to deliver.' [sic]*

In terms of 'product' in partnerships, issues related to design control and product interface were highlighted, which seemed to arise from the split of work between the different partner companies, either co-located or spread across the globe.

'As soon as you start splitting up manufacture all around the world that becomes more complex.' [sic]

'When you have other company as a designer, they have no reason to give you relaxation, so we have very difficult specification to meet.'

Analysing the above responses in this category, it can be seen that the underlying attributes of partnerships that give rise to project complexity were more related to people and process rather than the product. However, it does not mean that this implies to all partnerships or all partnerships are complex, but seems to be the case in the current context.

Novelty

Novelty was reported by 75% of the respondents as one of the factors giving rise to project complexity. Recalling the characteristics of a complex project, novelty was highlighted as one of its key characteristics. However, in this section novelty with reference to project complexity and in terms product, process and people shall be discussed. Although novelty is usually related to the product, however, the responses given below highlight that it is not necessarily the case.

In terms of product, the responses were related to uncertainty with the technology and methods to achieve the product, and/or simply the novelty or newness issues related to it.

'If you identify the root cause, it would be novelty that is causing the complexity. The novelty of the concept leads to the complexity of different elements with that project.' [sic]

'Design difficulty was significant but we were doing some things on this product that hasn't been done before, we were actually deploying new technologies, novel manufacturing approaches as well which were starting to add complexity.' [sic]

'Its technically complex nobody else could do that. Technology of this software and the integration of all this is causing it to be great demanding; both on internal & external IT.' [sic]

'The degree of novelty, technical aspects with the product, there are some technical things which have driven challenges & complexity.' [sic]

'Complex product from an engineering, technical stand point, cutting edge technology in terms of design. Certain things being done for the first time.' [sic]

Although the novelty related to product is the main attribute, however novelty in the following responses can be seen to be related to 'process' and 'people',

'We are writing specifications for things which have never been done before , we are writing specs and trying to use a few new technologies which have not been used before, thus making it unpredictable. The issue is a whole range of high risk technologies. Proven technology is much easier.' [sic]

'It is novel to the customer to do this, novel to the partners involved to work in this way of JV, its novel for the financial institutions to lend money to this sort of operation, because you have novelty at the higher level so that causes novelty of all sorts downstream. But nonetheless, I think the technical challenges are not sufficient on their own to deem the project complex. I think people often think of technology with novelty but there are other forms of novelty.' [sic]

In terms of the people, novelty in partnerships and relationships among companies and teams tends to make a project complex. Although it may be true for the initial phases, but down the line it all depends upon the relationships.

'Different partners have not worked before and now they are in JV, some of the companies are not used to each other and some of them are competitors to each other.' [sic]

'All my time is spent to manage the relationship between them, its relationship management.' [sic]

Novelty is one of the key characteristic of a complex project, which gives rise to uncertainty. As uncertainty has been highlighted as characteristic of a complex project, novelty seems to be the underlying cause. It can arise from and/or related to the three project elements i.e. product, process or people.

Requirement Capture/Product Specification

Requirement capture/product specification was reported by 56% of the respondents as one of the factors contributing to project complexity. It is one of the important aspects of a project, as lack of requirement capture and/or floating specification affect project complexity as it gives rise to uncertainty, ambiguity and lack of clear directions. The lack of requirement capture and floating specifications may be due to issues related to people, process or product.

In terms of process, it is highlighted by the following response,

'So for instance the huge problem that we have at the moment is the change process, and there are series of contract changes from many minor items to quite significant terms, none of these have not agreed, for the process through which it has to go to is very long and unique.' [sic]

In terms of product, it is highlighted by the following responses

'We kind of had the technical solution, but in addition we had the requirements coming in that weren't just about achieving that technical but we had to bring the weight & cost down, manufacture it much more quickly.'

'You are trying to build & design that no one has done before and the mode that no one has ever done before, so the requirements keep on changing as you are moving through sometimes in an unpredictable way.'

In terms of people, it is highlighted in terms of behaviours as

'The specs to date are not signed, 7 yrs into the program, but that's a customer behaviour, who are renowned for leaving contracts & specifications open so that they can change when they feel the need. Its type of complexity that was built in the start.' [sic]

Lack of requirement capture as highlighted above makes the project complex, which could be either due to the lack of information because of the product novelty, or due to lack of knowledge of methods / process to build it and / or due to the customer behaviour for keeping the specifications open or floating. Lack of requirement capture gives rise to uncertainty, lack of focus and clear direction, which then affects all the project elements throughout the project life cycle.

Stakeholders *(Internal & External)*

Stakeholders, by definition are those entities within or outside projects, which have an interest in the project, and are individuals and organizations that are actively involved in the project, which may also exert influence over the project's objectives and outcomes. As seen from the Figure 7-4, 56 % of the respondents reported stakeholders as one of the factors that made the project complex.

All projects have stakeholders, but the important aspect is to see the underlying characteristics within this category and to assess the way they can make a project complex. Complexities mainly seem to arise from the interactions and interdependencies, which are very much in the case of the stakeholders, and it is the outcome of these interactions and outcomes which makes affects project complexity.

The following responses indicate how complexity arises from this category and its effects on the project internally and externally,

'You have a continuous oversight of your customer, regular technical discussions, and exhaustive level of details. Very different drivers and behaviours drive different complexity.' [sic]

'Complexity is to do with stakeholders and executive level within the company. Agreeing and buying-in into this philosophy, this significant change and how we going to manage the business.' [sic]

'They were quite senior guys, there were other things happenings as well, which I was not aware of at that time, as it unfolded, some of the guys for instance who worked in Germany, very senior suddenly appeared literally next door, so half way through you could see there was obviously other wheels within.' [sic]

'I think there are issues because of the nature of the way you interact with people who build these on the shop floor. So there are lot of issues and instance around people and I still believe that the most of it is because of lack of communication.' [sic]

'If I dealt with one supplier it would be very easy simple.' [sic]

The most important aspect is complying and meeting stakeholder expectations and agendas, which at times either due to lack of communication and trust, or company politics or lack of interest of the stakeholders, is not managed properly thus giving rise to complexities.

Geographical Locations / Multiple Sites

Geographical location of the teams, either on a single site or multiple sites, was reported by 56% of the respondents as one of the factors contributing to project complexity. Project teams either dispersed in different locations within a company or dispersed across geographical boundaries in different time zones tends to affect project complexity. The attributes highlighted within this category are related to the management processes, mainly arising from communication issues, lack of control over the dispersed teams and the coherence between the teams. In terms of product, the split of work at different sites seems to lead to product system level integration issues.

The above is highlighted by the following responses,

'Complex reporting structure, because it is split over different sites.'

'Communication is always tough making sure that everyone is kind of working towards the same goal, specially when people are in different time zones, and you can't be there in person all the time.' [sic]

'Internally, there are many other sites who manufacture parts. They are not in your control, you don't go sit there daily, so you have to manage a degree of people uncertainty.' [sic]

'Data transfer between two geographical dispersed locations, sometimes to get it analysed in detail, get a go ahead etc certain decisions & analysis had to be done back home. That was difficult because obviously you got to get the data across to the right people, we were working quite a lot over the weekends, whereas the people in back home weren't working weekends.' [sic]

'Large number of people located at multiple sites. In terms of where I sit we have a complex reporting line, because it is a split over different sites, there are many who feel they are stakeholder or have say in how to run the program.' [sic]

As can be seen from the above responsive, the locations of teams have an impact on the project, as it will be discussed at the end of the chapter.

Project Organization

Project organization was reported by 56% of the respondents as a factor contributing to project complexity. Since all the respondents were working in a pure matrix organizational structure, it could be one of the reasons for reporting project organization as one of the factor.

'The structure within this business is pure Matrix. So there are some challenges in terms securing resources.' [sic]

'The nature of matrix organization is more complicated, don't have everybody sat here working for me.' [sic]

'Functional managers in some respect has an easier job, because in a matrix organization they have direct line accountability, they tend to deal with the group of people, but with the project manager, one is cutting across a lots different groups in a matrix, the skill of the PM is that you have talk in one language to the accountant and other to the engineer.' [sic]

Complexity arises due to the inherited weakness in the matrix structure, some of which are highlighted by the respondents, in terms of share or allocation of resources, work prioritization issues and degree of control.

'Engineers have their own priorities and management structure has their own.' [sic]

'The resource commitment process certainly offer come challenges. I have asked for 10 and they give 8, they have not met the commitment but the important thing is that the skill set of those people need to match the requirement role, thus leading to inefficiency.' [sic]
'I have to create a structure and work a lot more on the softer side, through influence in other business unit in order to achieve my objectives for those people have other priorities.' [sic]

At times for the senior management, the project may not appear to be complex; however it might not be the case for the project manager. As the lack of strategic importance and senior management focus, especially in a matrix structure, makes it more complex for the project manager, e.g. lack of availability of resources can be one of the reason, for resources are usually engaged on high visibility projects. As highlighted by this response,

'Availability of resource is also based on the level of priority the project has in the organization, so strategic importance is another factor.' [sic].

Project organization structure may not be a factor for all complex projects, but particularly in this case it has been highlighted by the respondents due to their experiences of working in a matrix structure organization, coupled with the nature of the product which involves multi-disciplinary technologies, with multiple inter-departmental interfaces and interdependencies. The same is the reason for the next factor reported by the respondents.

Product System Level Issues

As seen from the Figure 7-4, 44% of the respondents highlighted product system level issues, i.e. issues related to product sub-systems and their interface/integration, as one of the factors contributing to project complexity. As stated earlier this factor may be considered specific to this case, keeping in view the nature of aerospace products and the importance given to systems engineering. The underlying attributes related to system level issues mainly originate from the product but the interaction and interdependencies between processes and people makes it further complex. Multi-disciplinary complex product involves multiple departments and people working on it and in certain cases concurrency acts as an additional factor contributing to project complexity.

'Concurrency and inter-relatedness, I think concurrency is multiplying effect with the novelty.' [sic]

'The part of complexity is the concurrence of development & production.' [sic]

Interface and non-conformance issues crop up especially when sub-systems are manufactured by different partners/suppliers; this is also coupled with the poor interface/functional definitions issues.

'Interfaces are just notoriously difficult to agree between the kinds of partner companies.' [sic]

'It was kind of both there is a failure on the part of the technical team because it was certainly not the right first time design, there was a failure in terms of the interface definitions which actually meant when we had all the modules from the respective partners it didn't perform as it should have.' [sic]

'The complexity is more about the integration of the product, the way you have the boundaries between, so when the products get divided amongst the partners, complexity is how you interface.' [sic]

The other important aspect highlighted is the element of change; rather it is the impact of change i.e. the impact of change in one element of the system on the whole system, usually linked to product specification issues.

'There was always a difficult bit, when they change something over here and the impact of change on the whole system – that was a major issue.' [sic]

'A change here will have an impact there so its really complex set of interdependencies you trying to manage.' [sic]

As highlighted before that at a system level perspective there are issues such as change control, concurrency and interface definitions, and these issues multiply when there are lot of interdependencies and inter-relationship in terms of product, process and people thus creating a ripple effect.

Time Constraints / Duration

Issues related to time constraints and/or duration was reported by 44% of the respondents as shown in Figure 7-4. The underlying attributes in this case were more related to the duration of the project, for the reason that the majority of the respondents were affected more by the duration of the project rather than the time constraints. However, a few which were involved in a different nature of projects did report time constraints as a factor contributing to project complexity.

The issues highlighted were related to obsolescence, requirement changes and social/political impacts, which were either to do with the product, people and/or process.

'Specifications within the contract are quite clear but inevitably there are elements which need to be change driven by things like obsolescence due to supply going out of business keeping in view the nature and the duration of the contract (2035).' [sic]

'When the contract was first developed it was in the Cold War thinking mode, the World Environment has completely moved on, changing the need and requirements. Unpredictability in the changing environment drives complexity, complex set of relationships and changing environment evolving all the time. [sic]

However, there were issues highlighted which were related to the effect of time constraints on the project life cycles and also related to the customer's pressures regarding the project delivery.

'Design phase is characterise by iterative changes in design, adds to risk and complexity. Designing block 3 from very little experience of the 1st & 2nd iterations.' [sic]

'In my point of view the area of difficulty is the transition at the moment, everybody is focused on developing the product, so its trying to move a large body of people from the development to industrialization phase.' [sic]

‘The pace at which the program was carried out was very difficult, customer wanted to get this to market in a quite aggressive time scale.’ [sic]

‘What you need to understand is we are late, so it affects the behaviours and relationship, so it is very difficult to have a team ethos.’ [sic]

Project dynamics changes with time, depending on the project life cycle phase, the affect of time constraints vary in severity. Duration of the project has long term affects which may or may not be realised at the beginning of the project but may slowly creep up with the passage of time related to product as mentioned above. However the people aspect is not mentioned by the respondents, but in the long duration projects, continuity of the team members and stakeholders is an important consideration, i.e. the relationship element between the members.

Contractual

The issues related with contracts, either between the partners, customers, suppliers etc, has been reported by 38% of the respondents as one of the factors contributing to project complexity. Partnerships has been discussed as a separate factor, although they tend to have contractual agreements between them, the issues highlighted under that section were pertaining more related to the work execution, where as in this section it relates more to the terms and conditions, and factors influencing the contractual clauses, i.e. more on the legal issues with the contracts.

Keeping in view the contextual nature of the responses, Intellectual Property Rights (IPR) issues was one of the major attribute reported by the respondents.

‘Big issue is we are subcontractor to over competitors, very difficult, they are trying to manage us and we wont tell them anything because they are the major competitors, they want to know what to know how things work and you don’t want to tell them because that is intellectual property right.’ [sic]

‘From a product point of view we kind of walk the line, where we can share the data with the consortium lead, but not with one of the consortium partners, so kind of very careful to segregate our data in terms of what we can share....’ [sic]

'Partnership nature of the program is, its performed with our bitter rivals, that itself drives come unique factors and some unique complexity in this project.' [sic]

However, the other factors that were highlighted were more or less similar to the ones related to partnerships, but these factors were highlighted in order to stress the needs that they should be properly and carefully addressed in the contract clauses. Thus highlighting that these factors should be addressed and deliberated upon before the agreements are signed, as later on they can create issues and problems, thus affecting project complexity.

Financial / Budget

As can be seen from Figure 7-4, 25% of the respondents reported financial/budget related issues as one of the factors contributing to project complexity. The attributes highlighted by the respondents were either related to the availability of budget or the factors affecting it in general. The variability and unpredictability associated with availability of the budget or the uncertainty element effecting proper budget planning, were some of the issues highlighted by the respondents.

'Because its politically driven, whether money is available or not, or the focus is or not kind of changes quite frequently that makes it difficult.' [sic]

'You are trying to manage on financial budget constraints on unknowns; you are not sure what the outcome is going to be. When you have to certify your new product, you test it and you are likely to have issues coming up in the test that you haven't thought for. You have quality issues that unknown at that point.' [sic]

'…Variable and unpredictable amount of budget…' [sic]

At times the cost or monetary value of the project is taken as a factor to assess project complexity. However, based on the above responses, it can be seen that none of the respondents reported project cost as a complexity contributing factor rather the political and social, and availability / stability issues related to it were highlighted.

7.5.1. Summary and Discussion

In the previous sections factors contributing to project complexity have been reported. The factors reported were based on the respondents' experience on working in projects, which in their consideration were complex The factors highlighted shall be discussed in the light of the practitioner's age, experience and number of project and their types referring to Table 7-5. The discussion is also done in the light of the proposed complexity triangle, as factors have multiple dimensions in which they can contribute to project complexity, which has been summarised and shown in Table 7-6.

As it can be seen from Table 7-5, majority of the complexity factors for this particular case study were recognised by most of the respondents regardless of their work experience, number of projects and age. One of the reasons for this is that all of the respondents were working in a similar domain and on similar type of products, spread over different business units in the company. Looking at the most reported factors it is obvious from Table 7-5 that the factors have been recognised at all levels, however, based on the respondents' explanations it can be deduced that there is a difference in the underlying characteristics in perception and/or impact of these factors. Although the factors are the same but the way they impact is different e.g. at the project manager level it was more to do with the contractual issues and stakeholder management whereas at mid and lower level management level the same factor is more related with process and product, more to do the with issues related at the level where actual work being implemented.

It can be seen from Table 7-6 that the reported project complexity factors are linked to people, product and process groups. For example, novelty, it is not only related to product in terms of technology, but also to process in terms of methods and relationship in terms of people. So similarly the relationship of all the factors in terms of people, process and product can be seen from the table, which highlights the links of all the factors to these three project elements.

Interviewee	*1*	*2*	*3*	*12*	*15*	*13*	*8*	*5*	*4*	*6*	*9*	*10*	*14*	*11*	*7*	*16*
Designation	*PE*	*PE*	*PE*	*PE*	*PE*	*PE*	*PE*	*PE*	*PM*	*PM*	*PM*	*PM*	*PM*	*PL*	*PL*	*PC*
Work Experience	*32*	*22*	*24*	*20*	*24*	*24*	*19*	*17*	*13*	*13*	*5*	*29*	*17*	*14*	*20*	*2*
Number of Projects:	*10*	*10*	*3*	*5*	*A lot*	*A lot*	*5*	*12*	*6*	*6*	*3*	*4*	*4*	*3*	*5*	*6*
Age	*50+*	*42*	*41*	*41+*	*41+*	*52*	*41*	*38*	*36*	*34*	*36*	*45*	*30+*	*37*	*46*	*25+*
Partnerships / Consortiums	√	√	√	√			√	√	√	√	√	√	√	√	√	
Novelty	√	√	√			√	√	√	√	√		√		√	√	
Requirement Capture	√	√	√		√		√			√	√	√			√	
Stakeholders (Internal & External)		√			√	√	√	√	√		√	√		√		
Geographical Location / Multiple Sites		√		√	√					√	√	√	√	√	√	
Project Organization						√	√	√		√	√	√	√		√	√
System Level Issues	√	√	√				√	√			√					√
Time Constraints / Duration	√		√						√	√			√	√		√
Contractual	√		√				√		√	√					√	
Financial / Budget		√					√	√	√							

Table 7-5: Summary of response on factors contributing to project complexity

Factors	People	Process	Product
Partnerships **(13/16) 81%**	Motivation Objectives Element of Trust Prior Experience Level of Agreement Hidden Agendas Cultural Issues	Uniformity of Process Uniformity of Methodologies Work Share Company Profile Reporting formats Reporting Channels	Design Control Difference of Software; Tools & Techniques
Novelty **(12/16) 75%**	Relationship	Methods to achieve Tools & Techniques	Product Technology
Requirement Capture / Product Specification **(9/16) 56%**	Hidden Agendas Floating Specifications Frequency of Changes	Floating Specifications Frequency of Changes	Novelty of the product
Stakeholders (Internal & External) **(9/16) 56%**	Working Relationship Prior Experience Number Expectations Agendas	Communication	Novelty of the product
Geographical Location / Multiple Sites **(9/16) 56%**	Degree of Control	Communication System Level Integration Issues Work Prioritization Management Time Zones	System Level Integration Issues
Project Organization **(9/16) 56%**	Level of Expertise Number of Business Units Involved	Availability of resources Organizational Structure Team Size	Work Priority Strategic Importance
System Level Issues **(7/16) 44%**	Interdependencies on various functions in the organization / partnerships/suppliers	Concurrency Functional / Interface Definitions Change Control	Impact of changes Physical & Functional Interface issues
Time Constraints / Duration **(7/16) 44%**	Duration Socio / Political Issues	Duration Requirement Changes Project Phase	Time Pressures Obsolescence issues
Contractual **(6/16) 38%**	Share of Work Political Issues Government Drivers Type of Contract	IPR Issues Level of Control Financial Duration Legal Contract Change Accountability	Specifications
Financial / Budget **(4/16) 25%**	Political Drivers Stability of the Budget Availability of the budget	Stability of the Budget Availability of the budget	Novelty of the product

Table 7-6: Relationship of factors contributing to project complexity with People, Product & Process Groups

7.6 Key Project Management Practices

This section focuses on the key Project Management Processes reported by the practitioners based on their experience of working in and/or managing complex projects. The replies to this question were in continuation to the project discussed in the previous sections, i.e. to highlight the factors contributing to project complexity.

It is important to highlight here that the practitioners were asked to mention both hard and soft project management skills, with the objective to assess their importance separately. Based on the responses the key project management practises that were reported are as follows:

- Soft Skills
- Stakeholder Management
- Gated Reviews
- Scope Management
- Communication
- Requirements Management
- WBS
- Cost Management
- Change Control
- Procurement
- Planning
- Risk Management
- Organizational Structure
- Resource Management
- Conflict Management
- System Engineering

It can be seen that the key project management practices highlighted comprises of both hard and soft skills. However, soft skills have been shown here as a single entity as compared to the hard aspects which are mentioned individually. The reason for this is that soft skills were categorically mentioned by all the respondents as one of the key aspects, whereas for 'hard' project management skills, different processes were reported which have been listed in terms of their importance. Communication and stakeholder management has been discussed in soft project management practices, as their importance was highlighted more in this context. Figure 7-5 presents the percentage response for each project management aspect mentioned above.

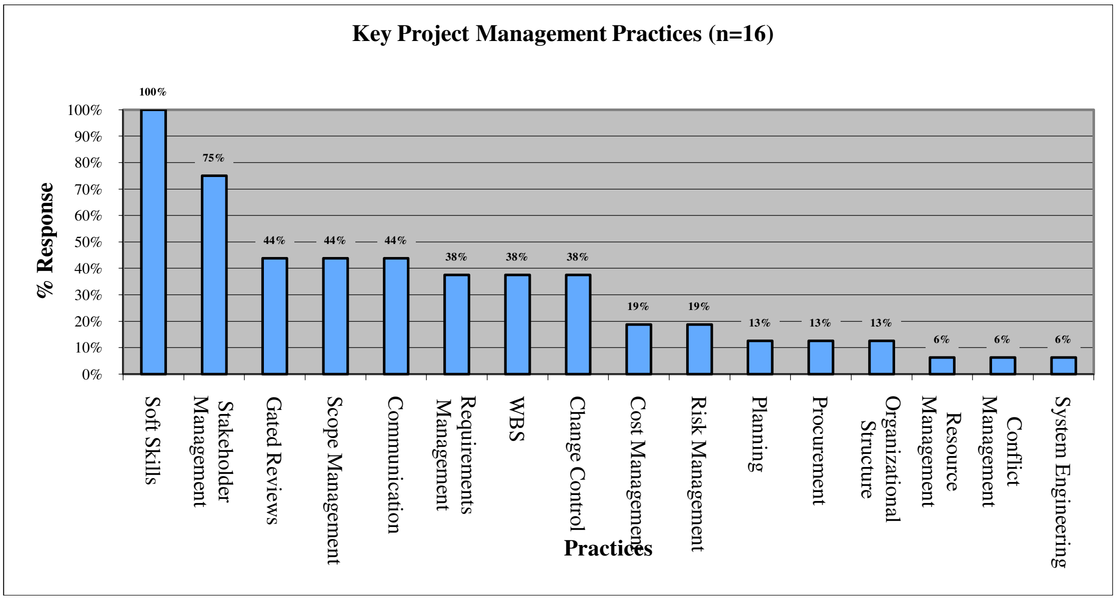

Figure 7-5 : Response on Key Project Management Processes

Key project management practices are discussed below, along with the respondents' remarks / statements, to highlight the importance.

7.6.1. Soft Project Management Skills

7.6.1.1 Soft Skills

As seen from Figure 7-5, all (100%) of the respondents reported soft skills as one the key project management practices, and this was based on their experience of working/managing complex projects. Invariably respondents did mention the hard aspects, but when it came to discussing the soft aspect, there was a definite positive shift in the tone and emphasis to highlight its importance.

'Mainly to be honest, mainly soft. Soft skills were the absolute key.' [sic]

'The key ones are soft really, working with the guys and getting them on board, its about getting them to realise that what we are doing and how it is helping them.' [sic]

The other aspects mentioned to elaborate on this category were related to the importance of leadership skills of project/program manager, because at the end of all the efforts it is all about managing and leading people to achieve the desired objectives and goals, particularly in the case when uncertainties prevail in the project.

‘It is more about the people side and having good leadership.’ [sic]

‘Overwhelmingly I would say because of floating uncertainty, therefore you can’t really set up processes so well for the things you don’t know, so its more about people side and having good leadership.’ [sic]

‘It is definite more important to have the leadership ability than its to have a technical background. It is a leadership role but you need to understand, you need to be able to make a balanced judgement.’ [sic]

‘It is the management style, I am not dictatorial manager, I am probably the softer side of leadership. I would sit and listen and we make a decision as a team.’ [sic]

‘Flexibility is a soft skill, I don’t contract it really.’ [sic]

Similarly, team building/team work was highlighted as an important aspect. In all projects and particularly in complex projects where there are lot uncertainties, the trust element in the team is important to overcome and face the ambiguity in a positive and receptive manner.

‘Certainly there are times on the program where you certainly have an unexpected event and you need to have the confidence of your team behind you and sometime you end up working all weekend, now you don’t do that without being able to influence and manage and you know support of the team.’ [sic]

‘It is getting people on your side, getting people on board with you and trust you’ [sic]

In general, the influence and relationship and getting the team onboard are all important aspects which the project / program manager have to build / develop upon to get things going on track. In this particular case, the respondents by virtue of their working in a matrix organizational setup realise the criticality of these aspects.

'Meet the people, understand big customers, understand what is required, go and meet the people in the hall, built up a bit of Trust, a bit of relationship, make sure I act in the way I expect others to act.' [sic]

'The feeling part of the team is the driver and its not only the guy who looks after the program, its all the engineers, its all the shop floor and its all the test guys. Big part of the team understands what the deliverables and understands more about you normally would, which gives the motivation.' [sic]

'…it was just the case of influencing that guy so he reallocates the resources, buts it personal relationship. So the relationship is probably the most important thing.' [sic]

'In my experience, individuals need to feel as they are being looked after from individual perspective and also part of the team, so the daily reviews, daily meetings, you know the sit down, have a cup of coffee is all about belong to the team.' [sic]

It can be seen from the above responses that practitioners realise the importance of soft skills. Since inter-relationship and interdependencies has been highlighted as the key aspects of a complex projects, so in terms of people in projects, to manage these people interactions and inter-dependencies, soft skills are one of key management skills required to ensure the smooth functioning of the project. The importance of soft skills is summarised by this remark given by a project executive,

'At the end of the day all you do is deal with people, you don't deal with technology directly. The technological challenge puts more uncertainty into the program, but people have to deal with that, so you can boil everything down to people management. Eventually it people who are doing it.' [sic]

Stakeholder Management

As seen from Figure 7-5, 75% of the respondents highlighted stakeholder management as one of the key project management practices in managing complex projects/programs. APM BoK defines stakeholder management as,

'Stakeholder management is the systematic identification, analysis and planning of actions to communicate with, negotiate with and influence stakeholders.

Stakeholders are all those who have an interest or role in the project or are impacted by the project.'

Looking at the above definition, soft skills and stakeholder management are interrelated, as one needs the soft skills to manage the process i.e. stakeholder management. The most important aspect is the identification of who the stakeholders are and their interest in the program and only then they can be managed effectively. The critical point is the realization of the importance of this process and it is reflected in respondents' response. The importance of this aspect was obvious at all level in this case study, the reason for this could the company's project management office effort in making its personnel aware of this aspect. As highlighted by the following responses,

'I think, this is not very original observation, but nonetheless it is true. There are tools and technique and processes, which help you manage the project against the iron triangle, and those are important but the very bit that is important is the stakeholder management and that is sort of above that.' [sic]

'Stakeholder management big time, Stakeholder management and relationships…' [sic]

'Stakeholder management for the multinational, knowing the customer, knowing what he wants.' [sic]

One of the important attribute that has been highlighted in regards to this process is the relationship between the stakeholders. Looking at the key attributes of complex project it is interrelationships and interdependencies, and so in projects in terms of people they are the most crucial and critical aspect.

'It is definitely relationship management internally and externally.' [sic]

'Certainly you have to work at the relationship much more than if you are trying to run the same project within more than one company. Relationships matter internally, but if the relationships are not working out you have ways to do it, things can be mandated, and things can required. You cannot mandate things in the partnership. You can take a heavy handed approach internally but not in a partnership.' [sic]

All of the above is summarised in the following statement by a respondent which actually reflects on the dynamics and reality of projects,

'You need the PM tools and techniques all the way through, but as you get into implementation, things start to happen and project shift around a bit and there is always some element of change, nothing ever goes on as you planned out originally, when you reach those difficulties, that's where the stakeholder management come into play.'

The following response summarises the importance of stakeholder management in the practitioners' point of view,

'When I came in PM years ago, it was very much PM Triangle, that was like the core of PM, but I think there is more and more recognition that stakeholder management is more and in fact you look at project / program managers to be successful its more important to have stakeholder management skills than the triangle.' [sic]

As highlighted from the above responses it can be seen the emphasis of stakeholder management is more on its criticality and managing relationships. Similar is the case with communication which is described below, the focus of the responses is more on its affects on the softer side rather on establishing or formalising communication channel or process.

Communication

As seen from Figure 7-5, 43.8% of the respondents highlighted communication as one of the key skill in terms of managing complex projects/programs. In relation to the first two reported practices i.e. soft skills and stakeholder management, communication is the key process and skill, required to effectively manage stakeholders to build trust, relationship and team cohesion.

Communication is one of the most important aspects required in any project to clarify, resolve any differences, built the relationships and to establish team spirit for successful implementation of projects. Especially in complex projects since it is the interrelation and interdependencies between people, communication is the key process, and communicating in an appropriate and timely way is the critical skill to manage such projects. As highlighted by this response,

'The biggest issue which I think stands out across the board is simple communication. Communication in my opinion is the biggest factor that will impact your project, absolute key is to get that right.' [sic]

The importance of communication has also been highlighted in conjunction with the stakeholder management internally and externally, as show below

'The clarity of communication and the clarity of goals, making sure that everybody understand at higher level and detailed level of what they need to do.' [sic]

'Investing the time in communication such that the individual parties are aware of and focused on the overall achievement of the program.' [sic]

'Communication is a big one, just talk to people understand their views, so being open, honest and listening, I think to me are major ones.' [sic]

'Open and frequent communication...' [sic]

In the context of project complexity, the above responses show the realization of the importance communication and its impact on the project outcomes.

7.6.1.2 Project Management Processes (Hard Skills)

The key project management practices highlighted in the Figure 7-5 above, are in the context of projects discussed by the respondents which they deemed were complex.

The following project management processes reported shall be discussed in this section,

- Gated Reviews
- Scope Management
- Requirements Management
- WBS
- Cost Management
- Change Control
- Procurement
- Planning
- Conflict Management
- Risk Management
- Organizational Structure
- System Engineering
- Resource Management

Gated Reviews

As seen from the Figure 7-5, 43.8% of the respondents reported gated reviews as one of the key project management process in managing complex projects. Project reviews are important for all the projects, but for projects which have lot of multiple interfaces in terms of people, product and process and are dependant on multiple technologies and processes, gated reviews are critical to manage and track the progress and observe any deviations. Gated reviews have to be timely, well planned and focused. As highlighted by the following responses,

'We use various gated process to control our technological inputs and determine the maturity of those, I think they have been particularly important.' [sic]

'You have to be in touch with development on an hourly or daily basis because the changes happen so quickly. Frequent reviews at all levels.' [sic]

Gated reviews are important both internally and externally to the project, internally to monitor the progress and externally to report the progress.

Scope Management

As seen from the Figure 7-5, 43.8% of the respondents reported scope management as one of the key project management process in managing complex projects. Scope management and gated reviews are interlinked The purpose of scope management is to give clarity of what is required to be done to achieve the project objective against the well defined objectives.

'Scope is really important and if you control your inputs you have a better chance of controlling your outputs.' [sic]

'Development programs are late & overspent are due to lack of focus on what is important.' [sic]

The important aspect of scope management is to maintain a focused approach towards the project objectives and provide a clear focus to the team for the execution of the project. As highlighted by the following responses,

'Internally we had again a need of a clear focus, clear objective setting within the team, so we had to change the mindset , give people clear objective and get them deliver. Once you get people to understand what they got to do and do it, you start to see the project moving and people start to see the light.' [sic]

'The way I deal with the development which is specifically different to most of other projects I get involved in, is we take a different approach in terms of what I call is 'focus'.' [sic]

Requirements Management

As seen from the Figure 7-5, 37.5% of the respondents reported requirements management as one of the key project management process in managing complex projects. Looking at scope management which has been reported as an important process, requirement capture is an input to it, therefore it is the initial and most important step defining the course of work to follow. It is crucial to have the requirements documented at an early stage so that better project planning is done avoiding any major changes on down the course of project. The following responses highlight the importance of requirements management.

'You need well defined and tight processes and in retrospect more work should have done on establishing these processes before we enter into the contract or earlier in the contract.' [sic]

'Detailed specification and flow down to all parties.' [sic]

'Clarity of goals, making sure that everybody understands at all levels of what they need to do.' [sic]

The importance of requirements management in managing complex projects is underlined by the above responses, for the lack of requirement capture leads into issues which may have a multiplying affect on the factors affecting project complexity.

Work Breakdown Structures

Work Breakdown Structures has been reported by 37.5% of the respondent as an important tool/process in managing complex projects in Figure 7-5. It is interlinked with the requirement and scope management, because based on these documents, a detailed WBS can be made, which gives the details of project discrete tasks and helps in organizing and assigning resources to it. It gives a detailed picture of the work to be carried out at all levels, with the identification of resources required to manage and implement these tasks. The following remarks of the respondents support the above,

'Making sure that everybody understands at the high level and detailed level of what they need to do. One of the way to do that is WBS, so there is budget, accountability, deliverables associated with each element of it. The key thing is each amount of budget has a set deliverable.' [sic]

'Having a detailed plan of exactly how you going to do…WBS, OBS.' [sic]

'You have an extremely well defined WBS with very, very clear accountability statements.' [sic]

WBS is probably one of the most valuable tools, which in conjunction with the project scope and requirements forms a baseline in identifying tasks at all levels in the project/program, and on the basis of which resource planning and allocation encompassing all the other core project management aspects.

Change Control

Change control/management has been highlighted by 37.5 % of the respondents as a key project management process in managing complex projects. Keeping in view the importance reported for scope management and gated reviews, change control is one of the important functions of gated reviews and to ensure that the changes are done in according to a coordinated and controlled manner, and also decisions for these changes are made keeping in view the scope of the project. Changes are inevitable in a project, but the impact of these changes specially in a complex project have a ripple effect, which is one of the reason it has been highlighted as an important process. The following responses on this process are as follows,

'Change control is absolutely essential, we have multiple levels of change control, so there is a whole tier of change control.'

'I think the other thing we put in was more rigid change management….' [sic]

'Change Management, controlling change management and understanding consequences of changes.' [sic]

'Changing specifications are well controlled, it is a very rigorous and professional project framework, changes are made obviously but they are done in a very controlled manner.' [sic]

Keeping in view the dynamic nature of the projects and their environments, change control coupled with scope management, gated reviews, requirements management and work breakdown structures have been reported as the key processes by majority of the practitioners. This aspect will be discussed in detail in the summary section to highlight it importance in the context of complexity factors.

Cost Management

Cost management has been highlighted by 18.8 % of the respondents as a key project management process in managing complex projects. This process was very much subjective and related to the context, as the individuals which reported cost management were either facing financial problems due to lack of proper planning of the project, whereas the others reported in the context of project cost reductions.

'There is a cost management process that we are trying to adopt, I think if you adopt that it actually does a lot of things for you.' [sic]

'Also one of the big issues was spiralling cost, so we put in the cost management structure.' [sic]

The importance of this process was highlighted by the respondents due to the reason that the complexity in their project was affected either by increased cost, or in the other case managing a cost reduction exercise meant interacting with different people to come to an agreed optimised cost, which required a robust cost management process.

Risk Management

Risk Management has been highlighted by 18.8 % of the respondents as a key project management process in managing complex projects. However, like the other processes which were discretely mentioned by the practitioners, risk management was not highlighted by all and only a few mentioned its importance in the context of complexity. As it can be seen by the responses below that it is being mentioned as part of a routine management process without highlighting or discussing it in the context of managing project complexity.

'So there is much more use of PM tools, you have daily meetings, you have well defined WBS……….you have a very robust risk plan on which you weekly or monthly reviews, because that is the way you manage your variability. [sic]

'...and top of that you need budget, schedule management system which we would say is the EVM, you need risk management to proactively manages...' [sic]

Planning

Planning has been highlighted by 12.5 % of the respondents as a key project management process in managing complex projects, as shown in Figure 7-5. Although planning is considered to be an important aspect for all projects, however it has been only mentioned by few respondents that to into the context of adherence to project plan. It can be assumed that the projects discussed were well planned and also that the focus of the interview was on the factors that contribute to project complexity and key management processes to manage them. The aspect of monitoring of plan to manage and reduce deviations and monitor progress has been highlighted in the gated review section.

'Compliance, I mean broad sense compliance with existing processes and adherence to plans and milestones.' [sic]

Procurement

Procurement was reported by 12.5 % of respondents as one of the key project management process. Procurement management becomes critical when there are multiple suppliers working on a project. The issues reported are related to timely deliveries and also to the conformity of the parts delivered.

'When you have a supplier who he has got a lot of issues, so he slows down in term of delivery for he is concerned he is not being paid appropriately, so you have to close these issues for if you supplier is not happy you want deliver in time.' [sic]

'Kind of managing the supply base and production readiness is key factor.' [sic]

However, particular to this case study the critical aspect related to procurement was the contractual issue with the suppliers which in turn affect the timely deliveries.

Organizational Structure

Organizational structure in particular was reported by 12.5% of the respondents, as can be seen in Figure 7-5. There are many issues which arise due to the organizational structure, in this case a matrix organizational structure, and issues like influence and relationship, availability of resources, degree of control etc have been reported. Organizational structure mentioned by the respondents in this case was mainly in the context of prioritizing work.

'Internal IT supplier of the key data, who's got an external IT software supplier, is the key element of this whole capacity. That itself is complex in the sense that we don't own them, they have got their own project plans.' [sic]

'Engineers have their own priorities and management structures have their own.' [sic]

The issues reported above are the inherent problems related to the matrix organizational structure.

Resource Management, Conflict Management & System Engineering

Resource Management, Conflict Management & Systems Engineering was reported by 6.3% of the respondents as a key management processes. However these factors have been mentioned only by individuals who reported these factors in the context of projects they were working in.

The factors listed above were reported by practitioners at different project levels. The next section shall highlight relationship of perception of these factors in conjunction with project complexity.

7.6.3. Summary and Conclusion

One aspect that is prominent from Table 7-7, is the recognition of soft skills all the respondents regardless of the work experience, age, designation and management level. Looking at the actuality of projects i.e. the dealing with people in them, all the respondents realise the criticality of soft skills in managing and working in projects. Similarly, the next process mentioned in the order of importance is stakeholder management which is again in relation to people. Stakeholder management is also important, as most of the respondents in defining project success relate it to '*happy stakeholders'*, so in order to achieve this criteria it does need special attention.

Looking at the other factors (hard skills) presented in Figure 7-6, it can be seen that list of factors that have been reported by majority of the respondents (40% and above), include gated reviews, scope management, requirement management, work breakdown structures and change control. All the experienced respondents, who have worked in number of projects, recognise the importance of these factors, as these factors are also very much important in managing variations / changes. It is the variation in plans, processes and relationships which contribute to project complexity, bringing uncertainties and ambiguities.

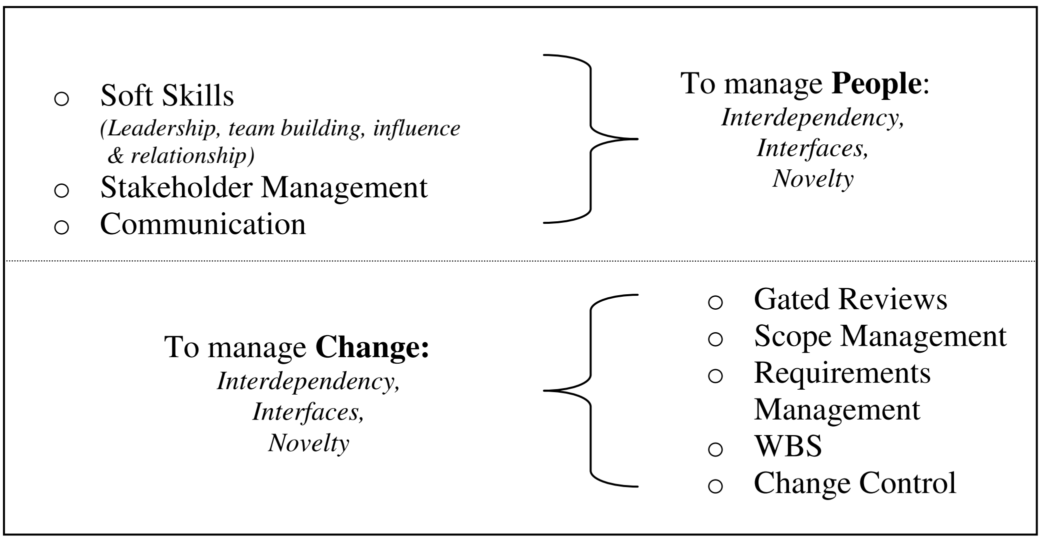

Figure 7-6 : Key Process and Project Complexity Relationship

Figure 7-6 above highlights the relationship of key project management processes and their relationship with project complexity. Analysing the responses given by the respondents it can be seen that the key processes highlighted focus on the management of two important aspects i.e. managing people and managing project dynamics. Soft skills, stakeholder management and communication are all very important skills to manage people and their inter-relations, interdependencies and uncertainties, and also to enhance the team-spirit and the team bonding to achieve the desired results. This is critical especially in the case of NPD projects, and the same has been reported as most of the respondents were involved or had discussed this type of project.

The other important aspect highlighted is managing change, rather trying to effectively manage key processes that minimise the element of change, i.e. in terms of the work required to be done to achieve the end product/services. This is not only about the process change control, but it is also about ensuring that all the elements which can influence deviations in project's plan and specifications are managed effectively to minimise its effects.

Looking at the key processes mentioned in Table 7-7 and Figure 7-6, it is important to highlight that these are not the only key processes in the overall execution of the project, but are critical in the light of managing project complexity. All the other processes, which have not been mentioned, are also important in each phase of the project life cycle, and if these processes are not managed properly shall affect the project working.

However, the key project management processes mentioned are based on this particular case study, specifically for complex new product development projects, however the focus of these key process are on two project aspects, people and project dynamics, which are common to all the projects. So in a sense these are invariably applicable to all the projects but their criticality varies with the degree of interdependencies, interfaces and uncertainties in the project.

Interviewees	1	2	3	5	8	12	13	15	4	6	9	10	14	7	11	16
Designation	**PE**	**PE**	**PE**	**PE**	**PE**	**PE**	**PE**	**PE**	**PM**	**PM**	**PM**	**PM**	**PM**	**PL**	**PL**	**PC**
Project Type Discussed	**NPD**	**NPD**	**NPD**	**P&D**	**NPD**	**Reloc**	**New S**	**CB**	**NPD**	**NPD**	**P&D**	**P&D**	**Qual**	**NPD**	**NPD**	**NPD**
Work Experience	32	22	24	17	19	20	24	24	13	13	5	29	17	20	14	2
Number of Projects:	10	10	3	12	5	5	A lot	A lot	6	6	3	4	4	5	3	6
Age	50+	42	41	38	41	41+	52	41+	36	34	36	45	30+	46	37	25+
Soft Skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Stakeholder Management	√	√	√	√	√		√	√	√	√	√		√	√		
Gated Reviews				√	√		√	√				√	√		√	
Scope Management	√	√		√	√		√	√	√							
Communication		√		√	√						√		√	√	√	
Requirement Capture	√	√		√					√	√						√
WBS	√		√	√	√				√	√						
Change Control		√	√	√	√				√	√						
Cost Management			√									√			√	
Risk Management		√		√								√				
Planning													√			√
Procurement			√							√						
Organizational Structure							√									√
Conflict Management												√				
Resource Management							√									
System Engineering		√														

Table 7-7: Summary of response on key project management processes

7.7 Project Critical Success Factors

This section focuses on the project Critical Success Factors (CSF) reported by the practitioners based on their experience of working in and/or managing complex projects. The replies to this question were based on the context of project discussed earlier.

The practitioners were asked to reflect back on the complex project discussed and highlight based on their experience the critical success factors for that project. They were asked to focus on the areas other than the key project management processes, and report the key skills/characteristics required for the successful outcome of the project. It was like the 'trump cards' or the differentiators, other than the key management processes, which were deemed important for the successful outcome of the project.

Project critical success factors (CSF) reported by the practitioners in the light of complex projects are as follows,

- Clear Objectives
- Influence & Relationship
- Senior Management Support
- Trust
- Team Cohesion / Motivation
- Flexibility
- Leadership
- Delegation
- Team Location
- Communication

Figure 7-7, shows the graphical view of the responses on the factors reported.

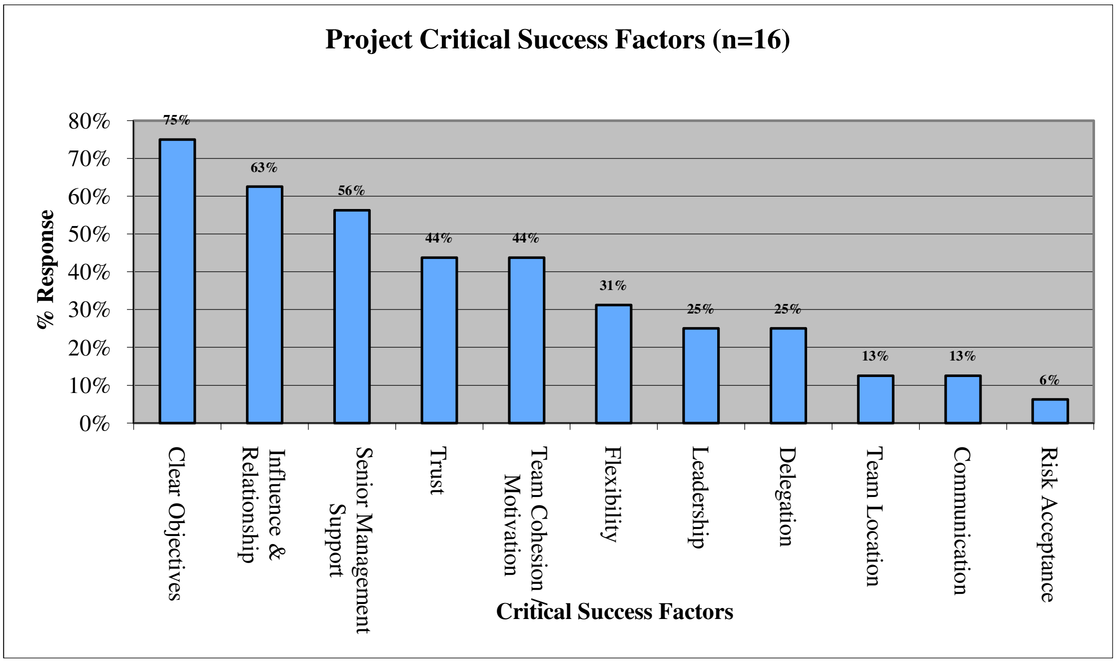

Figure 7-7 : Response on Project Critical Success Factors

Project critical success factors are discussed below, along with the respondents' remarks / statements, to highlight their importance.

Clear Objectives

As can be seen from Figure 7-7, 75% of the respondents highlighted *'clear objectives'*, as the most important critical success factor based on their experience of managing/working in a complex project. Having clear objectives and direction is an important project management aspect as it reduces ambiguities, provides clarity of responsibilities and gives a clear sense of direction as to what the objectives are.

'Provide clear and open direction to the team.' [sic]

'To present clear vision and focus, and have true objective for the team so they know where they are going, they know what they are doing, they can see what they are doing and contribute to the vision.' [sic]

Looking at the project complexity factors and key project management processes, requirement capture and scope management, have been highlighted as one of the key factors respectively. Providing clear objectives is more than just writing down specifications or assigning tasks and responsibilities. It is the achievement of these objectives which require both soft and hard skills, to manage and steer the team in the right direction. Clear objectives not only help to minimise uncertainty in a project but also it facilitates to clarify roles and responsibilities, especially when there are lots of interdependencies and interfaces in the project. As can be seen from the following responses,

'I think clear understanding of what the goal is, not only the understanding, but communicating to everyone involved.' [sic]

'Clear requirement, essential to do the planning.' [sic]

Influence and Relationships

As seen from Figure 7-7, 62.5% of the respondents highlighted influence and relationship, i.e. that is the influence and relationship between the project external and internal team members, as one of the key project success factors. Respondents invariably talked about relationships within the project internal and external teams. The focus of the previous views on complex project, factors contributing to project complexity and key project management processes, were related to the people aspect. Analysing project complexity due to stakeholders, their interfaces and interdependencies, it can be seen that it requires more soft skills to manage and in order to effectively implement the processes and plans. The key is the influence and relationship of the project manager and team to the external and internal interfaces to the project.

'Informal Relationship matters a lot…' [sic]

'All of my time is spent to manage relationship between partners.' [sic]

'Its influencing, its building a relationship with the individual you need to work with and influencing by communicating in a right way.' [sic]
'I do make emphasis to talk and talk on regular basis with your customer etc, it very easy to send emails or put words in a report. The relationship matters.'

'I do make emphasis to talk, talk on a regular basis with your customer, your board, your sponsor, its very easy to send emails or put words to the report and send it and you have done your job, I have learnt over the years its important to have that one to one relationship.'

The other reason for the respondents for highlighting this factor is the matrix organizational structure they are working in, and in order to secure the resources and/or to prioritise work, the influence and relationship plays a critical role when dealing with people.

'Here is my requirement, sit down analyse it, end of the day the answer is I get the resource, obviously there is bigger picture to be considered in this instance, its just the case of influencing that guy so he allocates the resource, but its personal relationship also, so the relationship is probably the most important thing.'[sic]

'Its very much influencing in functional side, its very critical to understand the matrix how it works.'

'Who you know is important…' [sic]

Projects are considered as a social set up and keeping in view the complexities arising from the interactions and interdependencies between people, the 'influence and relationship' is one of the key success factor, as it is people who are working in projects and specially in matrix structure *'who you know'* matters in the project actuality.

Senior Management Support

Senior management support has been highlighted by 56.3% of the respondents as one of the key project critical success factor. Senior management support becomes important in the case of a matrix organization as it helps in prioritising work in the supporting departments, for the supporting departments are working on multiple projects, the work usually gets prioritised according to the strategic importance or by the focus of senior management. Senior management supports becomes critical in the case when the project is not progressing according to the plan, and in that case the support, push and motivation provided by the senior management plays a vital role.

'Well there was a lot of senior management focus, we were suddenly put in the limelight, you were in a very, very visible environment in terms of the seniors, so you got a lot of high powered help.' [sic]

'Senior management support is good as far as you can get the priority on the job.' [sic]

'So you define the business case and then you effectively present that to the seniors, so that they can determine the priority of your product.'

Most of the respondents just simply summarised the importance of this aspect by simply saying,

'Senior management support absolutely!' [sic]

'Having very strong support from the senior management.' [sic]

Trust

As seen from Figure 7-7, 43.8% of the respondents highlighted trust as one of the project critical success factors. Since project complexity, is based on interdependencies and interfaces especially between people, and keeping in mind the reported importance of influence and relationship, trust is an important aspect to exercise influence and to build the relationship. In this particular case, the matrix organizational structure entails trust between functional groups and project teams to build the relationship. This is not only true within the organization, but it is an important aspect within the team and the program manager to build up the team cohesion and for the program manager to keep the team motivated in view of the uncertainties in projects. In the case of partnerships, it acts as one of the key parameters in maintaining successful and long term partnerships.

'Meet the people in the hall, built a bit of trust, a bit of relationship and make sure I act in the way I expect other people to act.' [sic]

'The most important element would be trust, I think with the nature of this kind of program with different parties you have normally not worked together, but who are joined together through a contract.' [sic]

'I think its very important if people believe in the success of the program, trust and empathise with the leader, then I think that will move us forward.' [sic]

In a project environment, trust between the stakeholders and project team is an important element which is essential aspect in having a strong and long lasting working relationship.

Team Cohesion / Motivation

Team cohesion was reported by 43.8% respondents as one of the project critical success factor, and in some cases it was in conjunction with team motivation as these two aspects are very important in team building. Keeping in the view the nature and dynamics of complex projects, team cohesion and motivation acts as crucial element to keep the team united especially when ambiguity and uncertainty prevails in a project.

'The feeling part of the team is the driver and its just not only the guys who look after the program, its all the engineers, its all shop floor, it is the test guys, big part of the team understand what the deliverables are and understand more about that you normally would, which gives the motivation.' [sic]

'Does all of the team buy in to these goals, do the feel the ownership of these goals, are they walking around feeling happy to be part of the team.' [sic]

'One of the key things is around collaborative working, so those sort of team working, flexibility, delegation and taking their responsibilities, its just not your job sort of a thing, its working together as a team and the team drive.' [sic]

The other reason for the respondents highlighting this factor could be that the majority of them are involved with NPD projects, which by the very nature of the project demands a high level of team cohesion and motivation.

'In the development, I guess more important is the need to form the team mentality.' [sic]

'All about belonging to a team, teaming aspect is important. In the development program there are lots of pressures, and feeling part of the program, and the same feeling at levels of the people involved.' [sic]

The importance of team cohesion, motivation, trust and relationships is summarised in the following response,

'In my mind, it goes back to building a team relationship, I think its honesty, clear objective, getting guys involved and making them feel involved and respected.' [sic]

Flexibility

Flexibility was reported by 31.3 % of the respondents, as one of the key success factors. The respondents reported this factor based on their experience of working NPD projects. However, in projects in which complexity arises from ambiguity and uncertainty, flexibility in management processes and procedures helps to adapt to the situation in order to make appropriate managerial decisions In NPD projects, the key is to give freedom and flexibility to the team, which promotes ownership, sense of belonging and motivation in the team, which allows to explore their full potential in the right direction.

'If there is one thing it is the flexibility of management team to deal with unpredictability.' [sic]

'All we have done we have very much pushed self directed teams, so its kind of pushing down accountability.'[sic]

'Flexibility in NPD teams specially.' [sic]

Production type of projects are more process driven, as there is clarity to what is required to be done for the final product, so adherence to processes is more important to ensure timely deliveries, whereas in NPD projects flexibility in processes and schedules at times are expectable to over come uncertainties arising from novelty, unknown methods, tools and techniques etc.

Delegation

Delegation was reported by 25% of the respondents as one of the project critical success factor. These respondents who reported this factor were at the senior level, and realise the importance of delegation, especially in complex project, where there are multiple interfacing, interdependencies and concurrent work going on at various project levels internally and externally, thus making it very difficult for one person to keep track of all the work. So by delegating work, is not only effective management, but it also builds the trust and confidence in sub-ordinates, by giving them responsibility and making them feel confident and elevated.

'Delegation is an absolute key, people call it off-loading, its not, you have all the accountability for your account, I am not going to get involved unless its going wrong for which I am going to come and help you manage that, but I expect you to know what you managing. You run your project, you own it.' [sic]

'You have to delegate to immediate tier, and then its delegation from them out to functions, and its that when you delegate to functions you can't just leave them.' [sic]

'I am all for delegating, delegating is easy but delegating effectively is difficult, passing the word down to someone else and having the confidence to let go and seeing how it going to turn out that is difficult. If you are prepared to delegate you have to live with the consequence.' [sic]

Project executives delegating work need to have the confidence of/in the team and should have a risk appetite too, as they should be prepared to take the responsibility and support the team in case of unfavourable results.

Leadership

Leadership was reported by 25% of the respondents as a project critical success factor. In this particular case, respondents were involved in complex new product development (NPD) projects, which demand visionary style of leadership, creating a trustful, cohesive and flexible working environment for the team and the ability to take timely calculated risks and decisions in order to gain confidence and respect of the team, specially when there is uncertainty prevailing in the project. As highlighted by the following remarks,

'I think you need a very visionary kind of leadership, for somebody needs to go beyond the project management processes and day to day management. I think its very important for people to believe in the success of the program, trust and empathise with the leader.' [sic]

'Single biggest is timely resolution of issues, we as business preferred to prevaricate, that itself builds complexity.' [sic]

'Cooperative when required and at time authoritative…. In development particularly, you need to have a much defined set of leadership skills which focus mainly on results driven.' [sic]

Team Location

It could be a project/case specific parameter; however 12.5% of the respondents reported team location as critical success factors. In their experience there were issues related to the location of the project team, as in multinational and multidisciplinary projects teams are usually at different locations which makes it difficult in building team cohesion and team spirit, and also makes the management process less efficient and effective, as compared to the collocated teams.

'We didn't sit together we were sort of disbanded team, first thing we did was we brought all together, we had regular communication, generated the feeling we are team and we are here to help each other.' [sic]

'You have got a lot of people in the program and they all sat together in the same project, its easier I would say for the program manager to coordinate your team.' [sic]

Communication

Communication has also been highlighted in the key project management process section; however, 12.5% of the respondents highlighted it again as a key success factor. No doubt communication is an important aspect of any project, but in multi-located, multi-disciplinary projects communication is essential as it has a critical impact on the overall project. Communication highlighted as a key process earlier focuses more on the aspects such as communication format and channels. In this section it relates to communicating to the teams formally and informally, to maintain the team spirit and cohesion, to inquire in general about the team, thus building a sense of belonging and trying to resolve their problems, and getting work update by Management by Walking Around (MBWA). Communication at levels, is a key to project success, as summarised in the following response,

'Generic critical success factor is communication. I am a strong believer that 90% of issue that have on any project that we have ever run is due to communication or lack of communication.' [sic]

Risk Acceptance

As can bee seen from Figure 7-7, 6.3% of the respondents highlighted risk acceptance as a critical success factor. This aspect was highlighted by a senior manager in the context of delegation and flexibility, and was referring to the risk appetite, as mentioned earlier in delegation section.

'You should be able to manage your risk and take acceptance for risk.. Something we are not good at in the company. Manage your risk but be prepared to take an acceptable level of risk.' [sic]

In this section the responses on various factors have been reported, in the next section a summary along with the discussion on these responses is presented.

7.7.1 Summary and Discussion

Project critical success factors have been presented by many researchers in the past based on a specific industry and/or based on a result of large survey across different industries, but the focus of these studies were to come up with a list of factors generally considered critical for project success. However, in this research the purpose of this question as mentioned earlier was to get an overview of project critical success in the context of complex projects, although it can be said that the previous studies invariably included projects which might have been complex, but in this study respondents were asked to highlight the critical success factors specifically in the context and light of project complexity.

Referring to Table 7-8 below, it can be seen that the factors reported are recognised by respondents at various levels. The perception of these factors seems to have no influence of respondents' work experience, age and number of projects. However, there seems to be an influence of project context and project type on the perception of these critical success factors. Looking at the factors in the context of project complexity, apparently most of these were related to the '*people'* side of the project, whereas, 'clear objectives' was the only process related factor highlighted. Keeping in view interdependencies, interfaces and inter-relationships in complex projects, in terms of people, factors like influence and relationships, trust, team cohesion/ motivation had been highlighted, and seemed to be relevant, as these factors are supportive in managing complexity arising from the people's side. Similarly senior management support is important as highlighted earlier, as in the case of a matrix organizational structure, it plays an important role in securing resources or prioritizing work linked to project strategic importance.

Comparison of the critical success factors listed in Table 7-8 with the list compiled by Fortune and White (2006) which includes critical success factors cited from 63 publications, it can be seen that there are a few factors which are specific to this study and have not been reported in reference publication. The factors shown below and not underlined are the ones found specific to this study,

- Clear Objectives*
- Influence and Relationship
- Senior Management Support*
- Trust
- Team Cohesion / Motivation*
- Flexibility
- Leadership*
- Delegation
- Team Location
- Communication*

(* *Fortune and White(2006)*)

Although all of the factors listed above are critical in complex projects and have been reported by the respondents, however the ones specific to this study seems to have linkage with project complexity. Looking at influence and relationship, and trust, these are critical aspects among the stakeholders in partnerships and otherwise, as when there are lot of internal and external interdependencies and interrelationships between partners, suppliers, teams, departments etc, these factors help to prioritise and manage work and also are critical in order to minimise any ambiguities.

The other factors, flexibility and delegation, are significant to complex projects, especially to the ones which involves multiple organizational functions internally and externally, as in partnerships, then delegation is a key aspect to successfully manage. Flexibility, in terms of specifications and time constraints, is another aspect related more NPD project, which provides environment for the project teams to work freely and independently without any pressures making the best use of their potential.

Team location, is important in two ways, firstly if the team is dispersed and is not co-located, this at times leads to lack of team cohesion may be arising from lack of communication, whereas on the other hand if there are multiple teams which are located at multiple sites at different geographical locations, it adds to managerial complexity, making the management process difficult, thus contributing to project complexity, specially when there lots of interdependencies and interrelationships within the project elements.

The respondents based on their experience have highlighted the CSF as these respondents were aware of the criticality of these factors and their relation to project actuality.

Interviewee	1	2	3	5	8	12	13	15	4	6	9	10	14	11	7	16
Designation	PE	PE	PE	PE	PE	PE	PE	PE	PM	PM	PM	PM	PM	PL	PL	PC
Project Type Discussed	NPD	NPD	NPD	P&D	NPD	Reloc	NewS	CB	NPD	NPD	P&D	P&D	Qual	NPD	NPD	NPD
Work Experience	32	22	24	17	19	20	24	24	13	13	5	29	17	14	20	2
Number of Projects:	10	10	3	12	5	5	A lot	A lot	6	6	3	4	4	3	5	6
Age	50+	42	41	38	41	41+	52	41+	36	34	36	45	30+	37	46	25+
Clear Objectives			√	√	√	√	√			√	√	√	√	√	√	√
Influence & Relationship	√	√		√				√	√	√	√	√	√		√	
Senior Management Support		√				√	√		√	√		√	√	√	√	
Trust	√	√		√		√	√		√				√			
Team Cohesion / Motivation	√		√	√	√	√						√		√		
Flexibility	√	√		√									√			√
Leadership			√	√	√				√							
Delegation		√		√							√	√				
Team Location			√								√					
Communication				√											√	

Table 7-8: Summary of response on project critical success factors

7.8 Summary and Conclusion – 2nd Phase Interviews

This chapter details the findings of the 2nd phase interviews which were conducted at the leading European aerospace company selected as a case study to validate the findings of the 1st phase interviews and questionnaires. The main reason for doing a case study was to investigate the impact of context in the perception of project complexity and to assess project complexity factors. In addition to this, the interest was to explore key project management processes and project critical success factors which were considered important by the practitioners working in the project actuality. In this regard, 16 interviews were conducted at two sites which involved discussion on 12 projects, the details are shown below in Table 7-9,

	Site 'B'	Site 'D'
Job Title	5 Project Executives 4 Program Managers 2 Program Leads	3 Project Executives 1 Program Manager 1 Program Controller
Projects Discussed	7 Projects	5 Projects

Table 7-9: Location wise distribution of Respondents and number of projects discussed

As mentioned earlier the interviews focused on the following aspects,

- Perception of Project Complexity / Complex Project.
- Factors contributing to project complexity.
- Key Project Management Aspects
- Project Critical Success Factors

The summary and conclusion of the above have been presented at the end of each section, however in this section it is discussed in the reference to the findings of the previous studies.

7.8.1 Perception of Project Complexity

The pragmatic view of project complexity identifies the key aspects/processes that make the project complex rather than categorising them into types, as the focus is more on the underlying characteristics. The key aspects highlighted are, stakeholders, interfaces, interdependencies, uncertainty, novelty and technology whereas the in the 1st phase interviews interactions, interdependencies, and uncertainty were highlighted. Novelty emerged as a key factor from these interviews, particularly due to the project types and settings in the case study organization. However, no major variation in the perception of the factors was seen either within the projects discussed or at various project management levels. The reason for this could be the context, that is, industry/company specific factors which seem to be recognised at all levels. The way these factors impact seemed to vary at different levels, which could be due to the difference in interactions, interdependencies and novelty at different levels.

7.8.2 Factors contributing to project complexity

The factors contributing to project complexity were similar to the ones highlighted in the previous studies and were related to product, process and people. However in this case the factors were related more to the interaction, interdependencies and novelty of ‘people’ and ‘process’ groups. The factors highlighted in this study can be categorised into project internal and external factors. Internal factors were linked with the company and its project settings such as the project organizational structure, distributed locations which further made these interactions and interdependencies complex and which in turn led to which system level issues related to product. External factors affecting the project/project complexity in this case were more related to contractual terms and working relationships with external partners, suppliers, contractors etc, and also to lack of requirement capture from the customer and financial/budget constraints issues.

7.8.3 Contextual Influence

No significant variation in the perception of complexity at various management levels and different projects was observed. This could be due to the reasons that the practitioners were working within the same company environment and nature of business, and the products were also in similar domain. However the other reason for this could be the less number of interviewees at site 'D' and type of projects. As there might be a possibility that a few specific factors may have been reported which could be location and project type specific. The example of this could be the factor 'novelty' which is reported by all at site 'B' but only by one person at site 'D' that too in different perspective.

7.8.4 Key Project Management Skills / Processes

The importance of soft skills was highlighted in the analysis of the first phase interviews and also in this study. All of the interviewees reported the importance of the soft skills in the context of complex projects. The PM processes highlighted in the light of project complexity focused on two aspects, processes/skills required to manage people and processes critical to manage and control changes during the course of the project.

7.8.5 Project Critical Success Factors

Project critical success factors were reported by the practitioners based on their experience of working in complex projects with the objective to assess them in the context of project complexity. Project critical success factors reported were specific to this case study and the complexity of the project discussed. The factors reported were influence and relationship, trust, flexibility, delegation and team location. Analysing these factors in the light of project complexity (i.e. interdependencies, interfaces and novelty); influence and relationships, and trust are key aspects required to manage human interfaces external and internal to the project. Similarly, flexibility and delegation are important when there are multiple interdependencies and interfaces in terms of managing people and processes, especially when the projects are either spread across different geographical locations or span across the organizational functions.

The summary of the 2nd phase interviews has been presented. The next chapter presents the results and analysis of the questionnaire which was administered after the 2nd phase interviews at two different business units of the case study organization.

Chapter 8

2nd Phase Questionnaire

8.0 Introduction

This chapter represents the results of the questionnaire administered (July-August '10) after the 2nd phase interviews. The purpose was to test the hypotheses and to validate and triangulate the findings of the previous studies, specially the 2nd phase interviews. The questionnaire survey yielded data from a representative sample which was analysed using qualitative and statistical techniques. Both descriptive and inferential statistical results are presented in detail in this chapter with the summary presented at the end of this chapter.

8.1 Research Methodology

8.1.1 Planning and Designing

Findings from the 2nd phase in-depth interviews provided an essential contextual data for this questionnaire, although the scope and the results of the previous studies were interlinked and inter-related, and were used in the design of the questionnaire. The analysis of the 2nd phase interviews helped to develop the questionnaire to test the hypothesis.

The questionnaire for this study is attached as Appendix 'E' – 2nd Phase Questionnaire. It is divided into 4 parts,

i. Biographical details
ii. Factors contributing to project complexity
iii. Key project management practices to manage project complexity
iv. Project critical success factors

The objective of the questionnaire was to address the following research questions pertaining to factors contributing to project complexity,

a) The variation of the perception of these factors with work location.
b) The variation of the perception of these factors with practitioner's age
c) The variation of the perception of these factors with practitioner's experience
d) The variation of the perception of these factors with work role.
e) The variation of the perception of these factors with project type.

Keeping the focus on the above the following hypothesis was tested.

Hypothesis 2

H_0: There is no difference between **project complexity** **<u>contributing factors</u>** with work location, practitioners' age, total work experience, work role and project type.

H_1: There is a difference between the **project complexity** **<u>contributing factors</u>** with work location, practitioners' age, total work experience, work role and project type.

8.1.2 Sampling and Data Collection

Since the 2nd phase interviews were carried out at a leading European Aerospace company, it was decided to administer the questionnaire in the same company to validate the findings of the interviews and to triangulate the results of the previous studies. Keeping in view the time constraints and other logistical considerations, the focus was limited to only two business units in the company, which were operating in similar project settings but working on different types of products. These two business units were located at two different cities and are referred to as, *Site 'B' and 'D'*.

As mentioned in the section 4.7.1, it is difficult to include the total population related to the research and also it is difficult to have a bigger population size due to the reason mentioned earlier. In the case of the aerospace company under consideration, it was also difficult to include all the managers and engineers in this survey, owing to the fact that the population was large in number, spread across the globe and were working on multiple types of projects. However, according to the industrial advisors the target population was more than 100 on both the sites, i.e. practitioners who were working in the management capacity. Therefore, with the company dispersed across the globe and working on diversified products and services, it was even difficult to include all the target population and the results are based on the accessible population.

The questionnaire was prepared in consultation with the supervisors and was shown to the heads of project management at the two sites during the detailed presentation on the research. In the presentation the questionnaire was also discussed and necessary amendments were made to clear out any ambiguities. The soft copy of the questionnaire was then emailed to the project management heads at the respective sites. The questionnaire was then forwarded to the practitioners selected by them at each site. At site *'D'* the questionnaire were distributed to about 100 managers and engineers at various levels and functions and at site *'B'* also to about 100 practitioners. The total feed back was 53 resulting in an overall response of 27%, with 18% response from site *'D'* and 35% response from site *'B'* respectively. This response rate was achieved after repeated reminders sent by emails for almost 3 weeks. Thus, highlighting the difficulty of getting a better response from the practitioners as they were busy in their own work. However, a reasonable response rate was achieved due to the fact the practitioners were asked to fill the questionnaire by senior management, thus highlighting the importance of senior management support as a critical success factor even for research purposes.

After receiving the questionnaires (soft copies) by email, they were coded and recorded in Microsoft Excel and also in the statistical analysis software SPSS-16 *(Statistical Package for the Social Sciences)*. The next section presents the descriptive and inferential statistics, the former describing the data and the latter to draw inferences about a population from a sample.

Another important aspect that needs to be discussed and highlighted is the rationale for the selection of statistical tests as there are many tests available and there are multiple views in the selection of these tests. This selection criterion is discussed in the next section, after which the details of descriptive and inferential statistics have been presented.

8.2 Rationale for the selection of statistical test

Choosing the right statistical technique is one of the most difficult and an important part of the statistical analysis which at times is tricky also (Kinnear and Gray, 2000, Motulsky, 2010 , Pallant, 2005a).

The wide varieties of statistical techniques that are available are classified into two main groups namely, *'parametric' and 'non-parametric'*. Parametric techniques are more powerful but have strings attached to them which make assumptions for the data more stringent such as normal distribution. Non-parametric techniques on the other hand and do not have such stringent requirements and do not make assumptions about the underlying population distribution, due to this reason they are also referred as distribution-free tests (Pallant, 2005a).

In order to choose between the two techniques certain aspects needed to be considered to facilitate the selection, although many researchers have given various views on this selection criterion, thus creating more confusion than clarity in making the right choice. The main aspects that have been cited by researchers, to be taken into consideration while choosing between parametric and non parametric tests are,

i. Shape of the population distribution e.g. Gaussian or normal distribution
ii. Sample Size
iii. Type of measurement i.e. scale of the data

The normal distribution of the variables can be checked either by observing visually the histograms, and/or checking the skewness and kurtosis values, and/or performing normality tests. The simplest method of assessing normality is to look at the frequency distribution histogram to check the symmetry and peakiness of the curve. Although, visual assessment provides good quick indication but should be used in conjunction with the quantitative methods, such as skewness and kurtosis, this gives a fair indication of the trend of the sample distribution. A common rule-of-thumb test for normality is to run descriptive statistics to get skewness (test for symmetry of distribution) and kurtosis (test for distribution of 'peakness'), and then divide these by the standard errors. A positive skew indicates a longer tail to the right than to the left and a negative skew indicates longer tail to the left than to the right. Kurtosis refers to how 'flat' a distribution is. In general if kurtosis and skewness are not between -2 and +2, the data is too far way from a normal distribution (Cohen, 1999).

'Tests of normality' is the other option to ascertain normality and can be done by using Kolmogorov-Smirnov test for a sample size greater than 50 or Shapiro-Wilk test if sample size is smaller than 50. The convention is that the Significane. value greater than 0.05 indicates normality of distribution.

Lastly, application of test that are based on normality are further limited by a lack of precise measurement. Parametric requires interval and ratio data, with the assumption that the scales are continuous and there are no gaps or breaks within them. With Interval data meaningfully calculation of mean and standard deviation can be done using the raw scores. On the other hand the non-parametric techniques are ideal when the data are measured on a nominal (categorical) and ordinal (ranked) scales.

Looking at the above criterion and analysing the data, the selection of non parametric tests was made for the reason that the data did not meet the stringent requirements of the parametric tests, for the reasons given below,

i. In order to assess normality, it was done by checking skewness and kurtosis, and also by performing the test of normality. Assessment of the ratio of skewness and standard errors showed that the values of many of the variables were beyond the acceptable range of -2 to +2 range, so it was reasonable to assume for this case that the data is not normally distributed. To further validate this result, the test of normality was also performed and significant value less than 0.05 indicated that the data was not normally distributed as it violated the criteria, as shown in Table 8-1.

ii. The sample size was less than 100, as the response from *site 'D'* was 18 and from site 'B' is 35, making a total of 53 responses. On the basis of which it was difficult to assume that the distribution was normal as the sample size was small. Non-parametric methods are suitable when the sample size is small, for with small data sets parametric tests can produce misleading results (Kinnear and Gray, 2000).

iii. Scale of measurement used was ordinal (rank order) and discrete, for this case the non-parametric techniques have been strongly recommended, as analysis based on means or standard deviations cannot be performed, whereas non parametric tests make no assumption for the distribution of data nor rely on estimates of population parameters such as the mean in order to describe variable distribution.

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Paternership - Complexity Factor (Experience)	.478	48	.000	.524	48	.000
Novelty - Complexity Factor (Experience)	.334	48	.000	.769	48	.000
Requirement Capture / Product Specification - Complexity Factor (Experience)	.356	48	.000	.754	48	.000
Stakeholder (Internal & External) - Complexity Factor (Experience)	.324	48	.000	.722	48	.000
Geographical Location / Multiple Sites - Complexity Factor (Experience)	.380	48	.000	.706	48	.000
Project Organizational Structure - Complexity Factor (Experience)	.299	48	.000	.773	48	.000
System Level Issues - Complexity Factor (Experience)	.344	48	.000	.790	48	.000
Time constraints / Duration - Complexity Factor (Experience)	.247	48	.000	.836	48	.000
Contractual Issues - Complexity Factor (Experience)	.229	48	.000	.810	48	.000
Financial / Budget Issues on Project Complexity based on Experience	.245	48	.000	.806	48	.000
Paternership - Complexity Factor (Current Project)	.353	48	.000	.763	48	.000
Novelty - Complexity Factor (Current Project)	.280	48	.000	.844	48	.000
Requirement Capture / Product Specification - Complexity Factor (Current Project)	.300	48	.000	.766	48	.000
Stakeholder (Internal & External) - Complexity Factor (Current Project)	.384	48	.000	.670	48	.000
Geographical Location / Multiple Sites - Complexity Factor (Current Project)	.250	48	.000	.808	48	.000
Project Organizational Structure - Complexity Factor (Current Project)	.276	48	.000	.783	48	.000
System Level Issues - Complexity Factor (Current Project)	.292	48	.000	.826	48	.000
Time constraints / Duration - Complexity Factor (Current Project)	.273	48	.000	.821	48	.000
Contractual Issues - Complexity Factor (Current Project)	.245	48	.000	.806	48	.000
Financial / Budget Issues - Complexity Factor (Current Project)	.232	48	.000	.808	48	.000
a. Lilliefors Significance Correction						

Table 8-1: Tests of Normality

Keeping in view the above reasons, non-parametric approach was adapted for the inferential statistics. Although the non-parametric methods are less sensitive and less powerful than the parametric ones, but due to the above reasons the choice had to be made for the data was not fulfilling the stringent requirements of parametric techniques.

8.3 Data Analysis

The data analysis is divided into two sections namely, descriptive and inferential statistics. Descriptive statistics summarizes the sample using statistical measures, such as average, median, standard deviation, and without employing any probabilistic formulation, rather it is used to support inferential statements about the population. Descriptive statistics condenses the data into a few simple values either numerically or graphically to simplify an understanding of it, whereas inferential statistics, on the other hand, is used to make claims about the populations that arise from the data collected. Thus, inferential statistics is used to make inferences; whereas descriptive statistics simply describes what's going on in the data.

8.3.1 Descriptive Statistics

Descriptive statistics is presented section wise, covering the following four parts,

i. Biographical details
ii. Factors contributing to project complexity
iii. Key project management practices to manage project complexity
iv. Project critical success factors

The questionnaire was distributed at two sites, namely *Site 'B'* and *Site 'D'*. The number of response received from *Site 'B'* and *Site 'D'* were 35 and 18 respectively, as shown in Table 8-2,

Location				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Site 'D'	18	34.0	34.0	34.0
Site 'B'	35	66.0	66.0	100.0
Total	53	100.0	100.0	

Table 8-2: Location wise distribution

Part A of the questionnaire includes biographical details, which is presented in the next sections.

8.3.1.1 Biographical Details

The biographical section of the questionnaires includes the information about respondents' gender and age.

Table 8-3 shows that there were 46 males (87%) and 7 females (13%) in the sample giving a total of 53 respondents. Table 8-4 shows the gender stratification location wise.

Gender				
	Frequency	Percent	Valid Percent	Cumulative Percent
Male	46	86.8	86.8	86.8
Female	7	13.2	13.2	100.0
Total	53	100.0	100.0	

Table 8-3: Gender Distribution

Gender * Location Crosstabulation				
		Location		
		Site 'D'	Site 'B'	Total
Gender	Male	17	29	46
	Female	1	6	7
	Total	18	35	53

Table 8-4: Location wise gender distribution

Table 8-5 shows the age ranges of the respondents, 45% of the respondents were in the range of 30-40 years and 30% of the respondents in 41-50 yrs bracket, showing their experience and maturity level of the respondents.

Age				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Under 30 yrs	2	3.8	3.8	3.8
30-40 yrs	24	45.3	45.3	49.1
41-50 yrs	16	30.2	30.2	79.2
Above 50 yrs	11	20.8	20.8	100.0
Total	53	100.0	100.0	

Table 8-5: Age Distribution

Age * Gender * Location Crosstabulation					
Location			**Gender**		
			Male	**Female**	**Total**
Site 'D'	Age	30-40 yrs	7	1	8
		41-50 yrs	8	0	8
		Above 50 yrs	2	0	2
		Total	17	1	18
Site 'B'	Age	Under 30 yrs	1	1	2
		30-40 yrs	12	4	16
		41-50 yrs	7	1	8
		Above 50 yrs	9	0	9
		Total	29	6	35

Table 8-6: Location wise Age Distribution

8.3.1.2 Work Experience / Role

Table 8-7 highlights the work experience of the respondents and it can be seen that 24 (45%) respondents had over 20 years of working experience and 79% of the respondents had more than 11 years of work experience, showing the rich work experience of the majority of the sample. The similar trend is exhibited in Table 8-6 which shows the age ranges with respect to the two sites.

Total Work Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 3 yrs	1	1.9	2.0	2.0
	3 - 6 yrs	1	1.9	2.0	3.9
	7-10 yrs	7	13.2	13.7	17.6
	11-15 yrs	8	15.1	15.7	33.3
	16-20 yrs	10	18.9	19.6	52.9
	Over 20 yrs	24	45.3	47.1	100.0
	Total	51	96.2	100.0	
Missing	System	2	3.8		
Total		53	100.0		

Table 8-7: Total Work Experience Distribution

Total Work Experience * Location Crosstabulation				
		Location		
		Site 'D'	Site 'B'	Total
Total Work Experience	Under 3 yrs	0	1	1
	3 - 6 yrs	1	0	1
	7-10 yrs	1	6	7
	11-15 yrs	3	5	8
	16-20 yrs	5	5	10
	Over 20 yrs	7	17	24
	Total	17	34	51

Table 8-8: Location wise Total Work Experience Distribution

Table 8-9 shows the current work role of the respondents, namely functional (engineering/technical) and project management. 73.6 % of the respondents were involved with project management, 11.3% involved purely in functional work whereas 15% of the respondents were performing in both the functions. From Table 8-10, it can be seen that the majority of the respondents from both sites are involved in project management.

Work Role				
	Frequency	Percent	Valid Percent	Cumulative Percent
Functional	6	11.3	11.3	11.3
Management	39	73.6	73.6	84.9
Both Functional & Management	8	15.1	15.1	100.0
Total	53	100.0	100.0	

Table 8-9: Work Role distribution

Work Role * Location Crosstabulation				
		Location		
		Site 'D'	Site 'B'	Total
Work Role	Functional	3	3	6
	Management	11	28	39
	Both Functional & Management	4	4	8
	Total	18	35	53

Table 8-10: Location wise Work Role distribution

8.3.1.3 Project Type

Table 8-11 highlights the type of projects the respondents were currently working on. 45% of the respondents were working on *'Support & Services'* type of projects, whereas 20% were working on *'New Product Development'(NPD)* type of projects. A similar trend was observed at the two sites, except in 'Upgrading a developed product' projects, more respondents were involved in that at *Site 'D'* as compared to *Site 'B'*, and similarly at *Site 'B'* there were more people involved in 'New Product Development' as compared to *Site D'*.

Project Type					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	New Product Development	11	20.8	21.6	21.6
	Upgrading Developed Product	5	9.4	9.8	31.4
	Production Dev Prod	3	5.7	5.9	37.3
	Support & Services	24	45.3	47.1	84.3
	Upgrading/ Production of a Developed Product	8	15.1	15.7	100.0
	Total	51	96.2	100.0	
Missing	System	2	3.8		
Total		53	100.0		

Table 8-11: Types of Projects respondents are working on

Project Type * Location Crosstabulation				
		Location		
		Site 'D'	Site 'B'	Total
Project Type	New Product Development	2	9	11
	Upgrading Developed Product	4	1	5
	Production Dev Prod	2	1	3
	Support & Services	7	17	24
	Upgrading/ Production of a Developed Product	2	6	8
	Total	17	34	51

Table 8-12: Location wise distribution of Types of Projects respondents are working on

Comparison between the type of projects respondents were involved, in 2nd phase interviews and questionnaire, shows that the in the former maximum number of respondents were involved in ‘New Product Development’ where as in the latter it was ‘Support and Services’.

8.3.1.4 Factors Contributing to Project Complexity

Table 8-13 present the median, standard deviation along with the percentage and frequencies of the level of impact of factors contributing to project complexity based on individual's experience and current project respectively. The responses were measured on a three point likert type (ordinal) scale ('1', denoting low, '2' denoting medium and '3' denoting high level of impact). The median for all the factors in both the tables were '2' or above indicating their level of impact on project complexity being recognised by all respondents. One reason for this could be that the factors used in the questionnaire were based on the analysis of the 2nd phase interviews which were also done in the same company.

	Median	Std. Deviation	Low		Medium		High	
			Freq	Percent	Freq	Percent	Freq	Percent
Partnership - Exp	**3**	**0.52**	**2**	**3.8**	**9**	**17**	**41**	**77.4**
Novelty - Exp	**3**	**0.61**	**2**	**3.8**	**20**	**37.7**	**29**	**54.7**
Requirement Capture / Product Specification - Exp	**3**	**0.60**	**2**	**3.8**	**18**	**34**	**31**	**58.5**
Stakeholder (Internal & External) - Exp	2	0.61	3	5.7	24	45.3	25	47.2
Geographical Location / Multiple Sites - Exp	2	0.54	4	7.5	36	67.9	12	22.6
Project Organizational Structure - Exp	2	0.67	7	13.2	27	50.9	18	34
System Level Issues - Exp	2	0.63	5	9.4	32	60.4	12	22.6
Time constraints / Duration - Exp	2	0.78	10	18.9	21	39.6	20	37.7
Contractual Issues - Exp	2	0.75	15	28.3	23	43.4	14	26.4
Financial / Budget Issues-Exp	2	0.72	11	20.8	25	47.2	16	30.2

Table 8-13: Ranking of complexity factors Based on Experience

	Median	Std. Deviation	Low		Medium		High	
			Freq	Percent	Freq	Percent	Freq	Percent
Partnership - CP	**3**	**0.73**	**6**	**11.3**	**13**	**24.5**	**31**	**58.5**
Novelty - CF_CP	**3**	**0.89**	**11**	**20.8**	**14**	**26.4**	**23**	**43.4**
Requirement Capture / Product Specification - CP	2	0.71	7	13.2	20	37.7	24	45.3
Stakeholder (Internal & External) - CP	**3**	**0.54**	**1**	**1.9**	**19**	**35.8**	**31**	**58.5**
Geographical Location / Multiple Sites - CP	2	0.71	12	22.3	26	49.1	13	24.5
Project Organizational Structure - CP	2	0.74	9	17	20	37.7	22	41.5
System Level Issues - CP	2	0.82	13	24.5	26	49.1	7	13.2
Time constraints / Duration - CP	2	0.82	11	20.8	17	32.1	22	41.5
Contractual Issues - CP	2	0.72	11	20.8	25	47.2	15	28.3
Financial / Budget Issues - CP	2	0.73	11	20.8	24	45.3	16	30.2

Table 8-14: Ranking of complexity factors Based on Current Project

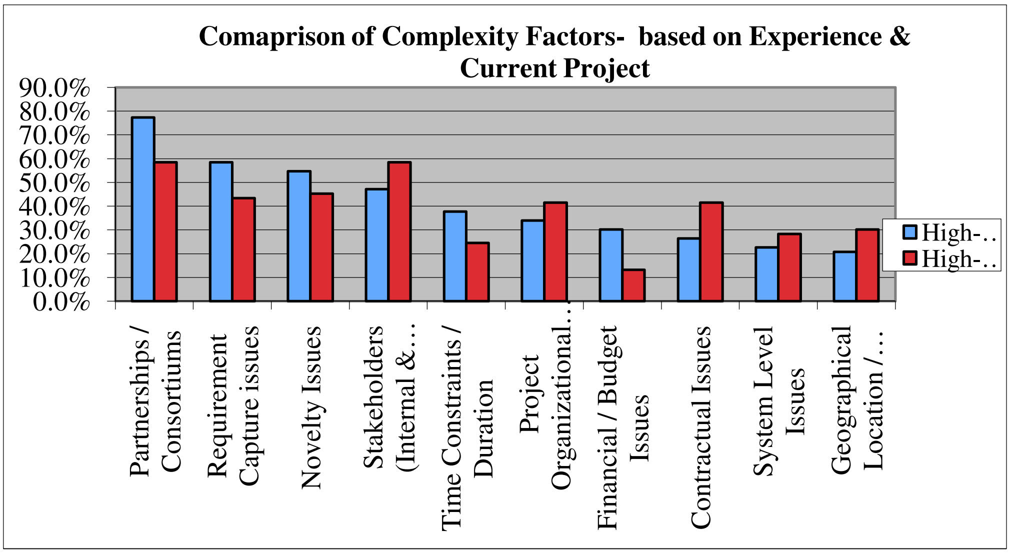

Figure 8-1: Comparison of ranking of complexity factors based on experience & current projects

The comparison between the responses shows similar trend that was observed through the interviews, although the respondents were from different projects and business units within the company and working on different types of projects. The reason for this similar trend could be due to working in similar type of industry, organization and project settings. Looking at the comparison between factors reported based on experience and current project, factors like stakeholder, organizational structure and contractual issues, geographical location were reported to have higher impact in current projects, which reflects the influence and impact of the day to day workings in projects i.e. the project reality, as these factors are interlinked with people, product and process.

Comparison of the ranking based on the 2nd phase questionnaire and interviews, indicate that the top reported factors such as, partnerships, novelty, requirement capture, stakeholder, remain the same, whereas in other half there is a shift in the ranking and recognition which could be due to the type of project and type of product/service. As majority of the respondents in interviews were engaged in 'new product development' as compared to 'services and support' in the case of this questionnaire. However, the importance of managing relationships, the realization of impact of novelty and efforts to minimise ambiguity is recognised by all the respondents.

8.3.1.5 Key Project Management Processes

Table 8-15 present the median, standard deviation along with the percentage and frequencies of the level of usefulness of key project management process based on both individual's experience and on current project working. The responses were measured on a three point likert type (ordinal) scale ('1', denoting low, '2' denoting medium and '3' denoting high level of usefulness).

	Median	Std. Deviation	Low		Medium		High	
			Freq	Percent	Freq	Percent	Freq	Percent
Stakeholder Management -Exp	**3**	**0.60**	**3**	**5.7**	**13**	**24.5**	**36**	**67.9**
Gated Reviews -Exp	2	0.75	10	18.9	21	39.6	21	39.6
Scope Management -Exp	**3**	**0.57**	**1**	**1.9**	**22**	**41.5**	**28**	**52.8**
Requirement Management -Exp	**3**	0.57	2	3.8	18	34	31	58.5
Work Breakdown Structure -Exp	2	0.74	11	20.8	27	50.9	13	24.5
Change Control -Exp	**3**	**0.70**	**6**	**11**	**18**	**34**	**28**	**52.8**
Communication -Exp	**3**	**0.41**	**0**	**0**	**11**	**20.8**	**41**	**77.4**
Risk Management -Exp	2	0.64	5	9.4	27	50.9	20	37.7
Procurement Management -Exp	2	0.90	16	30.2	19	35.8	13	24.5
Planning -Exp	**3**	**0.54**	**1**	**1.9**	**20**	**37.7**	**31**	**58.5**
Organizational Structure -Exp	2	0.80	14	26.4	22	41.5	15	28.3
System Engineering -Exp	2	0.83	13	24.5	26	49.1	10	18.9
Cost Management -Exp	2	0.76	11	20.8	25	47.2	15	28.3
Conflict Management -Exp	2	0.69	8	15.1	30	56.6	13	24.5
Resource Management -Exp	2	0.75	10	18.9	21	39.6	21	39.6
Soft Skills -Exp	**3**	**0.58**	**1**	**1.9**	**24**	**45.3**	**25**	**47.2**

Table 8-15: Ranking of Key PM processes Based on Experience

It can be seen from both Table 8-15 and Table 8-16, that the medians for all the processes listed are '2' or above signifying the realization of importance of these processes in managing / working in complex projects. Stakeholder management, scope management communication, planning and soft skills have been reported as highly useful, in both the cases. However in addition to this, respondents also highlighted change control and requirement management as significant processes based on their experience.

	Median	Std. Deviation	Low		Medium		High	
			Freq	Percent	Freq	Percent	Freq	Percent
Stakeholder Management -CP	**3**	**0.42**	**0**	**0**	**11**	**20.8**	**40**	**75.5**
Gated Reviews -CP	2	0.83	14	26.4	19	35.8	17	32.1
Scope Management -CP	2	0.64	3	5.7	23	43.4	24	45.3
Requirement Management -CP	**3**	**0.67**	**5**	**9.4**	**19**	**35.8**	**26**	**49.1**
Work Breakdown Structure -CP	2	0.79	16	30.2	23	43.4	11	20.8
Change Control -CP	2	0.75	10	18.9	21	39.6	20	37.7
Communication -CP	**3**	**0.42**	**0**	**0**	**11**	**20.8**	**40**	**75.5**
Risk Management -CP	2	0.71	7	13.2	26	49.1	17	32.1
Procurement Management -CP	2	0.95	18	34	15	28.3	14	26.4
Planning -CP	**3**	**0.61**	**3**	**5.7**	**17**	**32.1**	**31**	**58.5**
Organizational Structure -CP	2	0.79	10	18.9	24	45.3	15	28.3
System Engineering -CP	2	0.88	16	30.2	21	39.6	11	20.8
Cost Management -CP	2	0.71	10	18.9	25	47.2	16	30.2
Conflict Management -CP	2	0.72	7	13.2	29	54.7	13	24.5
Resource Management -CP	2	0.79	11	20.8	17	32.1	23	43.4
Soft Skills -CP	**3**	**0.65**	**4**	**7.5**	**18**	**34**	**28**	**52.8**

Table 8-16: Ranking of Key PM processes Based on Current Project

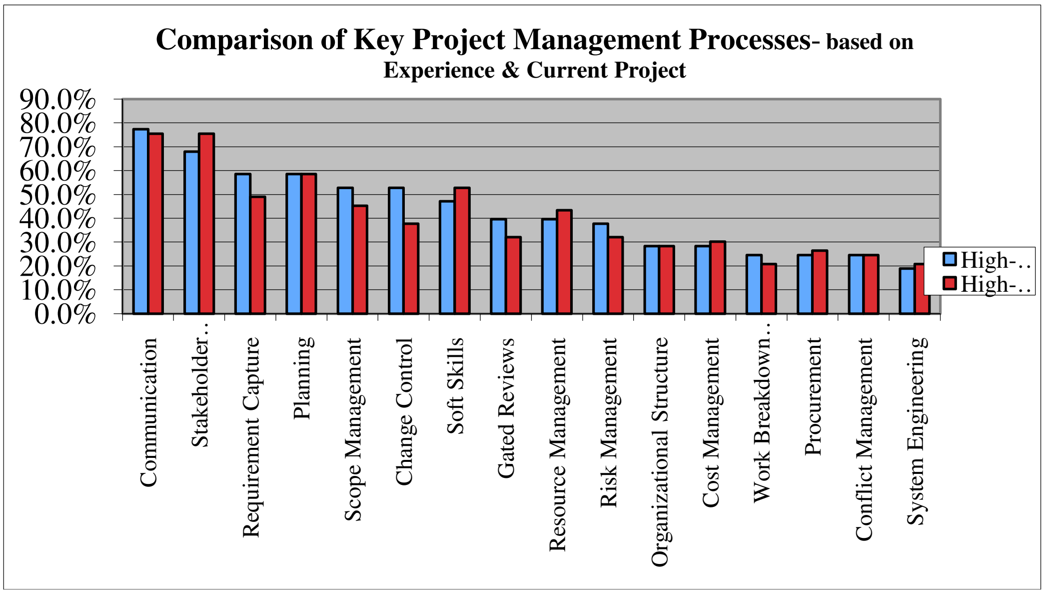

Figure 8-2 : Comparison of ranking of key PM Processes based on experience & current projects

It can be seen from Figure 8-2, that the importance of soft skills is realised by all the respondents, along with stakeholder management and communication, which again focuses on managing the people and their expectations, whereas scope management, requirement management and change control focuses on managing and minimising changes and deviations to project plans and product specifications. The similar trend was found in the 2nd phase interviews; however the only different process highlighted in this study as highly significant was 'planning'. The reason for this difference could be that during the interviews the respondents were specifically asked to mention key process in the context of project complexity specific to their reported projects and the majority of those projects were new product development, so planning might be over-shadowed by other more critical factors related to NPD projects, where as in this case more respondents are involved in support and services type of project, which is planning dominated process and require stringent adherence to it.

8.3.1.6 Project Critical Success Factors

Table 8-17 and Table 8-18 present the median, standard deviation along with the percentage and frequencies of the level of usefulness of key project critical success factors based on both individual's experience and on current project working. The responses were measured on a three point likert type (ordinal) scale ('1', denoting low, '2' denoting medium and '3' denoting high level of usefulness). The highly significant factors reported are senior management support, clear objectives, trust, influence and relationships, leadership, team motivation and communication.

	Median	Std. Deviation	Low		Medium		High	
			Freq	Percent	Freq	Percent	Freq	Percent
Senior Management Support -Exp	**3**	**0.61**	**3**	**5.7**	**20**	**37.7**	**29**	**54.7**
Clear Objectives -Exp	**3**	**0.41**	**0**	**0**	**9**	**17**	**42**	**79.2**
Influence and Relationship -Exp	**3**	**0.59**	**2**	**3.8**	**15**	**28.3**	**34**	**64.2**
Trust -Exp	2	0.66	4	7.5	24	45.3	23	43.4
Team Cohesion -Exp	2	0.58	1	1.9	27	50.9	23	43.4
Flexibility -Exp	2	0.63	4	7.5	24	45.3	23	43.4
Delegation -Exp	2	0.75	8	15.1	27	50.9	14	26.4
Team Location -Exp	2	0.74	13	24.5	24	45.3	15	28.3
Leadership -Exp	**3**	**0.56**	**2**	**3.8**	**14**	**26.4**	**36**	**67.9**
Informal Networks -Exp	2	0.72	8	15.1	22	41.5	21	39.6
Team Motivation -Exp	**3**	**0.64**	**4**	**7.5**	**15**	**28.3**	**33**	**62.3**
Risk Acceptance -Exp	2	0.57	4	7.5	33	62.3	15	28.3
Communication -Exp	**3**	**0.37**	**0**	**0**	**8**	**15.1**	**43**	**81.1**

Table 8-17 : Ranking of CSF Based on Experience

	Median	Std. Deviation	Low		Medium		High	
			Freq	Percent	Freq	Percent	Freq	Percent
Senior Management Support -CP	**3**	**0.73**	**6**	**11.3**	**16**	**30.2**	**28**	**52.8**
Clear Objectives -CP	**3**	**0.55**	**2**	**3.8**	**9**	**17**	**39**	**73.6**
Influence and Relationship -CP	**3**	**0.55**	**1**	**1.9**	**16**	**30.2**	**33**	**62.3**
Trust -CP	**3**	**0.67**	**3**	**5.7**	**21**	**39.6**	**25**	**47.2**
Team Cohesion -CP	2	0.64	3	5.7	24	45.3	23	43.4
Flexibility -CP	2	0.66	5	9.4	22	41.5	23	43.4
Delegation -CP	2	0.69	9	17	26	49.1	16	30.2
Team Location -CP	2	0.68	10	18.9	28	52.8	13	24.5
Leadership -CP	**3**	**0.42**	**0**	**0**	**11**	**20.8**	**40**	**75.5**
Informal Networks -CP	2	0.71	9	17	24	45.3	18	34
Team motivation -CP	2	0.61	3	5.7	23	43.4	24	47.2
Risk Acceptance -CP	2	0.66	7	13.2	31	58.5	12	22.6
Communication -CP	**3**	**0.44**	**0**	**0**	**13**	**24.5**	**38**	**71.7**

Table 8-18: Ranking of CSF Based on Current Projects

The comparison of the factors (Figure 8-3) reported based on experience and current project exhibits a similar trend; however trust was reported as highly significant based on current projects. Trust is an important factor when dealing with stakeholders (people) internal and external to the projects and plays a very vital role in the achieving project objectives.

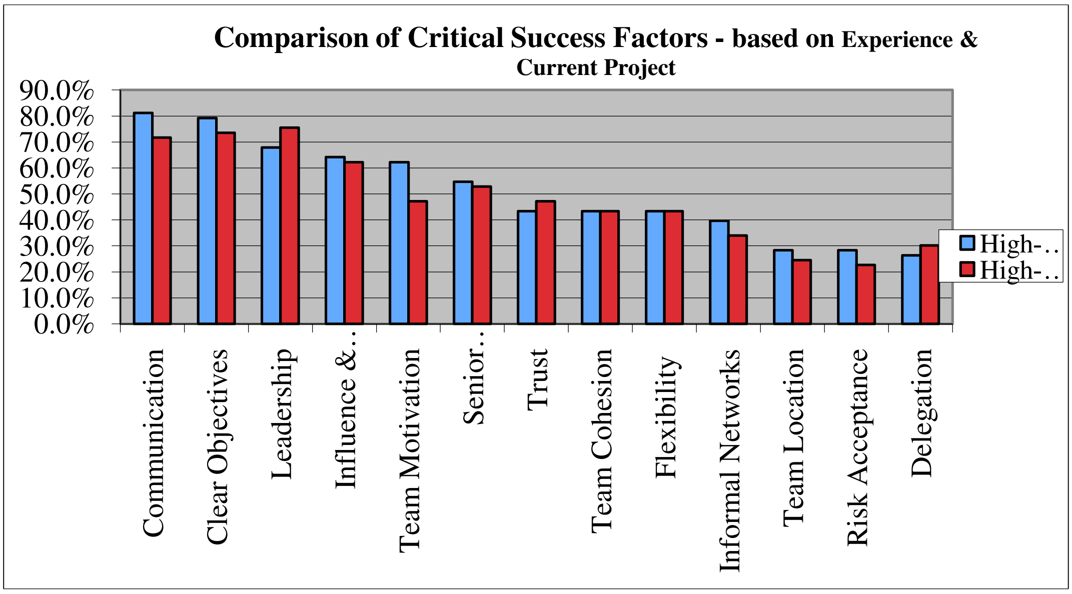

Figure 8-3: Comparison of ranking of key CSF based on experience & current projects

Critical success factors reported in this study are comparable to the previous ones i.e. the 2nd phase interviews, except that in this study communication was reported as the highest ranked factor which was not the case in the results of the

2nd phase interviews. Similarly leadership was given high significance too. The possible reason for this could be that the respondents in the interviews were senior executives were intuitively doing this role, whereas in the case of questionnaire, there were respondents at levels, which either look up to the leadership and/or are affected by lack of leadership. The reason for communication being reported highly significant in this study is due to the reason that majority of respondents were involved in support and services projects which require constant and effective communication with the customer to understand requirements and to provide timely and effective support, which is only possible with a proper feedback.

8.3.2 Inferential Statistics

This section presents test performed to explore the differences and/or relationships if any in the data in order to test the hypothesis.

8.3.2.1 Mann-Whitney U Test

Mann-Whitney Test was used to test for differences between two independent groups measured on an ordinal scale. This test is a parametric alternative to the ‘t-test’ for independent samples, instead of comparing means it actually compares the medians. As the scores are converted to ranks the actual distribution of the score does not matter (Pallant, 2005a).

Mann-Whitney U test was used to test hypothesis 2a.

Hypothesis 2a

H_0: There is no difference between project complexity contributing factors with work location.

H_1: There is a difference between the project complexity contributing factors with work location.

Level of impact of complexity factors (based on experience) were used in this case and the responses from two sites were compared using Mann-Whitney U Test. This is a non-parametric alternative to the t-test for independent samples and instead of comparing means of two groups it compares the medians (Pallant, 2005a). Table 8-19 shows the values of test statistics U, W, Z and significance level (2-tailed) in relation to the complexity factors. The ranks are given in Appendix 'F'.

Mann-Whitney U Test - Statistics[a]				
	Mann-Whitney U	**Wilcoxon W**	**Z**	**Asymp. Sig. (2-tailed)**
Partnership - Exp	194.000	365.000	-3.032	**.002**
Novelty - Exp	249.000	844.000	-1.250	.211
Requirement Capture / Product Specification - Exp	305.500	476.500	-.011	.991
Stakeholder (Internal & External) - Exp	286.000	881.000	-.433	.665
Geographical Location / Multiple Sites - Exp	218.000	389.000	-2.090	**.037**
Project Organizational Structure - Exp	304.000	899.000	-.043	.966
System Level Issues - Exp	257.000	818.000	-.566	.571
Time constraints / Duration - Exp	272.000	867.000	-.701	.483
Contractual Issues - Exp	299.500	894.500	-.134	.893
Financial / Budget Issues-Exp	261.500	856.500	-.928	.353
a**. Grouping Variable: Location**				

Table 8-19: Significance of project complexity factors with Location

The results are considered to be significant at significance value of $p < 0.05$. Since the hypotheses do not predict direction of the difference, the region of rejection is two-tailed. Since all the factors' p-values are higher than 0.05, except partnership and geographical location/multiple sites, there is no statistical significant difference in the complexity factors at two sites. So for these factors H_0 is accepted and H_1 is rejected. Whereas for partnerships and geographical location/multiple sites p-values is less than 0.05, which meant that there is difference of these complexity factors at two sites and as the confidence level is greater than 95%, so therefore H_0 is rejected and H_1 is accepted for these two factors.

Since the p-values for majority of the factors are higher than 0.05, therefore the null hypothesis of no difference (H_0) was accepted, i.e. there is no difference between the project complexity contributing factors at two sites.

The reason for significance difference in partnerships and geographical location/multiple sites factor is the type of projects at Site 'B' (see rank table in Appendix 'F' - Mann-Whitney U Test Ranks) as these projects involved multiple partnerships and were mostly dispersed at different geographical locations.

8.3.2.2 Kruskal-Wallis Test

Kruskall-Wallis is a non-parametric alternative to parametric one-way-between-groups analysis of variance (ANOVA), it is similar to Mann-Whitney test but it allows comparison of more than two groups. The scores are converted to ranks and the mean rank of each group is compared (Pallant, 2005a).

Kruskal-Wallis test was used to test hypotheses 2b, 2c, 2d and 2e respectively.

Hypothesis 2b

H_0: There is no difference between the perceived project complexity contributing factors with practitioners' age.

H_1: There is a difference between the perceived project complexity contributing factors with practitioners' age.

Kruskal-Wallis Test - Statistics[a,b]			
	Chi-Square	**df**	**Asymp. Sig.**
Partnership - Exp	.229	2	.892
Novelty - Exp	9.651	2	**.008**
Requirement Capture / Product Specification - Exp	4.375	2	.112
Stakeholder (Internal & External) - Exp	.951	2	.621
Geographical Location / Multiple Sites - Exp	1.091	2	.580
Project Organizational Structure - Exp	1.680	2	.432
System Level Issues - Exp	3.262	2	.196
Time constraints / Duration - Exp	3.857	2	.145
Contractual Issues - Exp	1.039	2	.595
Financial / Budget Issues-Exp	2.953	2	.228
a. Kruskal Wallis Test			
b. **Grouping Variable: Age**			

Table 8-20: Significance of project complexity factors with Age

The results are considered to be significant at significance value of $p < 0.05$. Since in Table 8-20, all the factors' p-values were higher than 0.05, *except for novelty*, so it can be said that there is no statistical significant difference in the perception of complexity factors with age. So therefore for all the factors accept novelty, H_0 is accepted and H_1 is rejected.

However, for novelty there was statistical difference found with age, which was highlighted in the results of 2nd phase interview, but in relation to job title rather age.

Hypothesis 2c

H_0: There is no difference between the perceived project complexity contributing factors with practitioners' total work experience.

H_1: There is a difference between the perceived project complexity contributing factors with practitioners' total work experience.

Kruskal-Wallis Test - Statistics[a,b]			
	Chi-Square	df	Asymp. Sig.
Partnership - Exp	2.866	3	.413
Novelty - Exp	.542	3	.910
Requirement Capture / Product Specification - Exp	.161	3	.984
Stakeholder (Internal & External) - Exp	1.357	3	.716
Geographical Location / Multiple Sites - Exp	3.255	3	.354
Project Organizational Structure - Exp	2.105	3	.551
System Level Issues - Exp	5.969	3	.113
Time constraints / Duration - Exp	1.877	3	.598
Contractual Issues - Exp	.320	3	.956
Financial / Budget Issues-Exp	1.492	3	.684
a. Kruskal Wallis Test			
b. **Grouping Variable: Total Work Experience**			

Table 8-21: Significance of project complexity factors with Total Work Experience

The results are considered to be significant at significance value of $p < 0.05$. Since in Table 8-21, all the factors' *p-values* are higher than 0.05, so there is no statistical significant difference in the perception of complexity factors with work experience. So therefore all the factors accept novelty, H_0 is accepted and H_1 is rejected, i.e. there is no difference between the perceived project complexity contributing factors with practitioners' total work experience.

Hypotheses 2d

H_0: There is no difference between the perceived project complexity contributing factors with work role.

H_1: There is a difference between the perceived project complexity contributing factors with work role.

Kruskal-Wallis Test - Statistics[a,b]			
	Chi-Square	**df**	**Asymp. Sig.**
Partnership - Exp	2.793	2	.247
Novelty - Exp	.454	2	.797
Requirement Capture / Product Specification - Exp	3.862	2	.145
Stakeholder (Internal & External) - Exp	.203	2	.903
Geographical Location / Multiple Sites - Exp	3.593	2	.166
Project Organizational Structure - Exp	1.108	2	.575
System Level Issues - Exp	.041	2	.980
Time constraints / Duration - Exp	2.119	2	.347
Contractual Issues - Exp	3.218	2	.200
Financial / Budget Issues-Exp	2.552	2	.279
a. Kruskal Wallis Test			
b. **Grouping Variable: Work Role**			

Table 8-22: Significance of project complexity factors with Work Role

The results are considered to be significant at significance value of $p < 0.05$. Since in Table 8-22, all the factors' *p-values* are higher than 0.05, so there is no statistical significant difference in the perception of complexity factors with work role. So therefore all the factors, H_0 is accepted and H_1 is rejected, i.e. there is no difference between the perceived project complexity contributing factors with practitioners' work role.

Hypotheses 2e

H_0: There is no difference between the perceived project complexity contributing factors with project type.

H_1: There is a difference between the perceived project complexity contributing factors with project type.

Kruskal-Wallis Test - Statistics[a,b]			
	Chi-Square	df	Asymp. Sig.
Partnership - Exp	6.856	3	.077
Novelty - Exp	.655	3	.884
Requirement Capture / Product Specification - Exp	1.600	3	.659
Stakeholder (Internal & External) - Exp	3.290	3	.349
Geographical Location / Multiple Sites - Exp	.294	3	.961
Project Organizational Structure - Exp	1.867	3	.600
System Level Issues - Exp	4.330	3	.228
Time constraints / Duration - Exp	2.558	3	.465
Contractual Issues - Exp	.561	3	.905
Financial / Budget Issues-Exp	1.237	3	.744
a. Kruskal Wallis Test			
b. Grouping Variable: Project Type			

Table 8-23: Significance of project complexity factors with Project Type

The results are considered to be significant at significance value of $p < 0.05$. Since in Table 8-23, all the factors' *p-values* are higher than 0.05, so there is no statistical significant difference in the perception of complexity factors with project type. So therefore all the factors, H_0 is accepted and H_1 is rejected, i.e. there is no difference between the perceived project complexity contributing factors with project type.

8.4 Summary and Conclusion – 2nd Phase Questionnaire

This chapter presented the details of the 2nd phase questionnaire, the purpose of this questionnaire was to test the hypothesis and to validate and triangulate the findings of the previous studies specially the 2nd phase interviews. The discussion in this section is divided into parts, firstly the discussion of the results in conjunction with the 2nd phase interviews and secondly in relation to the previous studies and the research questions. The results of this study are summarised below prior to their comparison to the previous studies.

The questionnaire was distributed at two sites 'B' and 'D' which were located at two different geographical locations. Since the interviews were done mostly at site 'B', the questionnaire were distributed to practitioners who had not participated in the interviews but were working in most of the projects which were discussed in the interviews, which helped in validating the findings of the results on a bigger sample. Site 'D' was selected for it had similar project settings and the types of projects as those at site 'B', thus helping in generalising the findings to some extent. The total of 53 questionnaires were received resulting in an overall response of 27%, with 18% response from site *'D'* and 35% response from site *'B'* respectively.

The results are summarised as follows,

- **Factors contributing to project complexity – most significant**
    - Partnerships
    - Novelty
    - Requirement Capture
    - Stakeholders

- **Key Project Management Processes**
    - Stakeholder management
    - Scope Management
    - Requirement Capture
    - Change control
    - Communication
    - Planning
    - Soft Skills

- **Project Critical Success Factors**
    - Senior Management Support
    - Clear Objectives
    - Influence and Relationships
    - Trust
    - Leadership
    - Team Motivation
    - Communication

Non-parametric tests, Man-Whitney U and Kruskal-Wallis Test, were done to test the hypothesis. However in this case the factors that emerged out of the 2nd phase interviews were used to test for differences whereas project complexity groups were compared in the 1st phase questionnaire. In all of the statistical tests done to test the hypotheses, statistical difference was not found except for the following factors,

- There was a significant difference found in the perception of level of impact of project complexity factors 'partnerships' and 'geographical location', with independent variable 'location'.

- There was a significant difference found in the perception of level of impact of project complexity factor ***'novelty'*** with age.

- No significant difference in the perception of the level of impact of the project complexity factors were found with work experience, work role, project type.

In the next section, the results of the questionnaire are discussed in conjunction with that of the 2nd phase interviews, as these two are interlinked.

8.5 Comparison of Results of 2nd Phase Questionnaire with 2nd Phase Interviews

8.5.1 Factors contributing to project complexity

In the 2nd phase interviews, the respondents were asked to list down the factors that affect project complexity based on their experience of working in project (s) deemed complex by them. The same factors were then used in the questionnaire to establish their validity and to assess any variation of them, such as within the company. Comparing the factors which are rated to have a high level of impact is as follows,

Factors contributing to Project Complexity	2nd Phase Interviews (%)	2nd Phase Questionnaire (Median)
Partnerships	81%	3
Novelty	75%	3
Requirement Capture	56%	3
Stakeholders	56%	3*

(- Based on experience)*

Table 8-24: Comparison of most significant complexity factors between the 2nd phase studies

It can be observed from the above Table 8-24, that there is no variation in the perception of project complexity factors in either of the studies

8.5.2 Contextual Influence

However, the contextual dependence on the perception was found in factors partnerships and geographical location only, whereas there was no difference in the perception of the rest of the factors based on location. This can be attributed to the fact the projects at Site 'B' the majority of the major projects are based on partnerships which are located at different geographical locations, and the practitioners' working there recognise the impact of these factors on project complexity. The rest of the factors are common across sites rather common to the organization, as the project settings and organizational environment is the same.

8.5.3 Key Project Management Skills / Processes

Key project management processes / skills in terms of managing complex project listed in this questionnaire were the ones compiled on the basis of the analysis of the 2nd phase interviews with the objective to validate them through the questionnaire. The responses for key management skills were qualitatively analysed. The results of the two studies are compared in the Table 8-25, below, showing only the factors which were reported to be most useful in managing project complexity.

Key PM Processes	2nd Phase Interviews (%)	2nd Phase Questionnaire (Median)
Soft Skills	100%	3
Scope Management	75%	3
Stakeholder Management	75%	3
Communication	44%	3
Requirement Management	38%	3
Change Control	38%	3
Planning	13%	3

Table 8-25: Comparison of most significant Key PM processes between the 2nd phase studies

It can be seen from the table that there is recognition of soft skills as key project management aspect in managing complex programs, which supports the fact that 'people group' have a significance impact on project complexity. The other factors which were reported to be important in the 2nd phase interviews had a similar importance given in the questionnaire. The only difference that emerged was the planning process, as it can be seen from Table 8-25 that in the questionnaire it was given high significance whereas based on the results of the interviews only 13% respondents reported it to be important. One of the reasons for this could be that the focus of interview revolved around project complexity and other processes had been given more importance in that context, whereas in the practitioners in the questionnaire were working on different type of projects related more to support and services as compared to the NPD projects in the interviews. Support and services projects are more 'planning' driven as compared to NPD. However, all the other factors were given an equal importance in the two studies which could be due to the similar organizational environment and project context.

8.5.4 Project Critical Success factors

Project critical success factors highlighted by the 2nd phase interviews were tested through the questionnaire for their validity and consistency. Project critical success factors were asked in the 2nd phase interviews in conjunction with the project complexity and key project management skills. The results of the two studies are compared in the Table 8-26 below, showing only the factors which were reported to be critical for project success.

Project Critical Success Factors	2nd Phase Interviews (%)	2nd Phase Questionnaire (Median)
Clear Objectives	75%	3
Influence and relationships	63%	3
Senior Management Support	56%	3
Team Motivation	44%	3
Trust	44%	3
Leadership	25%	3
Communication	13%	3

Table 8-26: Comparison of key CSFs between the 2nd phase studies

The factors with median 3 signifying high level of usefulness are listed in the Table 8-26, although all the remaining factors had a median of 2 signifying medium level of usefulness on a 'low-medium-high' scale. 'Communication' as a success factor was rated high in the questionnaire as compared to the interviews, the reason for this could be that in the interviews the respondents had highlighted communication as a key process and may not have reported it again in response to critical success factors. It is a similar case with 'Leadership', for it was mentioned as a key process when respondents were discussing the importance of 'soft skills' and for this reason they might not have repeated it again. Also, in the interviews, the 50% of the respondents were 'project executives' and 31% were program managers, majority at a senior level and/or managing project teams and intuitively practicing leadership and so they might have by chance not reported it.

Chapter 9

Discussion, Conclusions and Recommendations

9.0 Introduction

In this chapter the results and analysis of the four studies namely, the 1st phase interviews and questionnaires, and the 2nd phase interviews and questionnaires have been summarised and discussed in relation to each other and holistically. The findings of this research have been compared with previous research and its implications to academic and industrial perspective have been highlighted. In the end of this chapter, limitations of this study have been discussed and recommendations have been made for future research.

9.1 Summary - The four research studies

One of the main objectives of this research was to develop a better understanding of project complexity and to fill the perceived gap between project management theory and practice. This required a thorough review of the existing literature on complexity and project complexity, and also an update on the research on project complexity which has been presented in Chapter 2 along with the literature review of the supporting areas to this research presented in Chapter 3. In order to understand the pragmatic view, exploratory and in-depth studies were done which were divided into two phases namely Phase I and Phase II. The purpose of Phase I interviews and questionnaire was to establish a basis for the pragmatic view and that of the Phase II was to further validate it by exploring the project actuality.

Table 9-1 shows the research areas that were explored in each study.

	1st Phase		2nd Phase	
	Interviews	Questionnaire	Interviews	Questionnaire
Research Focus	*Exploratory Study*		*Case Study*	
Perception of Project Complexity / Complex Project	√	√	√	
Factors Contributing to project complexity	√	√	√	√
Key PM Aspects in managing complex project	√		√	√
Project Critical Success Factors for complex projects	√		√	√

Table 9-1: Research focus addressed in different research phases

As it can be seen from Table 9-1 that maximum effort was done to explore the research areas in each of the phases in order to validate and triangulate the findings. All the studies were interlinked, one leading to the other and the results and conclusions were gradually built upon as the focus of the research narrowed down as the studies proceeded. The findings of each of the study in relation to the research areas have been summarised for a quick overview in Table 9-2 below

		1st Phase		**2nd Phase**	
		Interviews *(Chapter 5)*	**Questionnaire** *(Chapter 6)*	**Interviews** *(Chapter 7)*	**Questionnaire** *(Chapter 8)*
Research Objective(s)	***Objective Achievement***	***Exploratory Study***		***Case Study***	
To investigate the pragmatic view of project complexity to establish a better perspective of project complexity	Pragmatic perspective on project complexity was highlighted in terms of people, product and process.	• Importance of 'People', 'Product' & 'Process' relationship to project complexity • Interactions and Interdependencies	• People as most significant • Product as least significant	Important characteristics: • Interfaces / Interaction, • Interdependencies, • Novelty / Uncertainty • No variation with age, work experience	
To investigate the factors contributing to project complexity in actual project settings	Factors contributing to project complexity were highlighted in terms of people, product, and process and the relationship of these factors with the project context was established.	Factors highlighted and stratified in terms of product, process and people Perception of factors influenced by • project context • number of projects • work discipline	• Perception of complexity groups influenced by Work Discipline (Context) • Perception of complexity groups influenced by PM Qualification / Certification,	• Similar factors reported as in phase 1 • No variation with age, work experience • Levels of project complexity	• Similar results in terms of factors • Perception of Factors influenced by Work location (Context) • Perception of Factor influenced by Age
To identify key project management processes and skills required by project managers to manage project complexity	The importance of soft skills was highlighted and the importance of managing people interfaces and change management was established	• Emphasis on Soft Skills		• Soft skills – to manage people – Interfaces, interdependencies, Novelty • Hard Skills- to manage change	• Similar results as reported in 1st Phase
To identify critical success factors, useful for the practitioners managing complex projects	New CSFs were highlighted in relation to project complexity, which were not reported in the previous researches.	• Similar to published research		• Influence & relationship • Trust • Flexibility • Delegation	• Similar results as reported in 1st Phase

Table 9-2: Summary of research findings phase wise and research objective achievement

The details of each study has been presented and discussed in the respective chapters. However Table 9-2 highlights the relationship between the phases and the similarity in their results, as the findings of the 1st phase studies were reconfirmed by that of the 2nd phase. However, there were some limitations of this study which have been discussed in section 9.3.

The findings of each study related to the research areas are discussed below.

- **Perception of Project Complexity / Complex Project**

The key characteristics of the complex projects were found to be interface, interdependency and novelty related to people, product and process. Based on the analysis of the 1st phase interviews and the literature review, the complexity triangle based on people, product and process groups was proposed. In the 1st phase questionnaire, the impact of the perceived complexity groups was assessed through the questionnaire, resulting in as people side being recognised as having the most significant role in contributing to project complexity. In the 2nd phase interviews, similar results were observed however 'novelty' was highlighted as one of the key aspects of project complexity related to people, product and process. It was also observed in the results of the 2nd phase interview that there was no difference in the perception of project complexity within the interviewees, meaning by there was no variation in the perception of complexity observed with practitioner's age and work experience. The reason for this finding could be that all the practitioners were working in the same context i.e. organizational environment and project settings, and which is also highlighted in the first phase interviews.

- **Factors contributing to project complexity**

This was an important aspect of the research as one of the objectives was to highlight the factors related to proposed people, product and process groups which contribute to project complexity. The 1st phase interviews along with the literature review, helped to generate a list of factors which were then stratified into the project complexity groups. It was also observed in the initial interviews that the perception of these factors were related to project context, which was further verified by the analysis of the 2nd phase interviews, as no variation in the perception of the factors were seen within the respondents, regardless of age, work experience and management levels. In the results of the 2nd phase questionnaire, the perception of factors, partnerships and multiple sites had significance with work location whereas novelty had significance with age, the reason for which can be related again to project context. The qualitative analysis highlighted that the significant factors contributing to project complexity were similar in all the studies; however there were some variations in their rankings.

- **Key project management aspects in managing complex projects**

In the first phase interviews the participants were asked to highlight the importance of soft and hard project management skills in relation to project complexity, invariably importance of soft skills was highlighted, which was then further explored in the 2nd phase interviews and questionnaires. The results of these studies highlighted the recognition and importance of soft skills in the perspective of managing complex projects, which was further established by the recognition of the process stakeholder management. The most significant PM processes highlighted focused on two aspects, first managing interactions and interdependencies between people and second minimizing changes and deviations during the course of project, as these both aspects have been found from this study to have an impact on project complexity. The recognition of soft skills in relation to project complexity is supported by the fact that 'people' were recognised as the most significant project complexity contributing group.

- **Project Critical Success Factors**

In the 1st phase interviews the respondents were asked to group the critical success factors according to approach introduced and used by Belassi and Tukel (1996), however for later studies the respondents were simply asked to list the factors. In the 2nd phase interviews, project critical success factors were discussed as the practitioners realise their importance and impact in the actual project settings. A list of factors was compiled which was further validated through the 2nd phase questionnaire. The critical success factors reported to be highly significant were the same in both the studies. However, factors particular to the case study, reported in view of project complexity were influence and relationship, trust, flexibility, and delegation. Assessing these factors in relation to project complexity, it can be seen that all of these factors are important in managing human interfaces within the project organizational structure and also to manage uncertainty arising in projects due to novelty related to product, process and / or people.

The inter-relation between the studies and their results have been highlighted and briefly discussed to recap the findings of the studies. The next section presents the conclusions of this research which are presented research area wise.

9.2 Conclusions and Discussion

The conclusions of this research are presented based on the analysis of the research and the literature review on the subject. The primary focus of the research is on better understanding and managing of project complexity. Key project management process and project critical success factors are discussed in the context of project complexity.

- **Project complexity**

Based on the analysis of the literature and the research studies, following conclusion can be drawn regarding project complexity,

- Project complexity is mainly linked with the interactions and interdependencies between the project elements and is also strongly related to the novelty issues related to them.

- Interdependency, interface and novelty issues related to people were found out to be the most significant and which is also supported by the fact the project actuality is '*characterized by tensions between unpredictability, control and collaborative interactions among diverse participants on any project' (Cicmil et al., 2006)*

- Perception of complexity and its factors are influenced by context, where as no statistical significance with age and experience was found

The interview studies helped in getting a better understanding of pragmatic view of project complexity, as the respondents were able to explain their opinions in detail and in conjunction to their work experience. The differentiating factor between complex and complicated projects was found to be 'novelty', which was related to the project elements, and it is the unknown/uncertainty element arising from it which in turn contributes to project complexity. Within the project elements – people, product and process, the most significant reported by the respondents was the people side (stakeholder, partners, clients, supplier, customer, project teams etc). This aspect is also reflected by the importance of 'soft skills' as key project management skill, and 'influence and relationship' as the key project critical success factor. The perception of project complexity and its contributing factors are seemed to be dependant on the project context, starting from the organization in a higher level, to work location and work discipline at the lower level, as no distinctive statistical significance with respondents' age, work experience and with qualifications was found from this study apart from one off factors which again had to do with the contextual issues. One of the reasons for this could be that all the respondents were working in the same project and organizational settings so regardless of age and experience, they were familiar with the complexity contributing factors related internally and externally to project and organizational settings. However the perception of novelty seems to vary with work role, as the senior managers have more recognition and realization of the dimensions and impact of novelty as compared to junior managers, due to the fact that at different levels in project and people have different interactions, interdependencies and exposure, as highlighted in Figure 9-1. It can be perceived that the same factor(s) has different dimensions at different project management and project working levels as shown below, as there will be different 'ROIs' – such as 'Return on Investment' at the top level and 'Return on Interest' at the lower level.

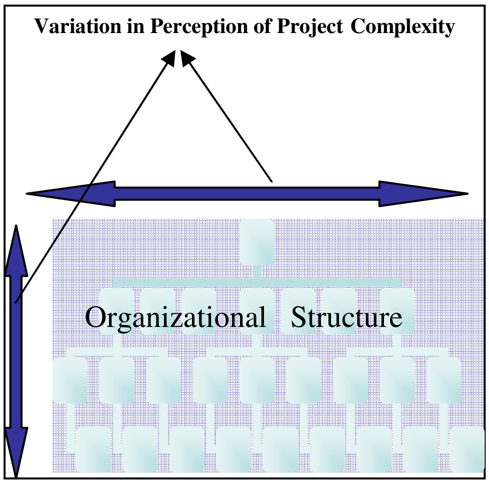

Figure 9-1 : Levels of Project Complexity

Finally, based on the interviews it was observed that project complexity was not formally assessed at the start and during the course of project, and also that the majority of the practitioners were not aware of the existing project complexity assessment tools and those who were aware of such tools did not find them practical and useful.

- **Key project management aspects in managing complex projects**

The objective of this question was to find out the key project management processes/skills considered important to manage project complexity. The focus was to highlight key processes which were important in specifically managing project complexity, although there would be other important processes to manage project in general however the processes reported were based with the focus on managing project complexity. The two aspects which influenced the perception of key management process in the context of project complexity were, 'people' and 'project dynamics'. The people side as mentioned earlier was prominent in the perception of factors contributing to project complexity, and was deemed to be the most significant factor. The recognition of soft skills, stakeholder management and communication as the most significant skills and processes were in line to the findings related to project complexity, as these are critical processes in managing interfaces and interdependencies between people and also the novelty of their relationships. The other project management processes reported focused on the ‘project dynamics’ i.e. the changes occurring in project such as in project plans and project settings, project teams, changes related to product and its related processes etc. Reported processes like gated reviews, scope management, requirement management, change control, focused on this aspect as they facilitate in managing changes and maximizing clarity in terms of process and products, which in turn reduces ambiguities and uncertainties in projects. The lesser the changes/unknowns lesser will be the uncertainties, and in turn minimal effects it would have on people and their interfaces and interdependencies. It is important to mention here that these process have specific importance in managing project complexity, however for the project to be successful, other hard management processes are equally important.

- **Project Critical Success Factors**

The objective for this question was to find out whether there are any specific critical success factors related to project complexity. The critical success factors reported were based on the 2nd phase interviews and questionnaire, which were compiled through the interviews and were validated through the questionnaire, however they were specific only to this case study. The comparison of these CSF with the previous research highlighted factors which were specific to this research. The factors reported by this research and were not reported earlier in the reference literature included, *‘influence and relationship’, flexibility, delegation, team location and trust.* Analysing these factors, ‘influence and relationship’ and trust are important in managing stakeholders internally and externally, and flexibility and delegation is an important aspect when there multiple teams located at different locations as one then require to delegate authority to ensure smooth running and also flexibility specially when there is an element of novelty present in projects.

Summarising the objectives for this study which were to have a better understanding of project complexity by exploring the ‘actuality’ of projects to understand the projects' social and dynamic setup. And also based on this understanding and the experience of practitioners, to identify not only the factors contributing to project complexity but also providing key project management process and critical success factors in relevance to project complexity. In this regards maximum effort was done to grasp and understand the context by getting feedback from practitioners. However, the analysis and conclusions drawn from this research were based on certain limitations and assumptions, which are discussed in the next section.

9.3 Limitations of the Study

This research had a few limitations which restricted its potential for generalization; however the pragmatic approach was adapted with the aim to provide a better understanding of project complexity beneficial for both academics and practitioners.

The first and the foremost limitation was the time constraints, related to both the researcher and respondents, which for the latter was indicated to some extent by the low feedback from the practitioners and/or availability for the interviews, and for the researcher by specific duration to finish this research which was due to financial reasons and academic regulations.

As the research was limited to the case study carried out in a leading European aerospace organization, so the findings were specifically related to this organization in particular, and thus cannot be generalised for the aerospace industry in particular and other industries such as construction, IT, automobile etc. This was one of the main factors which restricted its potential for generalization. The samples for the 1st phase were drawn from various sectors which gave a starting baseline for the generalising this research, however in the case study, the focus was particularly on a company in an industry.

The response for the questionnaire was relatively low and the number of interviewees was also less in the first phase, which might have depicted a limited picture and/or might have reduced the accuracy of statistical analysis. However in the second phase interviews although the number of interviews was less but the sample was highly relevant and suitable providing valuable feedback and all efforts have been done to present their view point in the truest form. As validity comes from the authenticity of interpretation and authenticity means giving a fair, honest and balanced account of the studied phenomenon “from the viewpoint of someone who lives in it everyday” (Neuman, 2000).

In both the phases of this research the data was obtained through interviews and questionnaires. In the first phase a limited number of interviews were done to establish a baseline for the research; however it may have presented a narrow perspective which could have been better explored by making use of focus groups. Focus groups would have helped to establish different point of views, as discussions would have highlighted various perspectives which might have not been highlighted in one to one interviews.

The perception of project complexity and its contributing factors presented in this research focused on getting practitioners’ point view based on their experiences in working in different projects. This resulted in developing a better understanding of project complexity however it lacked to capture the variation of project complexity over a certain time period in the project life cycle. This could have been done in the phase II case study and observations over a specific project cycle phase could have been ivestigated to find out the variations and the impact of project contributing factors over the project life cycle.

9.4 Contribution of this research

The research study has some significant academic and practical implications in the area of project complexity in particular and to a limited extent aerospace industry in particular. The research was undertaken with the objective to explore the perceived gap between project management theory and practice and to list down key project management processes/skills and critical success factors which are useful for the practitioners. This research not only highlighted the pragmatic perspective but also categorised the factors contributing to project complexity. Key project management processes/skills were in line to this perspective and the factors highlighted. This in-depth discussion with the practitioners resulted in a few critical success factors which have not been reported in the previous research and are important specially for complex projects. The next sections elaborate on the above.

9.4.1 Academic Perspective

The importance of project complexity is on the rise; however the theoretical perspective still lacks in defining it in a meaningful way which is relevant to project management practice. As this is attributed to limitations in addressing the dynamic, social and complex contexts of projects due to a hard systems approach (Winter et al., 2006). In addition, the Bodies of Knowledge (BoKs) have been criticised as being focusing on hard aspects, being based on linear, analytic and rational approaches, emphasizing planning and control, and focusing more on the hard skills than the soft skills.

In terms of project complexity, this research attempted to link the theoretical and industrial perspective of project complexity, as there were few research papers focusing on project complexity that too categorising project complexity and lacking to provide details of its contributing factors/areas. The contributions in regards to the perception are,

In terms of project complexity,

- Recognition of ‘novelty’ as one of the main characteristic of a complex project was highlighted through this study, which is related to people, processes and product, as opposed to the novelty of technology, which is generally the focus of the previous research. Also uncertainty has been highlighted as the main differentiating factor between complex and complicated projects.

- The influence of context on the perception of on project complexity and its factors has been highlighted throughout this research and it has been shown through statistical analysis that there is no difference in the perception of complexity and its factors with respondents' age and experience; however this finding is restricted to the case study at the moment.

- The significance of 'people', in conjunction to project complexity has been highlighted in this research, which also supported by the findings of key project management processes and critical success factors, signifying their importance with complexity perspective. These findings also highlight the importance and relevance of Stacey's (1996) Complex Responsive Process of Relating (CRPR) in better understanding of project complexity.

- Based on the proposed 'complexity triangle', the factors contributing to project complexity have been highlighted, which are based on the experience of practitioners' experience of working in project actuality, and have been ranked in importance to their practical significance. Also the contextual influence in their perception has been shown through this research

In terms of key management process and skills,

- The importance of soft skills in conjunction with project complexity has been highlighted and the key project management process which need special attention have been identified (although may be specific to aerospace organization in the case study) and are related mostly to stakeholder management through effective and timely communication. In addition, the processes important to track and manage changes in the project have been highlighted as key processes for complex projects.

In terms of project critical success factors,

- The factors which emerged out of this study and were not cited in the Fortune and White (2006) research based on 63 publications, were *'influence and relationship', flexibility, delegation,* thus highlighting their importance and practical implications in regards to complex projects and are in line and support of the CRPR concept. This again highlights the importance of taking into consideration the project actuality in order to address the social and dynamic processes encompassing the project environment.

Summarising the above, the perceived gap between PM theory and practice, needs to be addressed by giving more importance to the social and dynamic project settings. Many researchers have identified the lack of importance given to the soft skills and which is again highlighted by this research as an important aspect of managing projects especially complex projects. Secondly, courses like 'Project Management in Practice' be introduced, which are based on the various research finding, help reducing the gap between theory and practice and prepare project managers with the awareness of all the intricacies of 'project actuality'.

9.4.2 Industrial Perspective

There implications of this research have significance importance for the industry, particularly the case study organization.

This research has tripartite advantages as it not only highlights the source of complexity but highlights key project management aspects and critical success factors necessary for its management and eventually for the success of the project. The first and the foremost aspect is realising the importance of assessing project complexity and developing a framework suitable for an organization tailored to its project settings which shall provide meaningful and useful ways to give awareness of the 'complexity hotspots', which can be understood and assessed and only then proper planning can be done to manage them. Secondly, based on this comprehensive assessment a suitable project/program manager can be assigned keeping in view the expertise required based on the nature of complexity in the project. This research has provided a starting point by systematically identifying the complexity factors which can then be used in the complexity assessment framework. However these need to be further investigated across other areas and projects within the case study company in order to have a consolidated list of factors and test its reliability and validity. And then later on broader research can be done which is industry specific.

The factors contributing to project complexity have been consolidated and have been presented in terms of the project complexity triangle framework, i.e. in terms of people, product and process, so that the impact of these factors in relation to these can be highlighted to better understood in each category. This again provides better understanding of project complexity and in turn facilitate in making a meaningful framework. This proposed framework when further developed, is envisaged to provide organizations a kind of checklists to identify and assess 'project complexity hotspots' at the initial planning stages so that they can be managed in an effectively .

9.5 Recommendations for Further Research

As mentioned earlier, due to time limitations, not all of the emerging dimensions of this research were explored, as various aspects unfolded during the course of this research. The areas which require further exploration in order to generalise this research and also which have not been addressed by this research due to paucity of time are highlighted below,

i. The perception of complexity and the factors are based on analysis done in one company, in order to validate and establish the factors for the aerospace industry; it is recommended that similar research may be done in other aerospace companies in Europe, so that generic factors pertaining to aerospace industry can be established. This will not only help to validate the contextual aspect and but would also help to investigate any possible variations. And after establishing this it can be then validated for the aerospace industries across the globe.

ii. The variation of perception of complexity at different organizational levels was identified through the research but was not fully explored. It is recommended that further research be done to investigate the variation of complexity at different managerial levels within the organization.

iii. A need for more robust and practically meaningful tool/framework for the assessment of project complexity is required, as recommended by the practitioners also. This should focus more on highlighting the complexity areas, either company specific or industry specific, providing awareness and highlighting 'complexity hotspots' so that better and effective management can be done.

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Appendix 'A' – CIFTER Table

Crawford-Ishikura Factor Table for Evaluating Roles (CIFTER)

Project Management Complexity Factor	Descriptor and Points			
1. Stability of the overall project context	Very high (1)	High (2)	Moderate (3)	Low or very low (4)
2. Number of distinct disciplines, methods, or approaches involved in performing the project	Low or very low (1)	Moderate (2)	High (3)	Very high (4)
3. Magnitude of legal, social, or environmental implications from performing the project	Low or very low (1)	Moderate (2)	High (3)	Very high (4)
4. Overall expected financial impact (positive or negative) on the project's stakeholders	Low or very low (1)	Moderate (2)	High (3)	Very high (4)
5. Strategic importance of the project to the organisation or organisations involved	Very low (1)	Low (2)	Moderate (3)	High or very high (4)
6. Stakeholder cohesion regarding the characteristics of the product of the project	High or very high (1)	Moderate (2)	Low (3)	Very low (4)
7. Number and variety of interfaces between the project and other organisational entities	Very low (1)	Low (2)	Moderate (3)	High or very high (4)

Appendix ‘B’ – 1st Phase Interview Guide

1). <u>How would you define a complex project? Or What would you say is meant by the term “Complex Project”?</u>
✓ Could you say what forms the basis for your definition of complex project?
✓ Based on your definition, how would you differentiate between a complex and non-complex project? *[Factor (s) identified variably are exhibited in all project; how do these factors add to complexity?]* *[Can you give example for the Complex & Non Complex Project]*
✓ Based on your experience and/or perception can you identify the types of complexity that exist in projects
✓ Based on your experience/perception does a project exhibit all types of complexity that have been identified? *[If Yes: What is the reason for exhibiting all types of complexity?* *<u>What is the variation of the types of complexity with industry sectors</u>?* *What is the variation of the types of complexity <u>with Project Types</u>?]* ✓ *[If No: What is the reason for not exhibiting all the types of complexities?]*
2). <u>Based on your experience and/or perception what are the project internal & external factors that contribute to project complexity?</u>
✓ Could you say what forms the basis for the identification of these factors?
✓ Based on your experience and/or perception how do the factors you have identified contribute to project complexity and/or make it complex? o *Refer to Complexity Factor Sheet*
✓ Based on your experience and/or perception how do the factors you have identified contribute to the types of complexity?
o <u>Based on your experience and/or perception, is it possible to assess project complexity at</u>

start of project?
o What forms the basis of this assessment? Or How is project complexity assessed?
o Based on your experience and/or perception, how accurate was this assessment? ✓ *What is the reason for the variation*
3). Based on your experience and/or perception, how does project complexity vary with Project Life Cycle?
✓ Based on your experience and/or perception can you identify the reason for variation of Project Complexity with Project Life Cycle?
4). In your opinion what is the effect / impact of complexity on Project Management?
✓ Based on your experience / perception, what are the best practices to manage project complexity? Or ✓ Based on your experience / perception which PM aspects (hard and/or soft) play an important role in managing complex projects?
✓ In your opinion will these practices will vary for different types of Project Complexity?
Project Success **5).** Based on your experience / perception, how would you define project success?
✓ Could you say what forms the basis for your definition of success?
✓ Keeping in view your definition, in your opinion, will it hold true for all projects?
✓ In your opinion what is the impact of project complexity on project success Or ✓ Impact of Project Success on Project Complexity?
6). In your opinion, what is the measure for project success?
✓ *In your opinion, what is meant by successful project*   *(Based on the previous questions reply)*
7). Based on your experience / perception, which project elements (internal and external) are critical for project success?
✓ In your opinion, what is the relative importance of the project elements you identified which are critical for project success with each type of complexity?
✓ Based on your experience / perception, what is the variation of the project elements previously identified with project complexity?   *[If yes how, why…..* *[If No, then why….*
8). In your opinion, what are the critical determinants of each group identified in the previous question? *Refer to CSF Table*
In your opinion, the critical determinants identified would hold true for all projects
What is the variation of these determinants with project complexity and its types?

Factors Contributing to Project Complexity

Questionnaire

This questionnaire will take approximately 15 minutes to complete. These data are gathered in confidence and shall not be communicated in a form that would identify participants without permission. In order to carry out some follow up interviews, it would be helpful to have your contacts, but it is stressed that this is optional. Please use a **'X'** to mark your answers where applicable.

Personal Information

Biographical Data

1. **Name (Optional):-** ____________________________________

2. **Your Gender:-** Male________ Female__________

3. **Your Age:-** Under 30_______ 30-40________

   41-50_______ Above 50______

4. **Contact (Optional): email:**___________________________________

   Telephone: __________________________

Qualifications

5. **Your Academic Qualification(s) and subject(s):** *(Non Project Management)*

   Bachelor Degree___________ Master Degree______
   ______

   Doctorate Degree__________ Other ____________

6. **Any formal Project Management Qualifications / Certifications:**

APM level:- ______________ PMI level: _________

Academic/ Other: ____________________________

Job Experience / Role

7. **Company:- ______________________________**

8. **How would you describe your work discipline?**

Engineering __________ Management__________

Finance__________ Computer/IT__________

Marketing__________ Other__________

9. **What is your total work experience:-**

Under 3 years: ____________ 3 – 6 years: ____________

7-10 years: ____________ 11-15 years: ____________

16-20 years: ____________ Over 20 years: ____________

10. **Which of the following organizational contexts have you worked in?**

Functional ____________(years)

Matrix ____________(years)

Project ____________(years)

11. **Which of the following Project Types have you worked in?** *(Please just put 'X' mark to the ones applicable)*

Type 1 (**Goals and Methods** to achieve the projects **well defined**) : _______

Type 2 (Goals well defined, **Methods not well defined**): _______

Type 3 (Methods well defined, **Goals not well defined**): _______

Type 4 (**Methods and Goals not well defined**): _______

12. Based on your experience, please rank the following areas according to the importance in which they affect/contribute to project complexity?

(1= Most Significant; 2=Significant; 3=Least Significant)

People *(e.g. Project teams, stakeholder, client suppliers, etc)*

____

Product / Service *(e.g. Technology)*

____

Process *(e.g. Management, Technical, Engineering)*

____

Factors contributing to Project Complexity

12. People

This takes into consideration, project managers, project teams, stakeholders, clients, suppliers encompassing human factors, internal and external to projects. ***The factors listed below are envisaged to affect project complexity. Based on*** ***<u>your experience</u> please indicate, by placing a "X" on each line, the level of impact of each factor on overall project complexity.***

Factor		Level of Impact on Project Complexity			
		Low	Medium	High	Not Applicable
a	Number of teams / departments involved				
b	Diversity of teams / departments involved				
c	Number of Clients / Suppliers				
d	Diversity of Clients / Suppliers				
e	Number of stakeholders				
f	Geographical Location of the team(s)				
g	Technical knowledge of Project Manager				
h	Technical knowledge of team(s)				
i	Team Maturity *(Experienced team members working together for considerable duration)*				
j	New team				
k	Project Management skills of Project Manager				
l	Relationships between team members				
m	Lack of senior management support				
n	Lack of leadership				
o	Lack of team cohesion				
p	Lack of team motivation				
q	Lack of communication within the team				
r	Lack of coordination within the team				
s	Lack of agreement on objectives between stakeholders				

t	Inadequate skill base				
u	Shared resources				
v	Cultural and Cross-cultural issues				
w	Company Politics				
x	Multidisciplinary team(s)				

13. Product

This takes into consideration, the end-deliverable of the project. The factors related mainly encompass the technology involved (novelty, difficulties in the design processes, the number of sub-systems (their interactions and interdependencies) and the uncertainty related to technological aspects.

The factors listed below are envisaged to affect project complexity. Based on your experience please indicate, by placing a "X" on each line, the level of impact of each factor on overall project complexity.

Factor		Level of Impact on Project Complexity			
		Low	Medium	High	Not Applicable
a	Time to market				
b	Number of sub-systems				
c	Variety of technologies				
d	Newness / novelty of technologies required to deliver the product				
e	Technical Design Difficulties				
f	Lack of clear product specifications				
g	Number of processes				
h	Variety of resources required				
i	Variety of technology dependencies				
j	Variety of methods to achieve product				
k	Variety of technological skills required				
l	Technological process dependencies				
m	Maturity of technology				

n	Bespoke Product/service				
o	Impact of design of one assembly on the other				
p	Concurrency				
q	Zero rework tolerance				
r	Number of iterations to refine the product				
s	Number of product assemblies				
t	Number of components				

14. Process

This takes into consideration, the project management and engineering / technical processes required to achieve the project end objectives / deliverables. Both these processes are simultaneously taking place in different phases of the project life cycle, and can affect project complexity. The processes if not properly followed and/or adhered to, are perceived to affect project complexity.

The factors listed below are envisaged to affect project complexity. Based on your experience please indicate, by placing a "X" on each line, the level of impact of each factor on overall project complexity.

Factor		Level of Impact on Project Complexity			
		Low	Medium	High	Not Applicable
a	Project Success and benefits management				
b	Stakeholder management				
c	Value management				
d	Project management plan				
e	Project risk management				
f	Scope management				
g	Scheduling				
h	Resource management				
i	Budgeting and cost management				
j	Change control				

k	Earned value management				
l	Information management & reporting				
m	Issue management				
n	Requirements management				
o	Technology management				
p	Value engineering				
q	Project financing and funding				
r	Procurement strategy				
s	Legal awareness				
t	Project life cycles				
u	Project reviews				
v	Organization Structure				
w	Organization roles				
x	Methods and procedures				
y	Governance of project management				
z	Communication				
aa	Team-working				
ab	Leadership				
ac	Conflict management				
ad	Negotiation				
ae	Human resource management				
af	Behavioural characteristics of team members				
ag	Professionalism and ethics				
ah	Organizational Policies				
ai	Prototyping / Production Process				
aj	Production Technologies				

15. Can you think of any additional factors which are not listed in the above tables, and based on your experience can affect project complexity.

People:

Product:

Process:

Other:

If you have any further comments, please continue overleaf.

THANK YOU VERY MUCH FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE

Once you have completed this questionnaire, please hand it over to the module coordinator or post to Prof A W Gale, Room E11/12, Pariser Building, Sackville Street, P.O. Box 88, School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, Manchester, M60 1QD

Appendix ‘D’ – 2nd Phase Interview Guide

Purpose

The aim of the interview is to explore qualitative anecdotal self reported information from project practitioners in the industry. There are two aspects to my research, first to get a pragmatic view on Project Complexity, its types and the factors which contribute to project complexity and second to determine the critical success factors for complex projects and their relationship with the types of complexity.

Confidentiality Agreement

It is important that participants understand that the information given in the interviews is confidential to The University of Manchester. The University of Manchester is fully aware of the importance of maintaining anonymity of individual delegates. No individual will be referenced, identified or comments attributed to them by name without the express written permission of the participants themselves.

Section I

Biographical Data

1. Name :____________________________________

2. Your Gender: Male________ Female__________

3. Your Age: Under 30_______ 30-40________
   41-50_______ Above 50______

Section II

Qualifications

4. Your Highest Qualification:

   Bachelor Degree__________ Master Degree__________

Doctorate Degree__________ Other__________

5. Your Highest Academic Discipline:

Engineering __________ Management__________

Finance__________ Computer/IT__________Other__________

6. Your Project Management formal Qualification:

IPMA level __________ Other__________

Section III

Company Information

7. Company _______________________

8. Business Sector ___________________

Section IV

Job Experience / Role Current Project

9. What is your Job Title?___________________

10. What is the current project you working on?

11. What is your Job Function (Current Project)?___________________

12. How long have you been involved with the Current Project?_____ _________________

13. What is your total Work Experience in years? _____________________

14. How many years experience do you have in :

Project Management _Functional Management_____

15. How many Projects you have actively participated specially the planning and execution phases:

____

16. And in what capacity?

*Technical*______________*Management*________

Section V

Project Complexity (general)

- ✓ How would you define a complex project? Or What would you say is meant by the term "Complex Project"?
- ✓ Based on your definition, how would you differentiate between a complex, complicated and simple project?
- ✓ Based on your experience and/or perception, is it possible to **assess** project complexity at start of project?

Project Specific (Current Project)

- ✓ What is the project type? (NPD, D&D)
- ✓ Duration of the Project?
- ✓ Is the project divided into phases?
- ✓ Which phase the project is currently in?
- ✓ In which phase did you join the project?
- ✓ Your role in the project?
- ✓ How would you categorise this project as complex or complicated?

- ✓ Based on your experience and/or perception can you identify the factors that contribute to project complexity?

Or

- ✓ What are the factors which give rise to complexity?

Or

- ✓ What *is the source of complexity in projects?*

- ✓ Based on your experience and/or perception how do the factors you have identified contribute to project complexity and/or make it complex?

- ✓ What is the variation of the impact of the factors indentified with Project Life Cycle and its reason?

- ✓ Was project complexity assessed at the start of the project and how was it assessed?

- ✓ Based on your experience and/or perception, how accurate was this assessment?

Best Project Management Practices

- ✓ Based on your experience / perception, can you indentify the important PM processes which you think are important for managing a complex project?

Or

- ✓ Based on your experience / perception which PM aspects (hard and/or soft) play an important role in managing complex projects?

Project Success

- ✓ What was the success criterion for the project?

- ✓ Based on your experience / perception, which project elements (internal and external) are critical for project success and what are their critical determinants?

Factors Contributing to Project Complexity (Questionnaire Overview)

Purpose

The aim of this questionnaire is investigate the relationship of factors contributing to project complexity, key project management aspects and project critical success factors with the independent variables such as assessor's work experience, project type, and job function/role. The attributes listed in this questionnaire are based on the analysis of the in-depth interviews with experienced practitioners. The objective of this questionnaire is to validate the findings of the interview and to investigate the variation of these factors with the independent variables listed above.

Description of the Questionnaire

The questionnaire is divided into 4 parts, namely the biographical details, factors contributing to project complexity, key management process and project critical success factors respectively.

What are we hoping to find out from this questionnaire?

f) The variation of the perception of these factors with practitioner's experience.

g) The variation of the perception of these factors with project type?

h) The variation of the perception of these factors with practitioner's job role/function.

Questionnaire

You are invited to complete this questionnaire. It should take no more than **15 minutes**. The data being gathered from this questionnaire is in confidence and will not be communicated in a form that would identify participants without permission. **Please type in the grey areas or click on the grey boxes in front of each question.**

PART A (Personal Information)

Biographical Data

1. **Name (Optional):-**

2. **Your Gender:-** Male_____☐__ Female_____☐ _____

3. **Your Age:-** Under 30__☐_____ 30-40___☐_____ 41-50____☐___ Above 50____☐__

Job Experience / Role

4. **Company:**

5. **What is your current job title?**

6. **What is your total work experience:-**

   Under 3 years: ______☐____ 3 – 6 years: ______☐____

   7-10 years: ______☐____ 11-15 years: ______☐____

   16-20 years: ______☐____ Over 20 years: ______☐____

7. **Which of the following function describes your *current work role* and number of years working in that role?** *(Please mark one only)*

   Functional/ Technical/ Engineering years

   Project Management years

8. **Please indicate the type and name** *(optional)* **of project / product / services currently working on?** *(Please mark one only if possible)*

   New Product Development ☐

   Up-grading a Developed Product ☐

   Production of a Developed Product ☐

   Support & Services ☐

PART B : Factors contributing to Project Complexity

The factors listed below have been found from research to affect project complexity. Please indicate what you think is the level of impact of each factor on project complexity:

i. Based on your experience, and
ii. The impact of these factors on the current project.

Factor(s)	*Level of Impact on Project Complexity*					*Level of Impact on Project Complexity*			
	Based on Experience					**Based on Current Project**			
	Low	Med	High	N/A		Low	Med	High	N/A
Partnerships / Consortiums *Issues related with either partnerships and/or consortiums setup*	☐	☐	☐	☐		☐	☐	☐	☐
Novelty *Issues related with either novelty of product, process, methods, tools & techniques to achieve the product*	☐	☐	☐	☐		☐	☐	☐	☐
Requirement Capture/Product Specs *Issues related with either lack, unclear, floating and/or changing specifications / requirement capture*	☐	☐	☐	☐		☐	☐	☐	☐
Stakeholders (Internal & External) *Issues related to such as working relationship, prior experience, communication between stakeholders*	☐	☐	☐	☐		☐	☐	☐	☐
Geographical Location / Multiple Sites *Issues related with multiple locations / sites such as communication, degree of control, system level etc*	☐	☐	☐	☐		☐	☐	☐	☐
Project Organizational Structure *Issues related with project organizational structure such as work priority, strategic importance, team etc*	☐	☐	☐	☐		☐	☐	☐	☐
System Level *Issues related to system level(product) such as concurrency, interface, changes impact, functional etc*	☐	☐	☐	☐		☐	☐	☐	☐
Time Constraints / Duration *Issues related with delays, obsolescence, socio/political, changes due to time/duration*	☐	☐	☐	☐		☐	☐	☐	☐
Contract(s) *Issues related to the contractual terms relating to rights, work share, balance of work, control etc*	☐	☐	☐	☐		☐	☐	☐	☐
Financial / Budget *Issues related to budget such as availability ,budget cuts, planning etc due to external / internal factors*	☐	☐	☐	☐		☐	☐	☐	☐

PART C : Key Project Management Aspects

The PM aspects listed below have been found from research to be useful in managing project complexity. Please indicate what you think is the level of usefulness of each aspect:

i. Based on your experience, and

ii. Based on the current project.

Aspect(s)	Level of Usefulness in managing Project Complexity				Level of Usefulness in managing Project Complexity			
	Based on Experience				Based on Current Project			
	Low	Med	High	N / A	Low	Med	High	N / A
Stakeholder Management	☐	☐	☐	☐	☐	☐	☐	☐
Gated Reviews	☐	☐	☐	☐	☐	☐	☐	☐
Scope Management	☐	☐	☐	☐	☐	☐	☐	☐
Requirements Management	☐	☐	☐	☐	☐	☐	☐	☐
Work Breakdown Structure (WBS)	☐	☐	☐	☐	☐	☐	☐	☐
Change Control	☐	☐	☐	☐	☐	☐	☐	☐
Communication	☐	☐	☐	☐	☐	☐	☐	☐
Risk Management	☐	☐	☐	☐	☐	☐	☐	☐
Procurement	☐	☐	☐	☐	☐	☐	☐	☐
Planning	☐	☐	☐	☐	☐	☐	☐	☐
Organizational Structure	☐	☐	☐	☐	☐	☐	☐	☐
System Engineering	☐	☐	☐	☐	☐	☐	☐	☐
Cost Management	☐	☐	☐	☐	☐	☐	☐	☐
Conflict Management	☐	☐	☐	☐	☐	☐	☐	☐
Resource Management	☐	☐	☐	☐	☐	☐	☐	☐
Soft Skills	☐	☐	☐	☐	☐	☐	☐	☐

PART D : Project Critical Success Factors

The Project Critical Success Factors listed below have been found from research to be useful in managing project complexity. Please indicate what you think is the level of usefulness of each factor:

i. Based on your experience, and

ii. Based on the current project.

Factor(s)	*Level of Usefulness in managing Project Complexity*					*Level of Usefulness in managing Project Complexity*			
	Based on Experience					**Based on Current Project**			
	Low	**Med**	**High**	**N / A**		**Low**	**Med**	**High**	**N / A**
Senior Management Support	☐	☐	☐	☐		☐	☐	☐	☐
Clear Objectives	☐	☐	☐	☐		☐	☐	☐	☐
Influence & Relationship	☐	☐	☐	☐		☐	☐	☐	☐
Trust	☐	☐	☐	☐		☐	☐	☐	☐
Team Cohesion	☐	☐	☐	☐		☐	☐	☐	☐
Flexibility	☐	☐	☐	☐		☐	☐	☐	☐
Delegation	☐	☐	☐	☐		☐	☐	☐	☐
Team Location	☐	☐	☐	☐		☐	☐	☐	☐
Leadership	☐	☐	☐	☐		☐	☐	☐	☐
Informal Networks	☐	☐	☐	☐		☐	☐	☐	☐
Team Motivation	☐	☐	☐	☐		☐	☐	☐	☐
Risk Acceptance	☐	☐	☐	☐		☐	☐	☐	☐
Communication	☐	☐	☐	☐		☐	☐	☐	☐

Please write down below any additional factors which are not listed in the above tables and which you think are important.

Factor affecting project complexity:

Key Project Management Aspects:

Project Critical Success Factors:

If you have any further comments, please continue overleaf

Ranks

	Location	N	Mean Rank	Sum of Ranks
Partnership - Exp	Site 'D'	18	20.28	365.00
	Site 'B'	34	29.79	1013.00
	Total	52		
Novelty - Exp	Site 'D'	18	29.67	534.00
	Site 'B'	34	24.82	844.00
	Total	52		
Requirement Capture / Product Specification - Exp	Site 'D'	18	26.47	476.50
	Site 'B'	34	26.51	901.50
	Total	52		
Stakeholder (Internal & External) - Exp	Site 'D'	18	27.61	497.00
	Site 'B'	34	25.91	881.00
	Total	52		
Geographical Location / Multiple Sites - Exp	Site 'D'	18	21.61	389.00
	Site 'B'	34	29.09	989.00
	Total	52		
Project Organizational Structure - Exp	Site 'D'	18	26.61	479.00
	Site 'B'	34	26.44	899.00
	Total	52		
System Level Issues - Exp	Site 'D'	17	26.88	457.00
	Site 'B'	33	24.79	818.00
	Total	50		
Time constraints / Duration - Exp	Site 'D'	18	28.39	511.00
	Site 'B'	34	25.50	867.00
	Total	52		
Contractual Issues - Exp	Site 'D'	18	26.86	483.50
	Site 'B'	34	26.31	894.50
	Total	52		
Financial / Budget Issues-Exp	Site 'D'	18	28.97	521.50
	Site 'B'	34	25.19	856.50

Ranks

	Location	N	Mean Rank	Sum of Ranks
Partnership - Exp	Site 'D'	18	20.28	365.00
	Site 'B'	34	29.79	1013.00
	Total	52		
Novelty - Exp	Site 'D'	18	29.67	534.00
	Site 'B'	34	24.82	844.00
	Total	52		
Requirement Capture / Product Specification - Exp	Site 'D'	18	26.47	476.50
	Site 'B'	34	26.51	901.50
	Total	52		
Stakeholder (Internal & External) - Exp	Site 'D'	18	27.61	497.00
	Site 'B'	34	25.91	881.00
	Total	52		
Geographical Location / Multiple Sites - Exp	Site 'D'	18	21.61	389.00
	Site 'B'	34	29.09	989.00
	Total	52		
Project Organizational Structure - Exp	Site 'D'	18	26.61	479.00
	Site 'B'	34	26.44	899.00
	Total	52		
System Level Issues - Exp	Site 'D'	17	26.88	457.00
	Site 'B'	33	24.79	818.00
	Total	50		
Time constraints / Duration - Exp	Site 'D'	18	28.39	511.00
	Site 'B'	34	25.50	867.00
	Total	52		
Contractual Issues - Exp	Site 'D'	18	26.86	483.50
	Site 'B'	34	26.31	894.50
	Total	52		
Financial / Budget Issues-Exp	Site 'D'	18	28.97	521.50
	Site 'B'	34	25.19	856.50
	Total	52		

Ranks

	Age	N	Mean Rank
Paternership - Exp	30-40 yrs	25	25.78
	41-50 yrs	16	26.97
	Above 50 yrs	11	27.45
	Total	52	
Novelty - Exp	30-40 yrs	25	26.22
	41-50 yrs	16	33.34
	Above 50 yrs	11	17.18
	Total	52	
Requirement Capture / Product Specification - Exp	30-40 yrs	25	25.86
	41-50 yrs	16	31.41
	Above 50 yrs	11	20.82
	Total	52	
Stakeholder (Internal & External) - Exp	30-40 yrs	25	25.74
	41-50 yrs	16	29.12
	Above 50 yrs	11	24.41
	Total	52	
Geographical Location / Multiple Sites - Exp	30-40 yrs	25	24.74
	41-50 yrs	16	28.75
	Above 50 yrs	11	27.23
	Total	52	
Project Organizational Structure - Exp	30-40 yrs	25	25.26
	41-50 yrs	16	30.12
	Above 50 yrs	11	24.05
	Total	52	
System Level Issues - Exp	30-40 yrs	24	23.12
	41-50 yrs	15	30.30
	Above 50 yrs	11	24.14
	Total	50	
Time constraints / Duration - Exp	30-40 yrs	25	27.14
	41-50 yrs	16	30.28
	Above 50 yrs	11	19.55

	Total	52	
Contractual Issues - Exp	30-40 yrs	25	24.60
	41-50 yrs	16	29.19
	Above 50 yrs	11	26.91
	Total	52	
Financial / Budget Issues-Exp	30-40 yrs	25	26.24
	41-50 yrs	16	30.56
	Above 50 yrs	11	21.18
	Total	52	