UNIVERSITY OF KWAZULU-NATAL

CRITICAL RESOURCE LOADING FOR SMALL PROJECTS WITHIN THE PETRO-CHEMICAL INDUSTRY

By

Mfundo Verby

205 527 193

A dissertation submitted in partial fulfillment of the requirements for the degree of

Master of Commerce: Leadership Studies

Graduate School of Business and Leadership

College of Law and Management Studies

Supervisor: Dhanesh Rampersad

2015

HSSREC Research Office Contact Details:

Prem Mohun

Research Office: Govan Mbeki Building

Tel 031 2604557

Fax 031 2604609

E-mail mohunp@ukzn.ac.za

31 2604557

Fax 031 2604609

PREFACE

This dissertation is submitted in partial fulfillment of the requirements for the degree of Master of Commerce in Leadership Studies. The research herein was conducted under the supervision of Mr. Dhanesh Rampersad.

Submitted by: Mfundo Verby

Student Number: 205 527 193

Date: ____________________

Signature: 16/01/2016

As the candidate's Supervisor I agree to the submission of this dissertation.

Supervised by: Dhanesh Rampersad

Date: ____________________________

Signature: ________________________

DECLARATION

I, **Mfundo Verby** declare that:

(i) The research reported in this dissertation, except where otherwise indicated, is my original research.

(ii) This dissertation has not been submitted for any degree or examination at any other university.

(iii) This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

(iv) This dissertation does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a) their words have been re-written but the general information attributed to them has been referenced.

b) where their exact words have been used, their writing has been placed within quotation marks, and referenced.

(v) This dissertation does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the dissertation and in the References sections.

Signature: ______________________________

Date: 16/01/2016

ACKNOWLEDGEMENTS

Firstly I would like to thank the Lord Almighty for the guidance, strength and ability to complete my research project and studies towards my Master's degree. It has been a very long journey which I truly believe has taught me much about patience and perseverance.

I also want to thank and acknowledge the following people that supported and assisted me with this remarkable journey:

- My lovely wife, Ursula Verby who has be very accommodative and caring.
- My mother Pinkie Verby for always believing in my ability to achieve this milestone.
- My Supervisor, Dhanesh Rampersad who was extremely knowledgeable and kept me focused on the completion of my research within a very short time frame.
- My family and friends for being supportive during my studies.
- All the research questionnaire respondents that contributed directly to this dissertation.

I dedicate this research and my studies to the Lord Almighty, my Ancestors and the future descendants of the Madonsela-Verby clan.

ABSTRACT

The efficient management of the resources pool required in the successful completion of small projects within the petro-chemical industry is critical for organisation within the particular industry. The skills required to manage this efficiency specifically in projects has been viewed as a skill that does not necessarily require one to have a specific qualification in project management. The scope of the research project was to define a hypothesis, review relevant literature on previous research and review the hypothesis based on historical data and feedback from the industry received via questionnaires and observations. The key objective of the research project was the development of a model that would provide details of the level of effort for the critical resource types at different phases of the project life cycle. The quantitative research methodology focused firstly on the review and utilisation of academic literature conducted previously on this topic, secondly on the evaluation of feedback from questionnaires distributed to project managers and engineers within and external to Sasol and lastly on participant observations based on previous projects where the researcher had been part of the project team. The initial hypothesis that was adopted prior to commencement of the research process entailed graphical level of effort models for the project management, technical, sponsor and business resources required to successfully move through the different project phases. The hypothesis was analysed against the research results and updated accordingly to provide the proposed level of effort model. The model was then presented and explained in detail in the dissertation to ensure a clear understanding and alignment in terms of the complexity of the project, type of the project, total budget of the project and the planned duration of the project in months. The dissertation has therefore contributed to industry and academia a level of effort model that can assist project managers and engineers to define the phase deliverables and the level of effort required per resources for a particular phase of the four phased project life cycle model. The model presented is dynamic in that it clearly indicates the maximum percentage of effort required per resource; the model, however, does not provide a ramp up or ramp down rate within a particular phase. The details of the ramp up or ramp down rate among other ideas are provided in the dissertation as potential recommendations for future studies.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BD&I	Business Development and Implementation
CAS	Complex Adaptive Systems
EPC	Engineering Procurement and Construction
EPCM	Engineering Procurement Construction Management
HAZOP	Hazard and Operability
JV	Joint Venture
KSB:	Klein, Schanzlin and Becker
LOE	Level of effort
LoE:	Level of Effort
NTCP:	Novelty, Technology, Complexity and Pace
PMBOK	Project management body of knowledge
PMI:	Project Management Institute
R&D	Research and Development
RAM	Reliability Availability and Maintainability
SCADA:	Supervisory Control And Data Acquisition

CHAPTER ONE

Introduction

1.1 Introduction

The research project focused on project management, specifically for small projects, the different project life cycle phases, the deliverables per phase, the resources allocated to the project and the level of effort required for successful project completion. Many organisations execute numerous projects at any point in time; these can include human resource changes, administrative changes, development of new products and extension of organisations. Projects can have tangible results or intangible results. What is critical, as will be seen later in the research, is that a project needs to have a definite start and finish.

The measures utilised by many organisations to define projects are cost, schedule and quality. These measures are also generally utilised to define the success or failure of a particular project.

The scope of the research was primarily on small projects within the petro-chemical industry. The focus was on a quantitative analysis to understand the adopted project life cycle model, the types of resources utilised in projects, the required deliverables during the project life cycle and the level of effort required from the resources.

In obtaining this insight from numerous project engineers and project managers within Sasol Technology, Sasol Synfuels, Sasol South Africa Energy and consulting engineering companies that execute projects within the petro-chemical industry, the research project aimed to define a model that would define a project life cycle model, the deliverables per phase, the resources and lastly the level of effort required per resource at the different project phases.

1.2 Background

The utilisation of manpower effectively and efficiently within an organisation is an important aspect as the workforce increases. The need to manage and monitor these resources effectively has become a critical task for organisations. The task of ensuring that the work is distributed among the employees to attain a high productivity ratio is a serious challenge. Establishing a system to track the amount of time dedicated by an employee to their work requisite to measure performance in order to also track the effort and progress on a project, is essential for a large organisation.

In saying this, effort tracking should therefore play a significant role in project management. The responsibility for effort tracking then rests with the project manager as it is an essential requirement from senior management. The purpose of effort tracking is to give a clear picture about utilisation of manpower in various projects (Gupta and Dokania, 2013). Estimation of effort is also extremely important as it impacts numerous decisions during the planning stages of a project. The success of a project can be influenced by the accuracy with which one is able to predict the resource effort required throughout the project life cycle. When the actual effort is higher than the estimated effort, it impacts the project under execution in terms of cost, schedule, customer satisfaction, project/organisational reputation and profitability. Both under and over estimation in terms of level of effort required has impacted projects across the globe (Ramakrishna, 2015).

Some of the benefits of effort tracking are: support with workload management; improvements in terms of planning based on historical level of effort data; better management of resources and insight into activities or tasks employees are continuously working on.

The challenges faced in managing or tracking level of effort in industry can be summarised as follows (Gupta and Dokania, 2013):

- Integration of data from multiple sources.
- Inexperience of project managers in preparing project plans in detail so that effort tracking is more precise.
- Lack of understanding by project resources in providing the effort spent in the project accurately.
- Buy-in from project resources to use effort tracking systems as they are used in manual systems.

1.3 Problem Statement

A large number of organisations undertaking small- to large-scale projects on an annual basis utilise the best skill resources in the organisation for evaluation, execution and approval of projects. Different project management models or guidelines are utilised by numerous organisations as tools towards justifying the necessary funds for planned and unplanned projects.

One of the problems with small projects is the volume of these projects within any particular organisation. Due to the administrative requirements associated with projects, organisations have adopted an approach of defining projects according to size, complexity and budget (cost and potential benefits associated).

Once projects are categorised according to the scale utilised by the organisation, which varies from one organisation to another as will be seen later in the research, small projects are merely left to the appointed project manager to plan, execute and close out with very few governance requirements.

This of course has the potential to allow for a very dynamic, flexible system where projects flourish and organisations continue to grow from the numerous products and innovations that are the result of these projects. However, this does also have the potential of creating an environment that is filled with recurring project failures, revenue losses and missed opportunities.

Sasol Synfuels in Secunda budgets annually an estimated five hundred million rand for small projects which are generally grouped according to the following criteria:

- Renewal projects are replacement in kind due to technical reasons such as equipment reaching end of life.
- Project end-of-job estimate is below twenty million rand.
- Project is repetitive in nature.
- The technical resources required for the replacement are mainly single discipline, i.e. Mechanical or Electrical Engineering.
- Project is to be installed and commissioned within 24 to 36 months from time of initiation.
- Project will not necessarily generate a significant additional revenue stream, but merely restore integrity to continue operations.

These types of projects are seen in the organisation as simple repetitive type projects which are generally executed by project engineers, plant technicians and novice project managers, and are commonly referred to as tier 5 projects. The tiering system starts with tier 1 projects which are greenfields projects (projects with no prior work done and no prior constraints), tier 2 being brownfields (projects building on existing work, with the associated constraints), tier 3 being highly complex and multidiscipline, tier 4 being slightly complex multidisciplinary projects and lastly tier 5.

The success rate of these small projects in Sasol has been extremely low and has cost the organisation money over the years for the following reasons:

- Equipment delivered late for the installation window. The installation window is based on the refinery shut-down plan, which generally means an opportunity to replace a piece of equipment comes once every four years. Equipment not installed generally means more extensive expensive maintenance on an old unit which has reached end of life.
- Equipment that requires expediting the fabrication schedule to allow for installation during the installation window which comes at escalated costs.
- Rollover of approved funds due to projects not being on schedule which affects the entire renewal budget planning which is generally planned 10 years in advance.
- Competence in managing projects, contracts, fabrication queries, risk etc. which leads to delays, compensation events and equipment that is scrapped due to process, technical or legal concerns.

The potential future impact due to the abovementioned on the organisation's profit margin is a major threat as the Sasol refinery is over 30 years old and a large volume of the equipment on site is due for replacement as it has reached its end of life. The organisation's strategy is to continue operations up to the year 2050, which clearly means successful completion of simple "like-for-like" tier 5 projects, where outdated equipment is replaced by modern equipment with the same functionality, within the Secunda Refinery. This is a critical requirement for sustainable production and profitability into the future.

The Sasol Synfuels refinery is also seen within the organisation as the cash-cow of the organisation and a large number of future tier 1, 2 and 3 projects depend on the profitability of Synfuels. The successful execution of small projects to restore the asset base of the refinery to ensure sustainable operation up to the year 2050 can potentially affect the Sasol group strategy towards the funding of major projects.

In summarising the problem statement, the challenges faced in planning and managing small projects with the petro-chemical industry have a potential to significantly influence the sustainability of large organisations more than large-scale projects do. In understanding this aspects, these challenges faced by inexperienced project managers in the front end loading and management of multiple projects that do not necessarily have strict governance, are further exaggerated by the inability to define and obtain the required resources. Ensuring the required effort from these resources and the required deliverables throughout the project life cycle is also a challenge. This study aims to provide a tool that can assist inexperienced project managers working on small projects with a model that will assist in developing foresight in terms of the magnitude of effort that will be required, key deliverables and the key resources that will be required in ensuring project success.

1.4 Aim of the Study

The main motivation for the project was to develop a model that novice or developing engineers, project engineers and project managers can utilise for executing small projects. The aim was to develop a model that is very simplistic in its nature in that it can be used for guidance rather than as a procedure. A procedure is a document that is not dynamic, but is rather more prescriptive than a model that can provide reflective feedback based on the input parameters.

The model would then aid the project manager in developing multiple resource plans for a number of small projects for a number of resources based on the effort required per resource at a particular phase of the project. In defining the resources and effort level required per resource for projects that are not very strongly governed, the novice project manager will be able to see potential concerns in terms of resource effort level and therefore the potential impact on the successful completion of the projects on schedule, cost and as per the specified quality.

Furthermore the research was also motivated by the need to understand the perception by the participants regarding the perceived required level of effort at the different phases of the project from the different project resources. Clearly a serious misalignment in this regard can potentially impact the successful completion of a project.

The focus of the research was to understand the different project life cycle models used for small projects in the petro-chemical industry, the resources required, the deliverables required and to link accordingly to the level of effort required for the different resources.

The research undertook the analysis by means of literature review, participant observation and research questionnaires that were circulated to project engineers and project managers. The research was required as resources allocated to small projects are generally shared among a group of small projects and unrelated day-to-day activities executed by the associated resources.

1.5 Research Objectives

The objectives for the dissertation are as follows:

- Develop a hypothesis for the critical resources for a small project from starting to closure phase specifically on the level of effort required per phase.
- Review the hypothesis and theory developed by utilising theoretical data or literature to prove the relevance or accuracy of the hypothesis and theory.
- Develop qualitative and quantitative mathematical graphs in terms of percentage of effort (level of effort) recommended for the key resources at different phases of the project life cycle based on the deliverables per resource and as per the project team.

1.6 Research Questions

The research focused on answering three main questions, namely:

- What percentage of effort is required for the critical resources identified in projects for the activities required at the different phases of the project life cycle?
- Is there an alignment or congruency between the current literature and research data regarding the resources and percentage of effort required at different phases of a project?
- What graphical representation can be utilised to illustrate the resources and level of effort required for the activities required at different phases of the project?

Note that this research does not consider resources required for the actual construction of any equipment, product or structure required for the project. The specific focus of the research is on resources utilised for engineering, project management and business related activities required to deliver on the key deliverables as per project management principles.

1.7 Significance of the Study

This research project will contributed a model that for small projects within the petro-chemical industry in South Africa, which will assist in the definition, planning, allocation and utilisation of a dynamic project team, which will increase or decrease in size for different phases of the project life cycle.

Such a tool for project managers will allow engineering and project management firms the opportunity to effectively utilise the resource pool available to the company on various projects, and it can serve as an optimisation tool for skills required at different phases of the project life cycle.

The knowledge the study will add to the body of knowledge within project management can be summarised as follows:

- Additional information in terms of level of effort within projects in the petro-chemical industry.
- Better understanding in terms of the pattern and dynamic nature of the level of effort required per resource in projects.
- The understanding of perceived deliverables at project phase level within the petro-chemical industry.
- Contribution of a model for better front-end loading on small projects.

1.8 Limitations of the Study

The population group that was analysed for the research is people that are either Sasol employees or consultants that have executed projects for Sasol; the research therefore has the potential of giving feedback that is only specific to the Sasol environment.

Irrespective of the fact that the respondents do not only have Sasol-specific experience, most of the respondents have executed projects outside the Sasol environment. The literature review feedback included in the research was also not only specific to the Sasol environment.

The following limitations are applicable to this research:

- The research only applies to small projects within the petro-chemical industry.
- Respondents were project engineers and project managers.

1.9 Format of the Study

The two key concepts that were fundamental in this dissertation were developing a clear hypothesis that would later be developed into a theory and presenting the feedback from the research questionnaires. The theory would encompass numerous hypotheses regarding resource loading and level of effort for small projects at different phases of the project life cycle.

In order to narrow the research topic to add more value to a specific environment or industry the research topic was amended to only be specific to small projects within the petro-chemical industry. The analysis was quantitative in its nature with a sample size of 53 respondents from 120 questionnaires sent out for the study. The graphs that were developed to define the hypothesis were tested during the data collection, data analysis and literature review phases of the research project.

The research process utilised for the study was deductive, empirical cycle in the scientific expansion of knowledge indicated in Figure 1-1, the research methodology will however be discussed in detail in Chapter 3 of the dissertation. The format of the study entailed an extensive literature review of literature that was relevant to the research topic which will be provided in Chapter 2 of the dissertation, description of the research methodology as highlighted earlier in Chapter 3, discussion of the research results and findings will be provided in Chapter 4 and lastly the conclusions and recommendation from the research project will be captured in Chapter 5 of the dissertation.

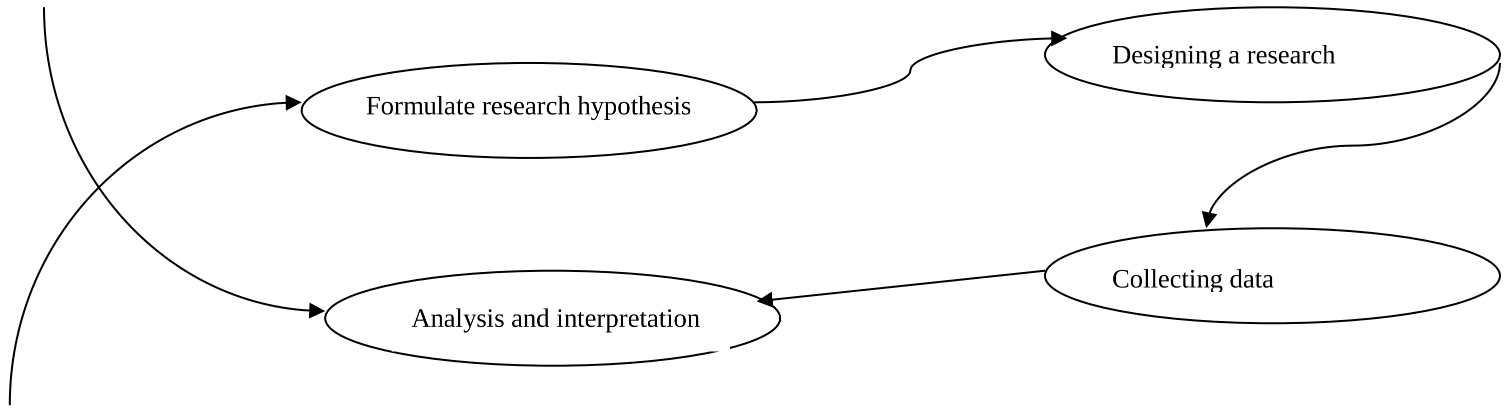


Figure 1-1: Cycle for Expansion of Knowledge

Adapted from: Welman and Kruger, 1999, p. 11

1.10 Conclusion

The definition of the project life cycle, the project phases, the deliverables required per phase, the resources and the level of effort required from project start to completion is critical in projects. These concepts are well understood by experienced project managers and are governed and managed well for large- and medium-sized projects in many organisations.

The concept of completing a project on budget, schedule and as per the specified quality is not a new one and is well understood in industry; however, for small projects in many organisations including Sasol it remains a serious concern, as it eludes many project managers in industry. Thus the motivation for this dissertation was to develop a tool for project engineers, engineers, novice project managers and plant technicians that are tasked with executing small projects year after year.

The focus of the research was to develop a model that can be utilised for small projects within the petro-chemical industry in South Africa after undertaking the research process that also entailed a very extensive literature review. The limitation of the study is that it was mainly on Sasol projects. The final contribution to the knowledge base and industry is a set of graphs that will define the level of effort required for the resources required throughout the project life cycle of small projects.

CHAPTER TWO

Literature Review

2.1 Introduction

This chapter of the dissertation will provide extensive background into the literature that was reviewed for the research project. The literature reviewed covers a period of over forty years with the oldest content reviewed being from as far back as 1975. The body of knowledge has evolved significantly with many authors providing in depth insight into numerous aspects in project management. The literature review that was conducted and discussed in this chapter will however be limited to six key concepts, namely, level of effort, project life cycle models, project typology, complexity, deliverables and key resources.

The areas of conflict or disagreement in terms of the literature that was reviewed will also be presented in order to provide a more holistic picture of the current understanding and views in terms of these key concepts by scholars and industry leaders.

The academic literature reviewed or utilised for this dissertation included electronic books, journals, standards, presentations, websites, government gazette guidelines and books which gave detail on the following:

- Definition of the different types of project life cycles and the associated phases of the project life cycle.
- Project management knowledge used to define, align and specify deliverables for the different phases of the project management cycle.
- Allocation of resources on small projects within the petro-chemical industry.
- Definition of "level of effort" in project management.
- Management's role in projects within organisations.
- Defining models for resource loading on projects.

The literature reviewed was specific to ensure that:

- It was organised around and related to the research questions.
- It summarised the outputs around what is known and what is not known.
- It discussed controversial areas or areas of misalignment on the research topic.

In ensuring a structured and wide literature review process, the extent of literature reviewed during the research process can be estimated to be 30 books (including electronic books), 65 five journals and 22 websites. The literature that was relevant to this research project is referenced in the bibliography section of the dissertation.

2.2 Project Definition

It was critical to define what constitutes a project versus normal maintenance or production activities. This section of the dissertation gives guidelines and definitions both from literature and industry on projects.

The definition of the word project comes from Latin where "pro" means forward and "jacere" means throw. In simple terms it refers to an event that requires forward planning.

A paper from the University of Aalborg (Munk-Madsen, c.2005, pp. 6–7) gives two definitions of a project namely:

1. A project is an organisational unit that solves a unique and complex task.
2. A project is an organisational unit where the prime coordinating mechanism is mutual adjustment.

The project management guide (Project Management Institute, 2000, p. 4) gives this definition: "a project is a temporary endeavour undertaken to create a unique product or service".

The literature definition of a project that has been adopted for the research study is one that was defined by the British Standards Institute (2002, p. 2):

> A unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or organisation to meet specific objectives within defined schedule, cost and performance parameters.

Literature utilised for this research project clearly indicates a project to be an activity or list of activities driven by change, proactive change rather than ongoing operations or a number of activities that have as few disruptions as possible.

It was also clearly noted from the literature that projects are initiated to generate additional revenue for the organisation or improve operational efficiencies while maintenance or production activities sustain or marginally improve the current revenue stream.

It was thus critical to understand and elaborate further on how a project differs from regular maintenance or production activities, for example replacement of pumps or vessels as per a maintenance strategy which is defined in most refineries as a shut-down or annual outage. A shut-down will have a definite schedule, budget and performance parameters and multiple activities; however, this is seen in industry as regular maintenance rather than a project and follows less stringent governance in terms of approvals and execution than any typical project.

This dissertation defines a small project on the following key parameters that were used to test data received from industry or literature before it was utilised with the hypothesis that will be introduced later in the research methodology chapter:

- A clearly defined project diamond (Schedule, Cost and Quality Performance or Scope).
- Total end-of-job cost (budget) of not more than one hundred million rand.
- A business case motivated by financial, legal, safety or environmental improvements.
- A project schedule from concept to hand-over phase equal to or less than 36 months.
- Compliance or clearly defined organisational governance and approvals from one phase to another.

It is however, imperative to accept that certain organisations will define projects in a manner that could conflict with the definitions discussed in this section. Despite this the research definition does cover the majority of key stakeholder definitions of what is understood as a project.

2.3 Project Typology

Organisations and scholars have adopted and utilised the word project very loosely when referring to work executed in a structured manner. However, as discussed earlier, a project can be clearly defined and key parameters should be ticked off when referring to a certain set of activities as a project.

This section of the dissertation will give insight on the different types of projects executed within organisations. Furthermore the size of the project will also be discussed as this does have an impact on the governance, interest and management associated with the particular project.

Previously the classification of projects was based on the size of the change associated with the project, minor changes being referred to as alpha projects and major changes being called beta projects (Blake, 1978). A more recent study however, classified projects according to the degree to which the project would change the organisation's product portfolio (Wheelwright and Clark, 1992).

Further studies have gone into more detail and have given insight towards defining the project typology according to four levels of technological uncertainty at initial stages and three levels of system scope (Shenhar *et al*, 1995). This approach is shown in Figure 2-1, where technology is defined from classic to super high and project management scope, which entails organising, controlling resources, managing communication between resources etc., is categorised from single unit to a set of projects within a project or programme.

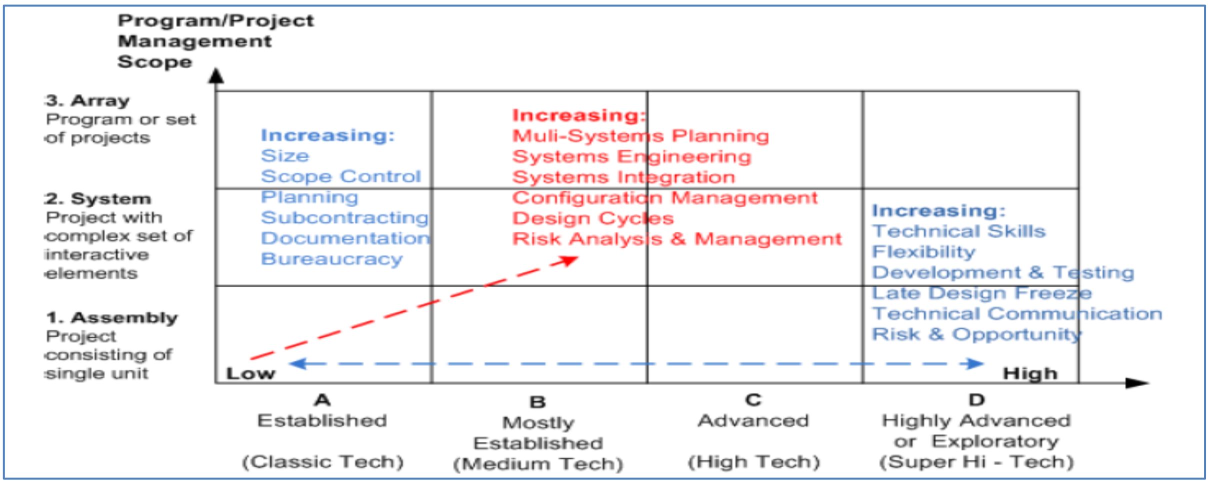


Figure 2-1: Project Typology (Technology and Scope Variables)

Adapted from: Slusarczyk and Kuchta, 2011, p. 144

This train of thought was further developed by classifying the nature of technology from high to low, the innovation from incremental to radical, and the market from new to existing (Balachandra and Friar, 1997).

More recent literature, however, introduced a new project classification tool, termed project diamond-shape NTCP based on four dimensions, given below and illustrated in Figure 2-2 (Slusarczyk and Kuchta, 2011, pp 145-147):

- Novelty
- Technology
- Complexity
- Pace

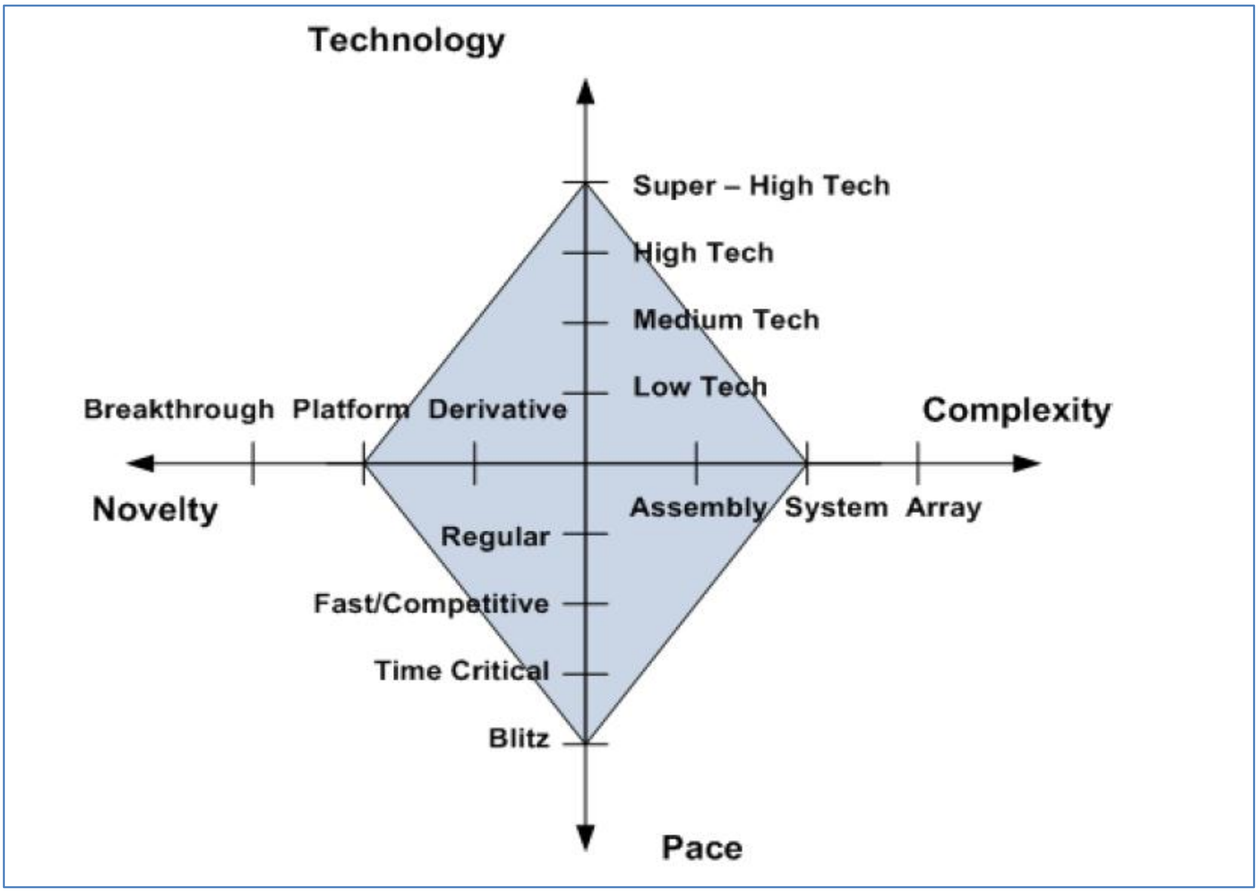


Figure 2-2: NTCP Diamond Model

Adapted from: Slusarczyk and Kuchta, 2011, p.147

2.4 Definition of Complexity in Projects

The definition of complexity within the project management knowledge environment and according to other literature will be evaluated in this section. Numerous organisations utilise operational parameters such as budget and size to give an indication of the project complexity. Other organisations that see complexity as key, in that it can influence project governance and success, utilise a set of key factors, such as technology selection, funding model constraints and project interfaces, both internal and external to the project. These factors are then updated into a complexity measurement tool to define complexity of different projects.

While management teams in many organisations strive to define complexity in organisations and projects, research relating to complex adaptive systems (CAS) shows complexity to be very dynamic and difficult to control or measure. Complexity is always prevalent because all systems are complex as there are numerous stakeholders, agents, systems that interface, connect, communicate and influence each other within an extremely dynamic environment or environments in order to survive, grow, innovate and sustain themselves (Chan, 2001).

In defining complexity, it is critical to understand that we not only need to define the parameters that influence complexity but also need to understand the level of severity of the complexity which makes it difficult to predict certain factors such as outcomes and controls required.

The accepted definition of project complexity for the research is given as consisting of many varied interrelated parts, namely differentiation and interdependency. Differentiation looks at the number of varied elements while interdependency considers the degree of interrelatedness between elements. Within projects, complexity is defined by two dimensions, namely structural uncertainty and uncertainty (Williams, 1999, p. 269). These concepts are simply defined as follows and as shown in Figure 2-3.

- Structural complexity: refers to the project or product complexity, thus the complexity associated with the project or product design, subsystems, components, connections, interactions, construction, manufacture, installation and commissioning.
- Uncertainty: refers to how well or not the goals and methods are defined for a particular project.

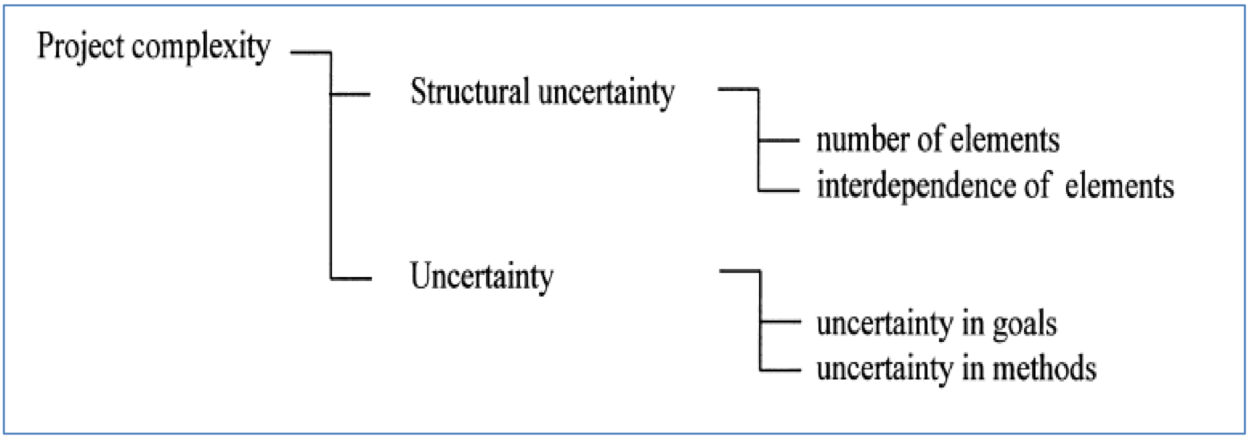


Figure 2-3: Project Complexity Factors

Adapted from: Williams, 1999, p. 271

Research obtained from the International Research Network of Project Management Conference (Remington, Zolin and Turner, 2009) indicates that project managers identify the following aspects as directly contributing to the complexity of a project:

- Goals
- Stakeholders
- Interfaces
- Dependencies
- Technology
- Management process
- Work practices
- Time

The impact of complexity on the research questions and objectives was evident from literature reviewed and had to be defined explicitly in order to ensure the research feedback and analysis could be restricted to projects that have a similar or equal complexity measure or perceived complexity.

The relationship between complexity and level of effort is shown in Figure 2-4, where the effort required from management; engineering and other disciplines will increase as the complexity of a project increases. The figure shows a qualitative relationship as it does not indicate the magnitude in complexity or management effort level. However, understanding the relationship is critical and has been considered in the hypothesis of this research.

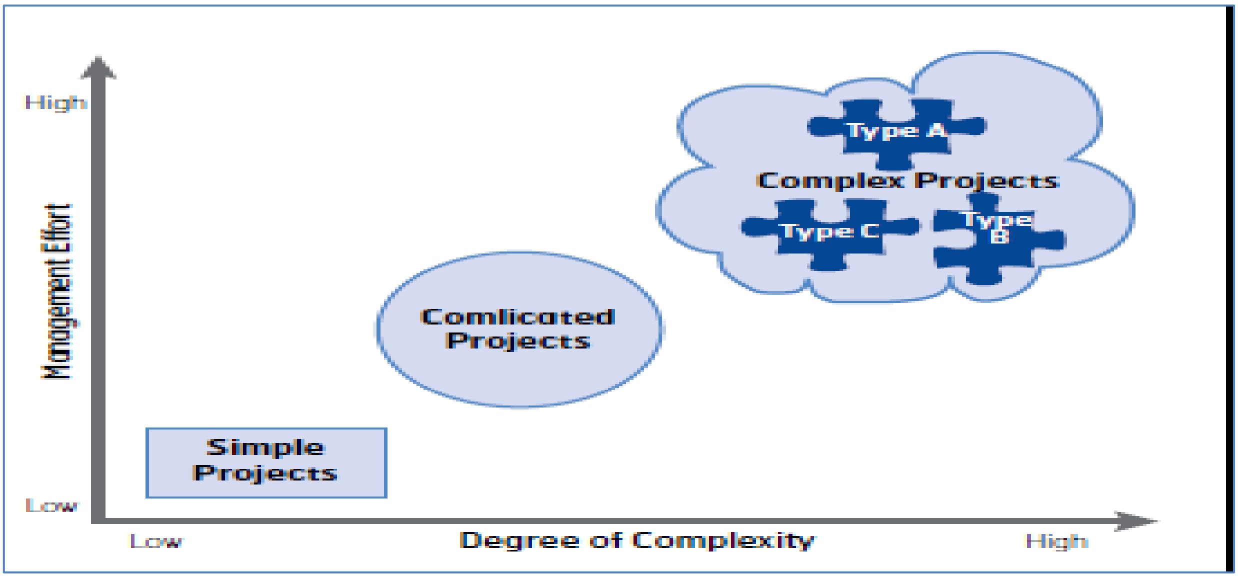


Figure 2-4: Degree of Complexity for Simple, Complicated and Complex Projects
Adapted from: Ireland, Gorod and White, 2013, p. 17

Small projects can also be as important as large projects to an organisation in that they can have a significant impact on the plant or organisation's profitability should they not be executed successfully, particularly because many small projects take place in operating plants. What compounds the importance of small projects further is that organisations can execute numerous small projects compared to the limited number of large projects executed or approved in a particular period.

2.5 Project Management

In defining the different aspects that are critical in projects, it is also imperative to understand what the term project management means and what are the associated responsibilities or roles associated with project management. This section will give insight on how this concept has been summarised in literature.

Project management is not a simple concept where the activities of individuals or groups of individuals constitute management of a project and later the success of a particular project. Project management needs to be seen in a very holistic manner. Project management success factors are directly influenced by the following (Cooke-Davis, 2002, p. 186):

- Adequacy of organisational knowledge on risk management in projects.
- Maturity of the organisation in assigning ownership to risks.
- The organisation's ability to maintain up-to-date and visible risk registers.
- Accuracy and commitment in maintaining documentation with organisational responsibilities on projects.
- Ensuring project phase duration is no longer than three years.
- Ensuring scope changes are governed through a controlled process.
- Maintaining the integrity of performance measurement baseline.
- Existence of cooperation between project management and line management.
- Portfolio and programme management practices that allow the organisation to resource fully projects that thoughtfully and dynamically match the organisational strategy and objectives.
- A suite of project and portfolio metrics that provide line of sight feedback on current and future project key performance indicators, a balanced score card for projects and corporate success.

Figure 2-5 gives a pictorial indication of the relationship between project management, operations management and the corporate strategy, thus the success of the project will directly impact operations and the long term strategy and organisational sustainability.

The qualities of the project management team or project manager are not discussed but are intended as the quality of human interactions in projects are critical and in essence it is the people that count, the people that develop the systems discussed and the people that make things happen.

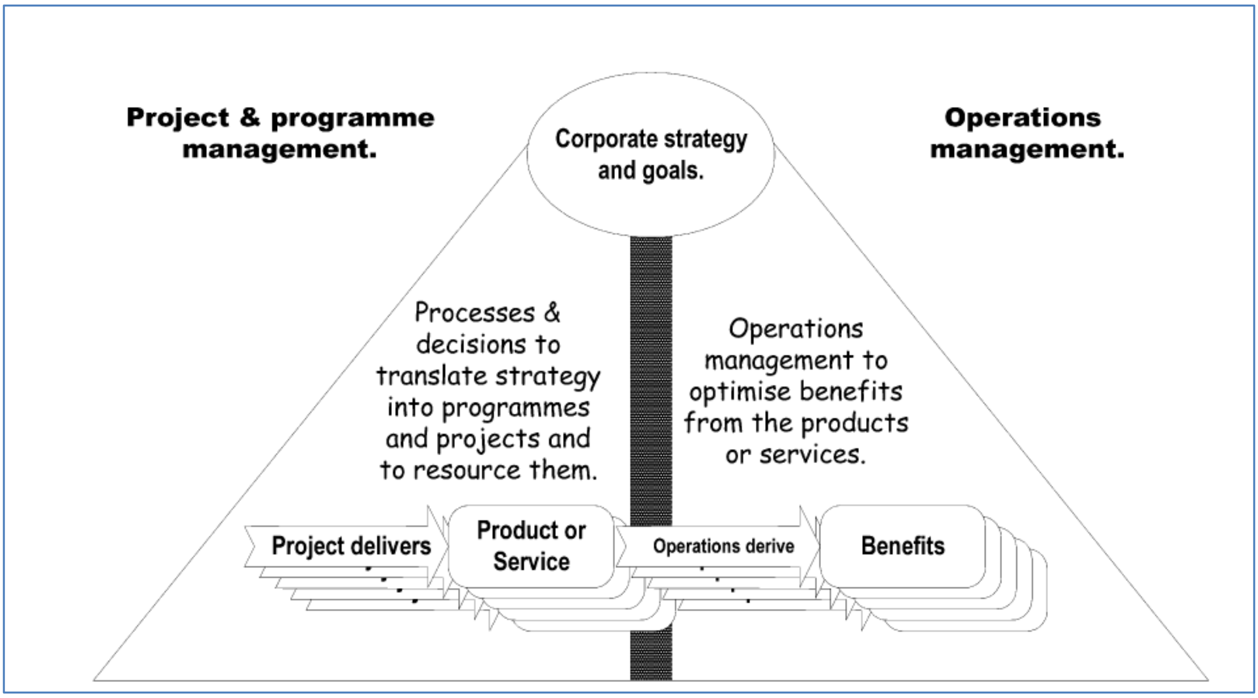


Figure 2-5: Importance of Project and Operations Management Alignment

Adapted from: Cooke-Davies, 2002, p. 187

2.6 Project Life Cycle Models

In order to manage projects more effectively and to ensure better control, organisations in the petro-chemical industry tend to divide the project period into different phases. These phases are defined as a project life cycle when considered collectively.

Different project management models or guidelines are utilised by organisations as tools towards justifying the necessary funds for planned and unplanned projects. Sasol as an organisation utilises three models for justifying, evaluating, approving and managing projects, namely: Business Development and Implementation Model (BD&I); the Joint Venture Model (JV) and lastly, the Research and Development Model (R&D) with the primary focus being on governance, managing risk and ensuring that there is alignment within the organisation.

These models ensure alignment and focus by indicating what work should typically be completed at various stages of the project by having “gates” to check that development is proceeding in a coordinated fashion within all resources and stakeholder groups in the organisation.

A recent benchmarking evaluation of small projects executed within Sasol highlighted several areas as being key to successful project implementation. These key areas were defined as follows:

- Good front-end loading;
- Better project controls, such as estimating, cost control, scheduling and change management;
- More extensive team integration to help with alignment and to optimise the project design earlier in the development phase; and
- Increased use of value-improving practices.

2.6.1 Business Development and Implementation Model

The BD&I model given in Figure 2-6 is primarily utilised for most projects in Sasol and defines the project life cycle in eight phases instead of the four phases commonly adopted by project managers. This model has been utilised by Sasol for numerous projects due to the strict governance requirements the model requires from the different project tracks, commonly referred to as resources, in order to move from one phase to another.

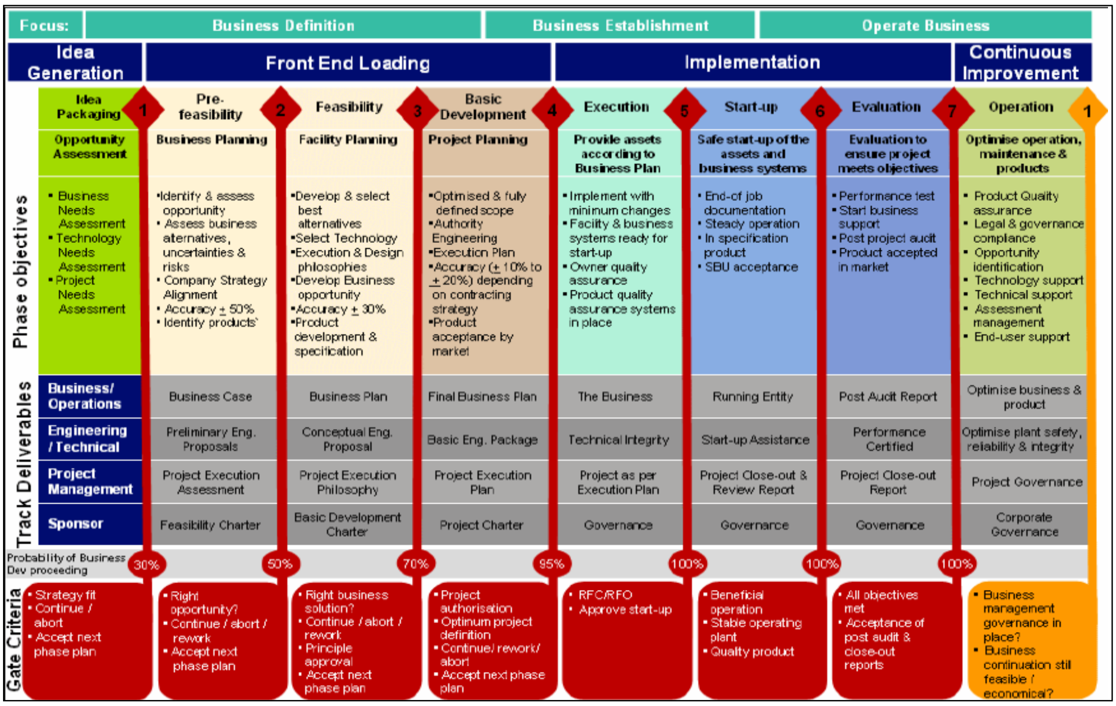


Figure 2-6: Business Development and Implementation Model

Adapted from: Sasol Limited, 2012

2.6.2 Joint Venture Model

The Joint Venture Model shown in Figure 2-7 is utilised in projects that Sasol is executing together with other stakeholders and only has seven phases instead of the eight seen in the BD&I model. The evaluation and operation phases are combined to allow for faster hand-over processes.

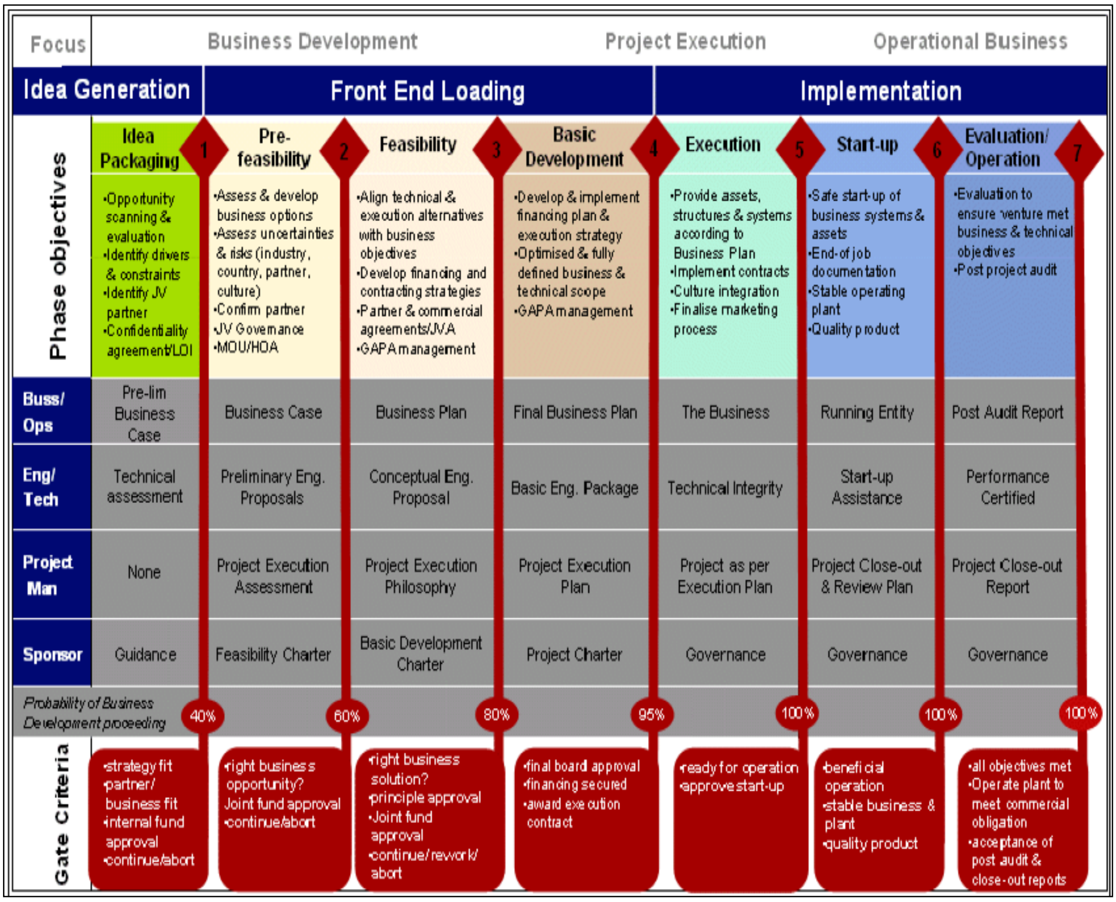


Figure 2-7: Joint Venture Model

Adapted from: Sasol Limited, 2012

2.6.3 Research and Development Model

The R&D Model is used for projects that are specifically implemented for new research or technology at a smaller scale. This model is more simplistic, with only four phases as seen in Figure 2-8.

The Sasol project management models will not form part of the focus for this dissertation; however, they have been illustrated for background purposes as they are heavily utilised within the Sasol environment on numerous projects.

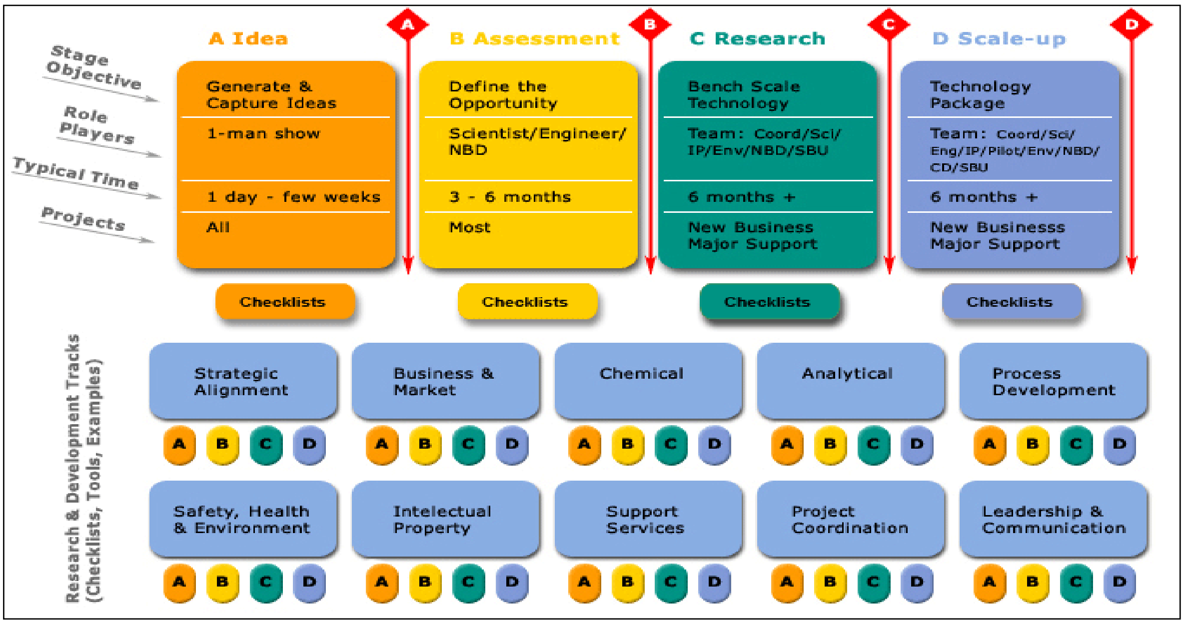


Figure 2-8: Research and Development Model

Adapted from: Sasol Limited, 2012

The phases are defined or marked based on the deliverables. These deliverables are tangible, verifiable work such as feasibility package, detailed package or a final product. The end of a phase is marked by hand-over and review of the required deliverables for that particular phase. PMBOK (2000, p. 11) refers to these phase-end reviews as phase exits, stage gates or kill points.

Therefore the project life cycle will define the scope that needs to be completed per project phase and give an indication of the resources involved in each phase. Most project life cycle model descriptions have a similar basis or foundation.

Projects globally as seen in research are generally managed according to the four-phase project life cycle. This is a very simplistic approach towards projects, as given in Figure 2-9.

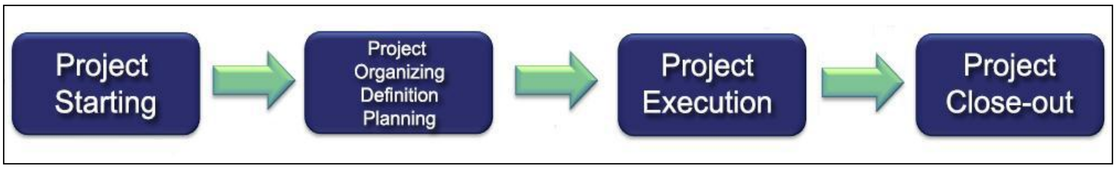


Figure 2-9: Four-Phase Project Life Cycle

Adapted from: Archibald, Di Filippo and Di Filippo, c.2011, p. 5

The four-phase project life cycle has been further developed as seen in Figure 2-10 and Figure 2-11 to a six phase project life cycle. The six phase project life cycle includes two additional phases namely, Feasibility and Post-Project Evaluation. This project life cycle allows for a more structured approach for review and investigation of projects post-closure and pre-starting of the project. Numerous benefits have been documented regarding this approach.

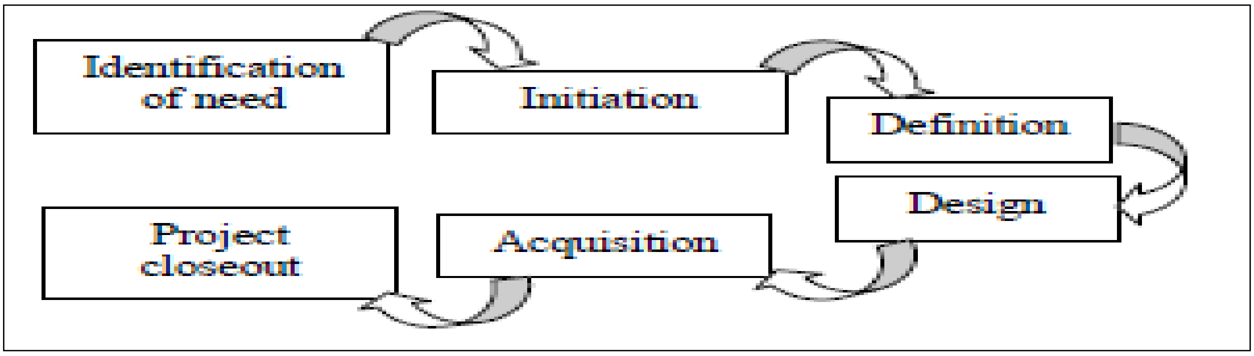


Figure 2-10: Six Phase SCADA Project Life Cycle
Adapted from: Mohamed and Mohamed, 2012, p. 159

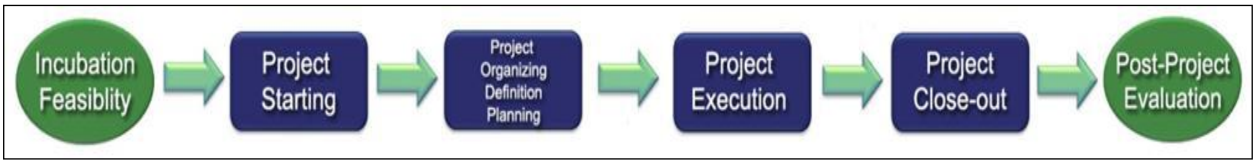


Figure 2-11: Six Phase Project Life Cycle
Adapted from: Archibald, Di Filippo and Di Filippo, c.2011, p. 8

More recent literature regarding the project management life cycle gives some indication of intermediate steps as seen in Figure 2-12, between phases which allow for project definition, detailed planning, monitoring and implementation review. This approach can also be considered in defining a four-phase project life cycle. Sasol Limited has adopted this approach, but developed this project life cycle to the seven gates of the BD&I model discussed earlier.

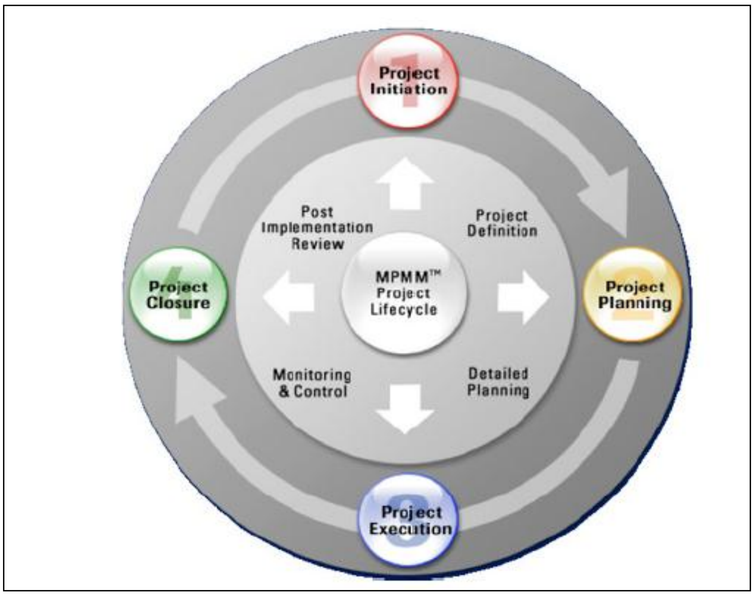


Figure 2-12: The Four-Phase Project Life Cycle

Adapted from: Westland, 2006, p. 4

The simplistic four-phase project management life cycle will be utilised for the purposes of this dissertation as it was one of the first models proposed by the Project Management Institutes in 1981 (Mikulskiene, 2014, p.31) and is a foundation that most project life cycle models are founded on. This model is also well understood within the petro-chemical industry.

2.7 Project Phase Deliverables

Once the project phases have been defined for the particular project, definition of the deliverables and schedule need to be finalised. This is however, at a very high level rather than at activity level which is detail that is finalised during detailed planning.

Deliverables are defined as the work or product located at the end of a hierarchy of activities. The deliverables can be actual equipment, plant, products or structures; however, they can also be abstract such as audits, systems or change processes, though the final project deliverable is generally defined by the project client.

The Project Management Body of Knowledge gives a very simplistic generic cycle which serves specifically to indicate that cost and staffing levels will be low when a project starts, increase gradually and drop rapidly towards completion of the project, also seen in Figure 2-13.

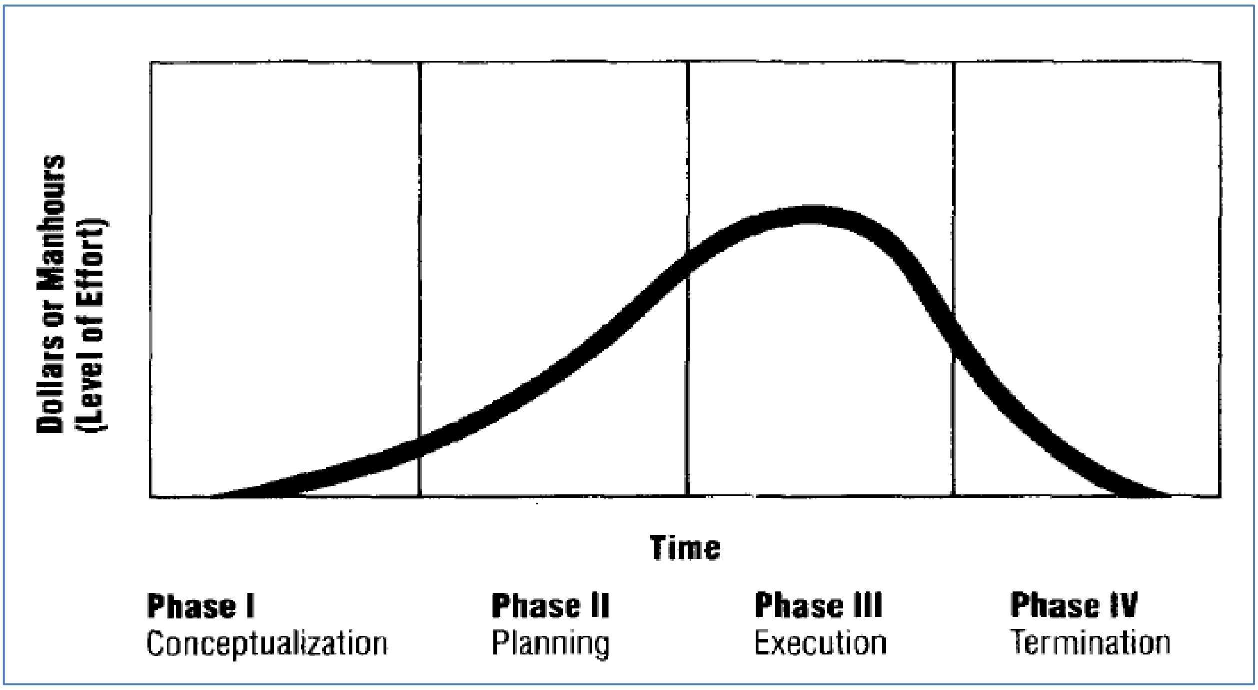


Figure 2-13: Total Resource Effort Level for Project Phases

Adapted from: Slevin and Pinto, 1987, p. 34

Figure 2-14 gives a graphical overview of a project life cycle with the respective activities. This schematic is a conceptual depiction of the hypothesis proposed by this research and was extensively used during the research process, as some of the activities defined in the schematic require a certain effort level from various resources.

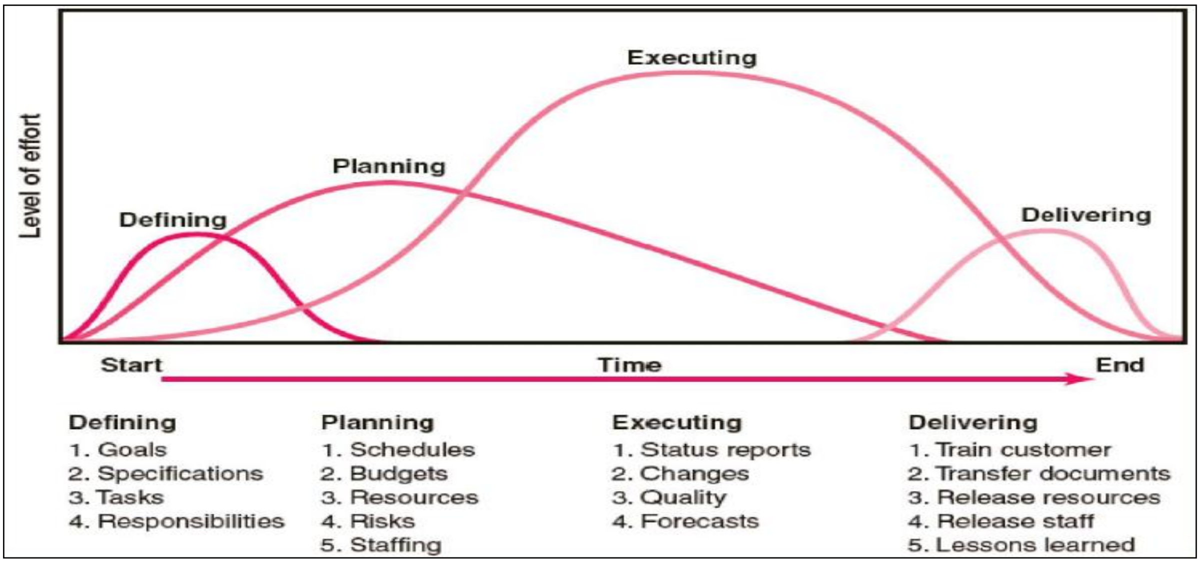


Figure 2-14: Effort Level for a Project Life Cycle

Adapted from: Abdou, c.2012, p. 23

In understanding the project life cycle phases and the project deliverables, it is critical to clearly indicate the level of effort while also mapping the project progress in terms of the project scope completed. Figure 2-15 gives a simplistic illustration of the percentage of work completed for the project at the different project phase gates. This graph is not to be mistaken with the level of effort required from particular resources a discussed earlier. This graph depicts the percentage in terms of progress to completion for a project, as shown with a project initiation being at the beginning of stage one (0% of the project scope completed) and completion at the end of stage four (100% of the project scope completed). The level of effort required, for example for project management resources, will typically start low, increase during stages 2 and 3, and then later decrease rapidly during the final stage.

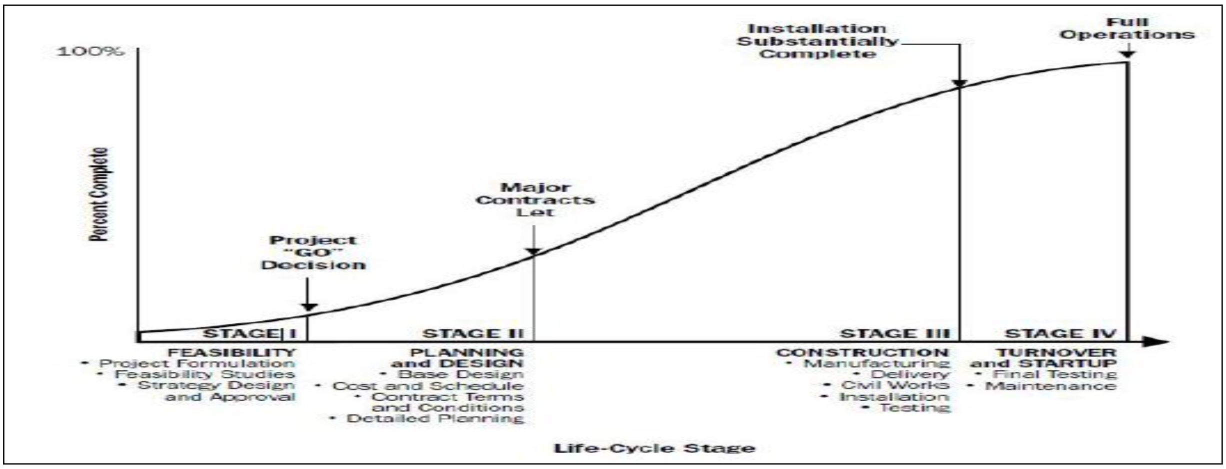


Figure 2-15: Project Life Cycle Stages

Adapted from: Project Management Institute, 2000, p. 15

The key deliverables required for the four-phase project life cycle are also given in Figure 2-16, Figure 2-17, Figure 2-18 and Figure 2-19 from project initiation or start phase to the project closure phase. These deliverables will be categorised according to the resource that is accountable for the deliverable and further research evaluated on the resource effort or magnitude required per deliverable.

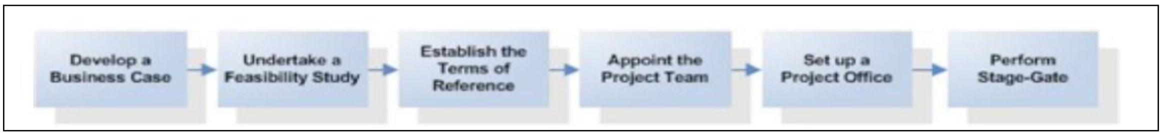


Figure 2-16: Project Initiation Activities

Adapted from: Westland, 2006, p. 5

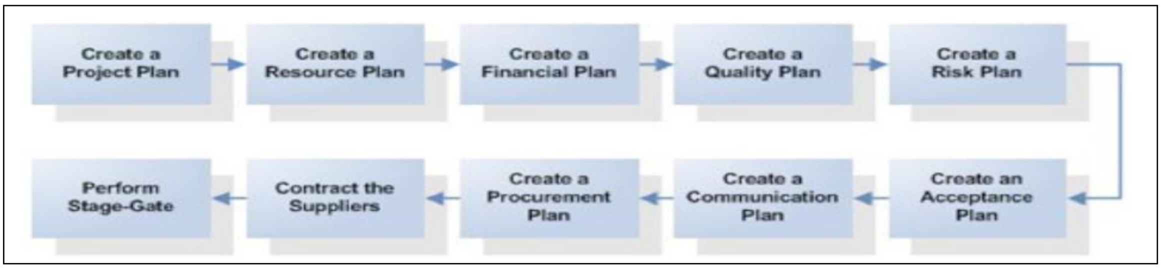


Figure 2-17: Project Planning Activities

Adapted from: Westland, 2006, p. 7

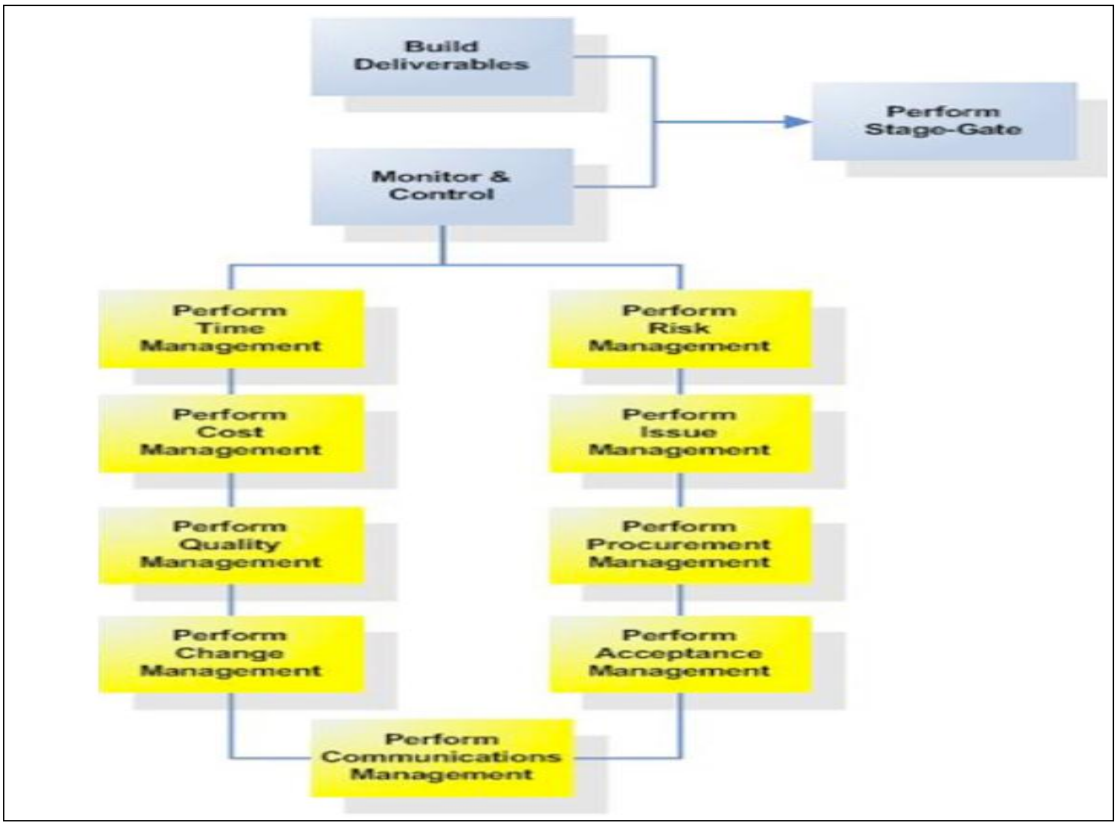


Figure 2-18: Project Management Execution Activities

Adapted from: Westland, 2006, p. 11

Figure 2-19: Project Closure Activities

Adapted from: Westland, 2006, p. 14

2.8 Project Phase Resources

Westland (2006, p. 8) highlights that the next action after developing a project plan is to define the resource plan which is not only limited to individuals but will include the following:

- Type and quantity of resources required.
- Roles, responsibilities and skill sets of all human resources required.
- Specification of all resource equipment required.
- Type and quantity of all material resources required.

Project resources are referred to as project stakeholders according to the PMBOK (2000, p. 11), which can be individuals or organisations that are actively involved in the project and can exert influence over the project and its results. These stakeholders need to be identified and their requirements clearly defined for each project.

The key stakeholders as defined in PMBOK, with their simplified responsibilities, are:

- Project Manager: responsible to manage the project.
- Customer: individual or organisation that will utilise the project's product.
- Performing Organisation: organisation whose employees are mostly doing the work of the project.
- Project Team Members: group of people doing the work of the project.
- Sponsor: individual or group providing financial resources for the project.

Abdou (c.2012, p. 17) is in agreement and also refers to the sponsor, project manager, customer, performing organisation and project team members as the stakeholders required for every project.

Sasol (Sasol Limited, 2012) defines the project stakeholder into four main resources, namely:

- Technical
- Business
- Project Management
- Sponsor

These are very similar to those adopted by PMBOK; however, this naming of resources is primarily for individuals and organisations to be aware of their responsibilities. Stakeholder roles and responsibilities may also overlap depending on the project, environment and other factors.

The project resources to be considered in the scope of this research project were limited to the following group of skills:

- Technical Resource:
    - All engineering disciplines resources
- Business Resource:
    - Business Analysts
    - Financial officers
    - Management in the organisation to assist with review and approval of documents according to the necessary governance
    - Steering committees
    - Employees to compile supporting documents, fund application and business cases
    - Operate the system or product
- Project management Resource:
    - Project managers
    - Site supervisors
    - Safety Officers
    - Cost controllers
    - Document controllers
    - Commercial officers
    - Planners/Schedulers
- Sponsor Resource:
    - Management personnel to support and give guidance to the project with regard to resources, governance and schedule compliance.

- Employee to draft documents as required from the sponsor according to the governance.

In defining the resources for the project life cycle, key issues to be considered are as follows:

- The type of work and the size of the team.
- The match between the job and the resource.
- The experience of the resources.
- The leaders in the project team.

The scope will not include defining the resources required for the construction activities required; only engineering, project management, business and sponsor resources will be considered.

Figure 2-20 and Figure 2-21 qualitatively indicate the relationship between time, scope and resources within projects. In the hypothesis this relationship will also be considered in defining the level of effort required from resources over the project duration or schedule.

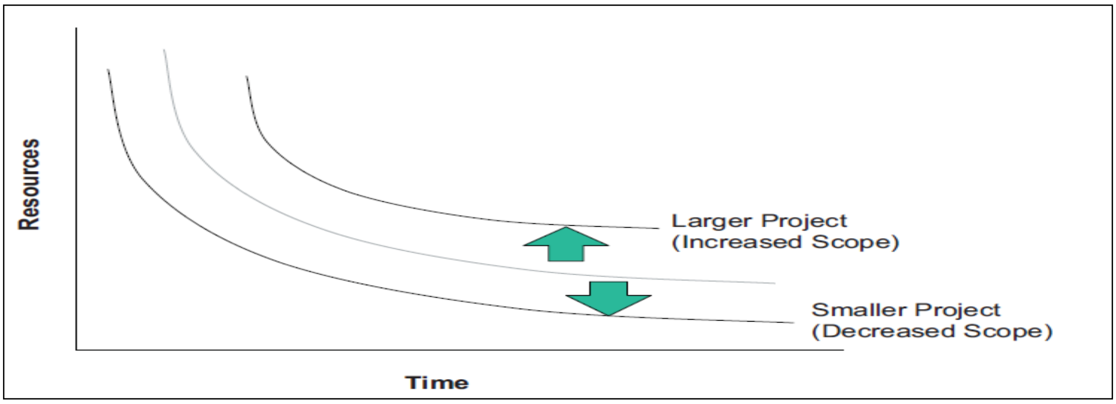


Figure 2-20: Variation in Scope, Time and Resource Impact

Adapted from: Lynch, 2003, p. 7

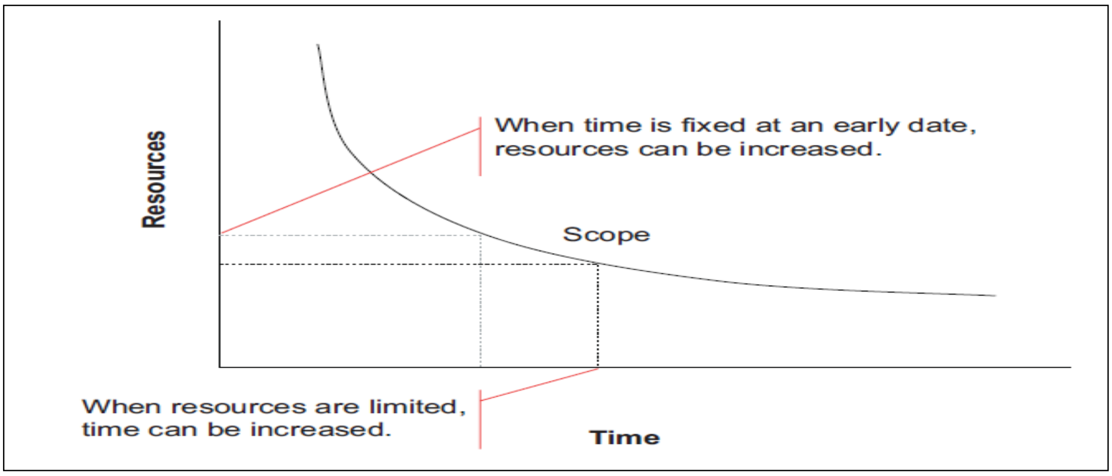


Figure 2-21: Trade-off between Resources, Scope and Time in Projects
Adapted from: Lynch, 2003, p. 8

Organisations are forced to prioritise a large number of small projects due to limited project, engineering, business representatives and other resources. It is crucial for an organisation to know when these resources need to be moved between projects as projects progress through their life cycle in ensuring the efficiency of resources (Gupta and Dokania, 2013).

Resource allocation is more of a challenge in smaller projects mainly due to changing priorities, difficulty in obtaining commitment from other parts of the organisation to provide resources, and sharing of a fixed pool of resources.

In small projects as discussed in literature (Westney, 1992, p. 77) it is generally assumed that the number of resources in each category or resource track is constant over the duration of the activity. Research has been done in this area where resource allocation is done utilising sophisticated computer systems. What has been revealed is when project resources are considered, there are sharp peaks in the resource requirement that can exceed the availability.

When reviewing a resource histogram over the project life cycle, specifically on resource consumption, Frame (1995, p. 191) states that at the early stages of the project few resources are employed; when the project reaches the middle the resources will be employed at full capacity and at the end of the cycle the resources will wind down.

2.9 Level of Effort

The term "level of effort" (LOE) in project management is defined as a support-type project activity that needs to be done to support other work activities or the entire project effort. LOE activity is therefore an activity that supports completion of work. The phrase LOE is thus utilised to define the amount of work of a general or supportive nature that does not result in a definitive end product or outcome (Business Dictionary, 2015). The estimation of the LOE is one of the key responsibilities of the project manager.

The Project Management Body of Knowledge defines LOE as a support-type activity and gives a more detailed definition as follows (Project Management Institute, 2000, p. 202):

> Support-type activity (e.g., vendor or customer liaison) that does not readily lend itself to a measure of discrete accomplishment. It is generally characterised by a uniform rate of activity over a period of time determined by the activities it supports.

Simplistically defined it refers to the specific and quantifiable count and measure of definable labour units required in the attempts to arrive at the completion of a phase of a particular project schedule (Project Management Knowledge, 2014).

Research regarding the LOE gives additional insight when estimating the LOE for a project, which needs to be completed before cost and schedule estimation is performed. The following ten steps can be utilised to determine effort hours (Mochal, 2014):

1. Understand the accuracy required from the estimate.
2. Utilise one estimating technique (analogy, prior history etc.) to define the initial estimate.
3. Factor the effort hours based on the resources available (optional step).
4. Include for specialist and part-time resources.
5. Add the time required for rework (optional step).
6. Include time required for project management: by rule of thumb 15% of total hours should be allocated to project management.
7. Add hours for contingency or risk associated with the estimate.

8. Calculate the total effort.

9. Review the information, assumption, calculations and results and adjust where necessary.

10. Document all the assumptions at that point in time.

2.10 Project Success Factors

The analysis and definition of different models to execute projects all comes back to the benefits of implementing a project successfully. This section will focus on the concept of project success rather than project management success which is mainly associated with traditional measurements of performance against cost, time and quality (Cooke-Davies, 2002, p. 185).

Project success refers to the project success or failure criteria. This concept is referred to in literature as the critical success factors for a project; it is the inputs that directly or indirectly lead to project success. Literature by Pinto and Slevin identified a list of 10 project success factors (Turner and Muller, 2005, p. 56) as seen in Table 2-1 below.

Table 2-1: Project Success Factors
Adapted from: Turner and Muller, 2005, p.56

Success Factor	Description
1. Project Mission	Clearly defined goals and direction
2. Top Management Support	Resources, authority and power for implementation
3. Schedule and Plans	Detailed specification of implementation
4. Client Consultation	Communication with and consultation of all stakeholders
5. Personnel	Recruitment, selection and training of competent personnel
6. Technical Tasks	Ability of the required technology and expertise
7. Client Acceptance	Selling of the final product to the end users
8. Monitoring and Feedback	Timely and comprehensive control
9. Communication	Provision of timely data to key players
10. Troubleshooting	Ability to handle unexpected problems

2.11 Alternative Literature

2.11.1 Project Phases

The life cycle for projects within the petro-chemical industry is sometimes seen as two phased rather than the traditional four-phase project life cycle. A paper dated January 2011 (Selaru, 2012, p. 276–277) states that projects are typically seen in these two phases:

- Development Phase which has a deliverable of a Basic Engineering Package.
- Implementation Phase which includes detailed engineering, procurement and construction.

The definition of the phases in this manner allows for easier allocation of contracts such as EPC (Engineering Procurement and Construction) and EPCM (Engineering Procurement Construction Management) which are very popular contracting strategies within the petro-chemical industry.

Westney (1992, p. 9) highlighted the need for treating small projects differently to the conventional approach discussed earlier in the research. He highlighted that any project management technique could be adopted provided it could allow the following:

- Allow one to handle many projects at once.
- Be used effectively without training or previous experience.
- Cope with short schedules.
- Simplify organisational interfaces.
- Handle complexities of work in an operating plant.
- Provide a basis to accumulate data (cost and schedule information) for future projects.
- Improve the multiple project managers’ capabilities regarding key responsibilities for projects.

In evaluating what other project life cycle models could be utilised for small projects (Archibald, Di Filippo and Di Filippo c.2011, pp. 5–6) also argue that the project life cycle needs to be more specific, and could include up to 10 or more phases. Literature indicates that predictive and adaptive project life models have been developed and can be utilised as they are more specific to the type of project.

Predictive models are more focused on optimisation rather than adaptability, whereas the adaptive models, as seen in Figure 2-22, accept and embrace change during the planning or development process of the project life cycle.

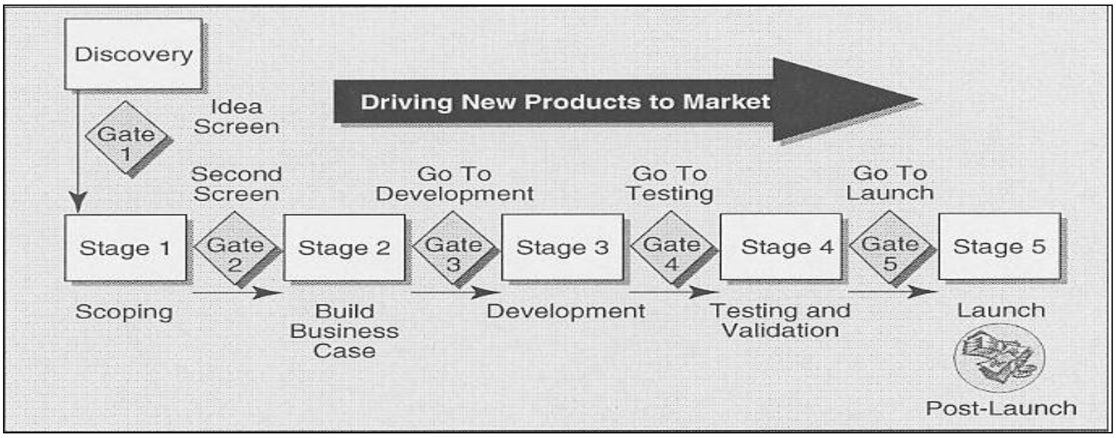


Figure 2-22: Adaptive Project Life Cycle for New Product Launch

Adapted from: Archibald, Di Filippo and Di Filippo, c.2011, p. 6

A project management project life cycle defined by Westney (1992, p. 50) in managing projects is given in Figure 2-23 below which does not necessarily define phases but rather key milestones for planning or executing a small project. This is commonly referred to in industry as the three phase project cycle.

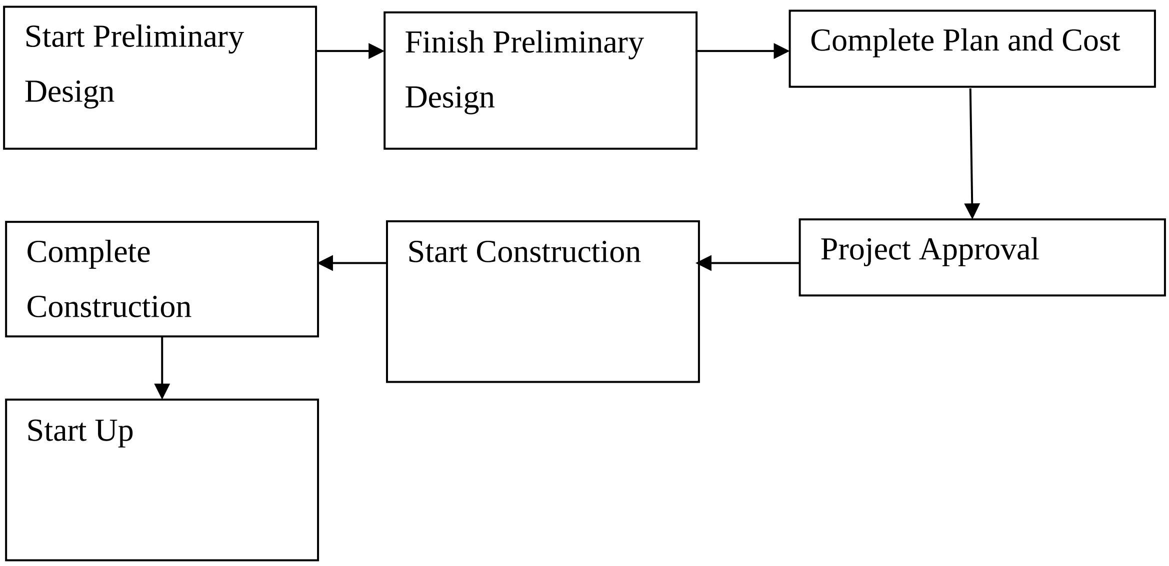


Figure 2-23: Small Project Life Cycle

Adapted from: Westney, 1992, p. 50

Other scholars Frame (1995, p. 7) Mikulskiene (2014, p.22) and have defined the project life cycle or projects as having a beginning, a middle and an end; this may seem simplistic but it is not trivial when considering management of projects.

Milton (2005, p. 34) defines a five phased project life which is defined specifically for the oil industry. Figure 2-24 gives some detail of the proposed project life cycle.

Figure 2-24: Oil Industry Stage Gate Framework
Adapted from: Milton, 2005, p. 3

2.11.2 Project Resources

Most literature gives an indication of the resources required to execute projects at the different phases; however, Frame (1995, p. 84–85) states that resources should be defined in such a way as to facilitate the effective management of projects, in other words structured to enhance team efficiency rather than to suit a particular project management model. A structure that leads to exceptional performance for one project can fail dismally for another project.

The role of the project manager is what is seen as critical as the project manager needs to have competencies in the following areas:

- Scope, time and cost management
- Human resource management
- Risk and quality management
- Contract and communication management

2.11.3 Critique of the Literature

The literature that was reviewed for the dissertation provided some background into the concepts that were key for the research project, as discussed in previous sections of this chapter. This section of the dissertation, however, will focus on the researcher's critique in terms of the literature; furthermore the critique will be followed by potential areas of development in terms of literature going forward as observed by the researcher.

2.11.3.1 Project Definition, Typology and Complexity

The definition of a project as seen from literature reviewed does allow room for development in that the definitions are somewhat outdated and simplistic in their nature. The definition presented by the British Standards Institute, however, was very comprehensive and clearly defined.

In defining projects in the current environment the term is being very loosely utilised for any activity or group of activities that resembles a project. A definition that speaks to the modern project manager's ambition in executing projects is needed, since from this research perspective the definitions noted from literature require a scholar in the 21st century to define the term project as projects are viewed within the current project management environment.

The two models defined earlier in Section 2.3 provided a very complex explanation for project typology which speaks extremely well to the current environment of defining the various types of projects. The nature of projects is extremely dynamic and complex and simplistic definitions such a small, large, medium, complex, single discipline or multi-disciple are no longer suitable. The literature provided good knowledge in terms of the NTCP diamond model and the four aspects of review in terms of typology, namely technology, novelty, complexity and pace.

In understanding how these concepts influence project typology and complexity, the literature reviewed also provided a concept that is currently being researched by many scholars, namely CAS. Defining and understanding complexity in projects is key as it can potentially influence the risks associated with the project. The structural uncertainty and uncertainty were explained further by input on complexity with literature from Remington, Zolin and Turner (2009).

2.11.3.2 Project Management, Project Phases and Project Deliverables

The body of knowledge in terms of discussions around concepts such as project management, project phases and project deliverables is extremely well documented, as observed in Sections 2.5, 2.6 and 2.7. The different project life cycle models, the phases and the deliverables per phase when managing projects are clearly documented. The literature that was reviewed also provided alternative models that are utilised in the petro-chemical industry and other discussions that have been introduced that do not necessary agree with the models discussed.

The literature currently available does not, however, provide the level of information that the researcher required for the research project, which is specific models for small petro-chemical projects. That information adequately covered generic models that can be utilised across industries, but project life cycle models such as the EPC and EPCM discussed in Section 2.11 are not well documented literature.

2.11.3.3 Level of Effort

The concept of level of effort is not well documented in current literature, irrespective of senior management's focus in industry on better reporting on level of effort as highlighted in Section 1.2. Level of effort qualitative presentations by means of graphs as shown in Figures 2.4. 2.13 and 2.14 seems to be where much focus has been placed in documenting this concept. The literature provided did, however, provide extremely good definitions of the concept and how it can be calculated from first principles.

2.12 Conclusion

Extensive research and theoretic literature have been documented on many project management concepts. The information obtained from the literature review was extremely valuable and is directly linked to research questions and objectives. A large volume of the information is in agreement or aligned; however, there are scholars and researchers that have expressed alternative concepts which were also reviewed in this section. In summary to this chapter the key concepts that influenced the research project will be discussed in brief in concluding this section of the dissertation.

The definition of what entails a project was critical and was clearly discussed and the final definition adopted for this research was based on the British Standards Institute definition:

> A set of coordinated activities with a definite start and finish with objectives centred around completing the activities on budget, schedule and as per the specified quality.

Once the definition of a project was finalised, research to understand how the types of projects are defined, or rather project typology, was also critical for the research as it does influence other factors within the project structure. The literature indicates that two main models have been adopted regarding project typology. The first defines typology using two concepts, namely nature of technology and project management scope. The second model defines typology based on four concepts, namely nature of technology, project management scope, novelty and pace.

The complexity of organisations which execute projects and the complexity of projects were evaluated. This area of research was found to have conflicting concepts as there are currently two schools of thought. The first is that all systems, projects included, are complex adaptive systems that are always changing, and their complexity cannot be managed or measured easily. Thus managing complex adaptive systems in a certain manner does not guarantee an outcome. The second school of thought states complexity can be measured and managed to ensure project success. Understanding the complexity of a particular project is critical as research has also shown that complexity does directly influence the level of effort required from the resources allocated and associated with the project.

Literature around project management, project life cycles, project phases and project deliverables has been adopted very well in industry and there are numerous books on the topic and much research completed. The literature evaluated for this dissertation clearly highlighted an agreement on the four-phase project life cycle which entails:

- Project Start/Initiation
- Project Definition/Planning
- Project Execution
- Project Closure

However, more recent literature gives insight into project life cycles that included additional phases which have been confirmed to be beneficial, specifically during the early stages of the project and towards the end of the project. The six phase project life cycle discussed in the literature review included two additional phases, namely the incubation or feasibility phase which precedes the project start phase. The other additional phase is post-project closure which is termed post-project evaluation phase.

The six-phase model was also further developed to an eight-phase model which is utilised by organisations that execute large projects, typically brown- and greenfields projects. This model allows two additional phases, one phase pre-execution and another post execution.

Once the literature regarding the project life cycle model was addressed, the next critical concept was the deliverables and resources defined or required as per the different models.

The literature reviewed provides some insight on the key deliverables and the resources but this concept has not been well defined by scholars and remains subject to numerous factors that are specific to a particular project. However, there is common ground on the generic resources and deliverables required for a project to move from one phase to another and finally in defining the project as complete or closed out.

The concept of LOE as seen in literature is quite a recent concept with evidence of the first definition by the Project Management Body of Knowledge in the year 2000, where the term was defined as a support activity that is measureable and is categorised by a uniform rate of activity over a period of time. More recent literature defines this term in line with the research objectives as a quantifiable count and measure of definable labour units that is defined to be required in the attempts to arrive at the completion of a phase of a particular project schedule.

Calculating or defining the LOE for the project is critical for this research project and literature by The International Community of Project Managers (Mochal, 2014) gives a 10 step guide which will also be used later in the research process.

In conclusion, literature was also reviewed to define the term project success and what constitutes failure or success in projects, and the concept of project success factors was investigated. Recent literature has defined clearly the difference between project management success and project success; Turner and Muller (2005) have defined critical project success factors in a very comprehensive table indicated in the literature reviewed.

CHAPTER THREE

Research Methodology

3.1 Introduction

This chapter of the dissertation provides detail on the research design and research methodology utilised for the research process. The quantitative research method was adopted for this research as it proved to be more beneficial especially as the aim of the research is to define a tool with graphical detail that can be utilised for different scenarios, based on feedback from a sample of research questionnaires.

Detailed insight will be given in this section on the key factors that were defined and investigated before the research process could be undertaken. These factors included but were not limited to defining the following:

- Detailed hypothesis.
- Null hypothesis.
- Research framework.
- Relevant research methods.
- The size of the research target group.
- The methods used to collect data.
- Method used to analyse information.
- Research questionnaire utilised for the research process.

3.2 Research Design

The research design was developed to allow the research process to ensure the research questions and objectives defined in Chapter 1 were successfully answered or achieved. The choice of the approach as previously discussed was determined by the nature of the research problem statement. The quantitative research methodology was considered for the research project in order to cater for the specific information that was required for the study. The detailed information was analysed and formed into a model that can be used for a large number of projects while maintaining confidentiality and anonymity.

The research design entailed the following:

- Literature evaluation, which entailed evaluating the concepts and theories that have been researched and accepted globally regarding the project life cycle phases, resources, deliverables and the LOE required from the resources throughout the project life cycle.
- Information gathering, focused on obtaining data from project engineers, engineers and project managers from Sasol Synfuels, Sasol Technology, Sasol South Africa Energy and engineering firms/consultants that have completed small projects successfully.
- Defining a detailed hypothesis based on experience, participant observations, literature and case studies.
- Data Analysis, which entailed a detailed analysis of the literature reviewed, feedback from questionnaires and input from participant observation notes.

3.3 Research Questions

The research questions as defined in Chapter 1 of this dissertation were defined prior to the research methodology being finalised. These questions were utilised in order to ensure alignment towards the research objectives during development of the research questionnaire, as discussed later in Section 3.5.4.

The research questions are summarised as follows:

- What percentage of effort is required for the critical resources identified in projects for the activities required at the different phases of the project life cycle?
- Is there an alignment or congruency between the current literature and research data regarding the resources and percentage of effort required at different phases of a project?
- What graphical representation can be utilised to illustrate the resources and percentage of effort required for the activities required at different phases of the project?

Note: This research does not consider resources required for the construction of any equipment, product or structure required for the project.

3.4 Hypothesis

In defining the research hypothesis, the research questions had to be clear and then translated into a hypothesis that states a relationship between two or more variables in one (or more) population(s).

Hypothesis Statement

It is hypothesised that the LOE (percentage of effort) of critical project resources will vary significantly depending on the phases of the project life cycle for small-sized projects, the four key resource tracks being technical, business, project management and sponsor resources.

Null Hypotheses

There are no critical resource tracks in the management of small projects and the LOE (percentage of effort) for the project resources is not dependent on the deliverables or the phases of the project life cycle but rather other internal and external factors.

Detailed Hypothesis

There are four critical resource tracks in projects, namely technical, business, project management and sponsor resources. The LOE for each of these resources is dynamic and changes as the project moves from one phase to another of the four-phase project life cycle.

The resource track LOE increases and decreases mainly due to the deliverables (scope, governance requirements, accountability, responsibility, cost, schedule, safety and quality) required during the particular phases of the project life cycle.

The research hypothesis was developed into graphs before the research process was initiated. The researcher developed these graphs in line with the hypothesis that was developed for the research project. Figure 3-1 to Figure 3-5 give a graphical hypothesis prior to the research process conducted for the project. The graphs indicate the LOE per resource from project initiation to project completion. The project life cycle is defined from zero to one hundred percent. The four phase project life cycle is utilised; therefore, the project life cycle is divided into four phases. This concept is derived from the basic principles of project management, in that a project is divided into four phases, and the critical assumption in the development of the hypothesis was that each phase of the project life cycle is equal to the next. This is a valid assumption as the hypothesis does not provide for the large volume of resources utilised during the construction exercise of the project.

The hypothesis graphs were generated from the researcher's understanding of projects and the project management environment based on previous experience and interactions with other stakeholders within the project management fraternity.

1. Project Start/Initiation: 0% to 25% of project completion.
2. Project Definition/Planning: 25% to 50% of project completion.
3. Project Execution: 50% to 75% of project completion.
4. Project Closure: 75% to 100% of project completion.

The graphs were then developed by the researcher with the aid of Microsoft Excel as the tool that generated all the graphs represented in the dissertation. It is critical that the graphs are interpreted with the understanding of the different phases and percentage of the project completed, as defined above. The detailed hypothesis graphs for the LOE required per phase for the four different resource types are given in Appendix 1.

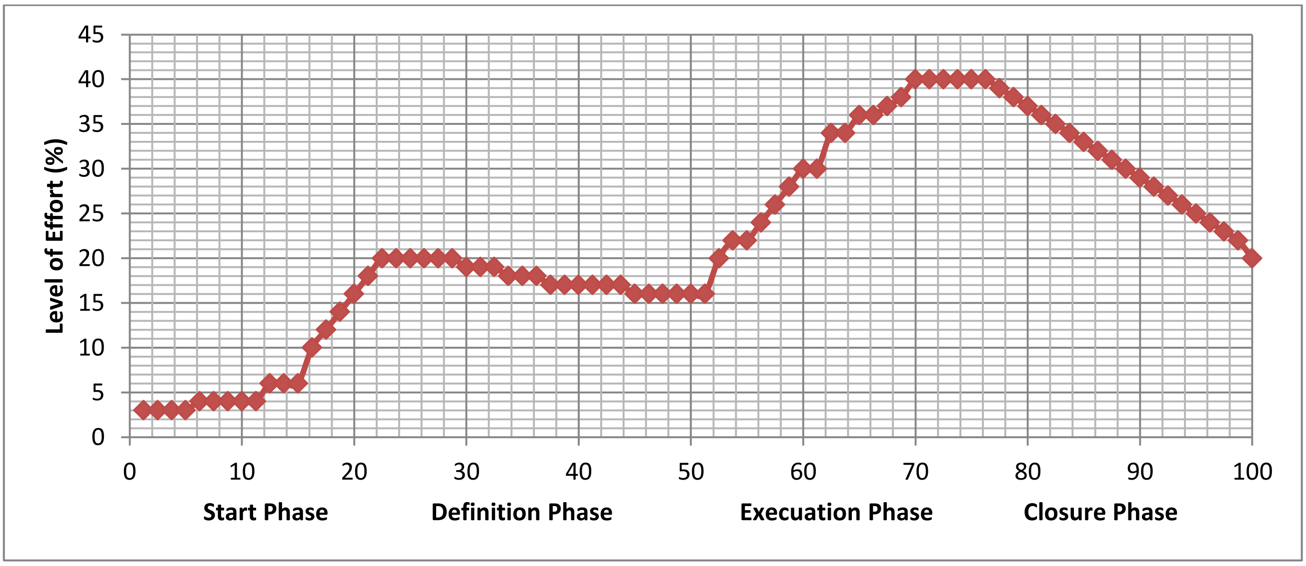


Figure 3-1: Level of Effort Hypothesis for Project Management Resources

Figure 3-2: Level of Effort Hypothesis for Technical Resources

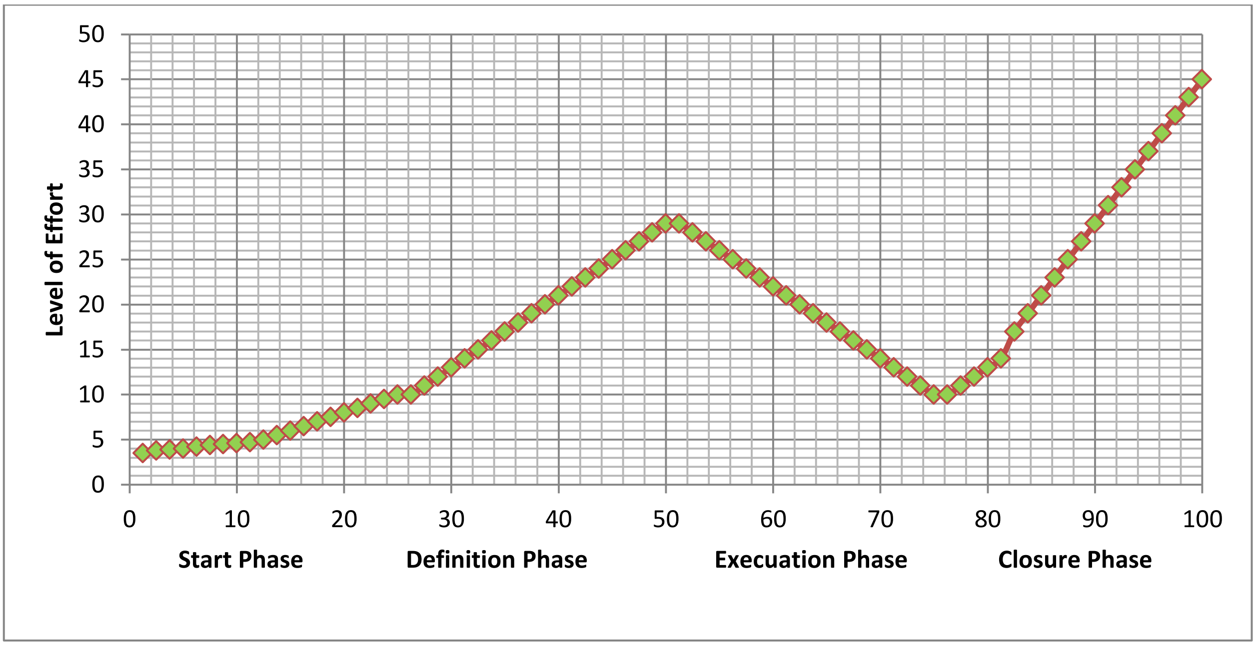


Figure 3-3: Level of Effort Hypothesis for Sponsor Resources

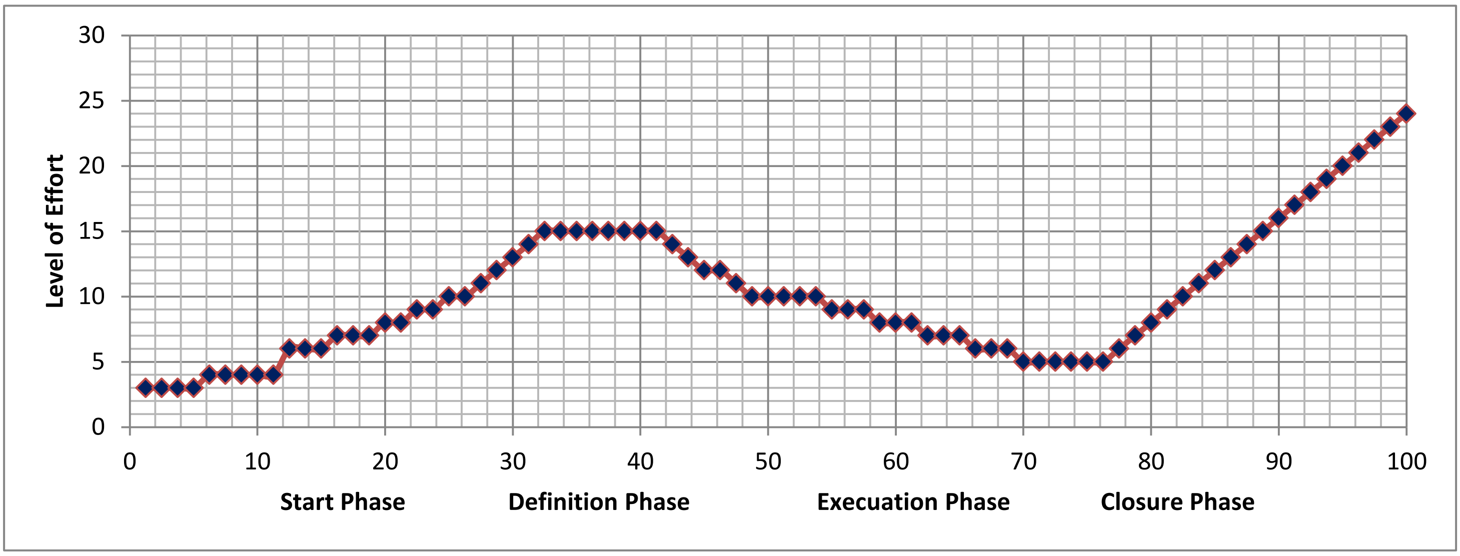


Figure 3-4: Level of Effort Hypothesis for Business Resources

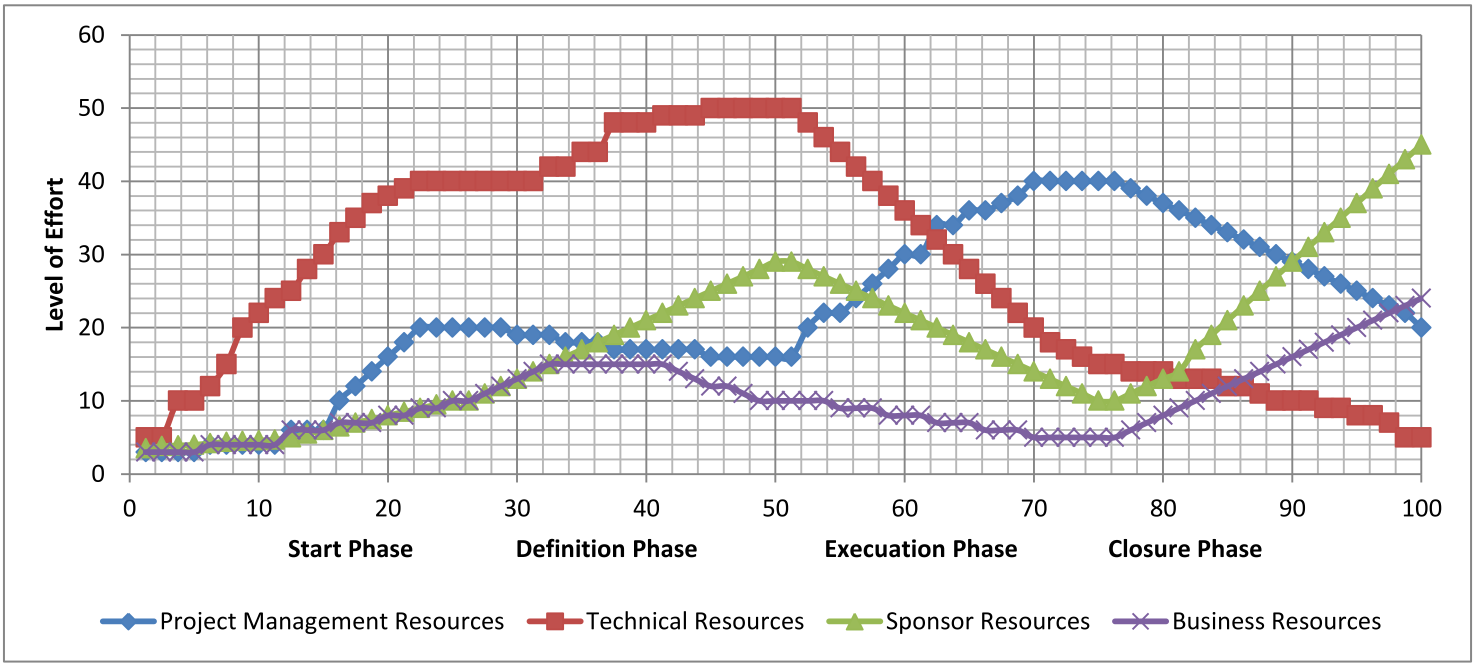


Figure 3-5: Level of Effort Hypothesis for All Project Resources

The approach of testing a counter hypothesis currently available in literature or industry will not be considered for this dissertation but can be considered by future scholars.

3.5 Research Methodology

The research methodology that is adopted for a particular research project is generally dictated by the type of data required to answer the research questions and meet the pre-defined research objectives. The three research methodologies utilised for research projects are qualitative, quantitative and mixed. As noted the researcher would decide on the preferred method based on the type of data required for the research process; in a research project where the research question requires numerical data, the preferred research method would be the quantitative.

Quantitative research emerged around 1250 AD; it has been simply defined as the general approach researchers take in carrying out research projects (Williams, 2007, p.66). This particular research would entail numerical data collection, historical research, mathematical models in the analysis of data, testing of data, hypothesis testing, standardised questionnaires, measurement procedures and statistical analysis. The methods used for quantitative research can include survey research, structured questionnaires, validity and reliability.

Qualitative research is more of a holistic or natural research process, the research process involves discovery as it allows the researcher the opportunity to develop a level of detail from high involvement in actual experiences (Williams, 2007, p.67). Qualitative research is simply defined by Nigatu (2009, p.5) as developing concepts that assist in understanding phenomena in natural settings which give emphasis to the participants' views and experiences. The methods utilised particularly for qualitative research are case study, ethnography study, observations, open-ended research questionnaires and content analyses.

The combination of qualitative and quantitative, commonly referred to as the mixed method, was utilised in research around the mid-to-late 1900s (Williams, 2007, p. 69) with the intention of showcasing that researchers can incorporate methods used to collect and analyse data from the qualitative and quantitative methods for a single research project. The research methods would, of course, entail the collection of numerical data and narrative data to meet the research objectives and answer the research questions.

After the brief explanation into the different research methodologies available to prospective researchers; it is also important to also establish the key weaknesses and strengths of the different research methodologies. Figure 3-6 provides detail into the key weaknesses and strengths that each research methodology provides.

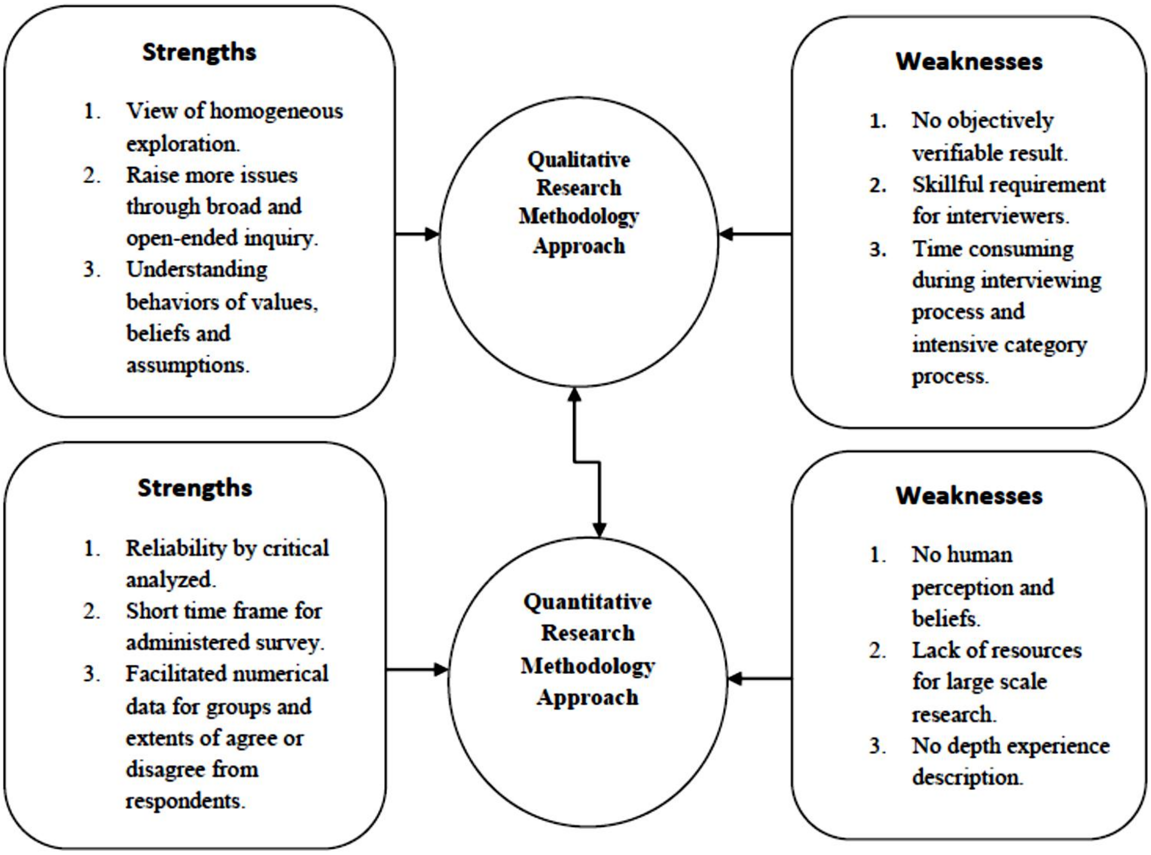


Figure 3-6: Strengths & Weaknesses of Qualitative and Quantitative methodologies
Adopted from: Choy, 2014, p. 101

3.5.1 Quantitative Method

The quantitative method is extremely valuable as it can render the strengths which are in line with the requirements of this research project, such as allowing the facilitation of numerical data analysis in reviewing for agreement or disagreement from respondents. Numerous methods are commonly utilised in quantitative research, which are namely:

- Hypothesis Testing
- Experiments
- Structured Questionnaires
- Historical Research
- Case Study
- Participant Observation

This dissertation however, only focused on four key methods: historical research, case study, structured questionnaires and participant observation in obtaining information that was used in evaluating the hypothesis and developing the proposed model.

One of the critical issues relating to a quantitative research methodology is to maintain ethical standards in that confidentiality and consent must be addressed and ensured before and during the research process.

3.5.2 Historical Research

Historical research was used to add value in evaluating the hypothesis defined in the dissertation, and the primary sources of historical data were sourced and utilised in defining and refining the hypothesis as discussed in detail in Chapter 2.

In quantitative analysis, it was critical to utilise primary rather than secondary sources and this was fundamental in evaluating the relevance of the information from secondary sources as it can be inadvertently or deliberately distorted and influence the research findings.

3.5.3 Case Study

A detailed analysis of Sasol as an organisation that manages numerous small projects within the petro-chemical industry formed the basis for the case study section of the dissertation. The focus was on the resources utilised at different phases of the project life cycle which was used to gather data that was used in reviewing the quantitative graphs developed as the hypothesis. The pool of projects considered was limited to the following criteria:

- Small technical projects within the Secunda Refinery Complex.
- Small-scale projects being managed by Sasol Technology and engineering consultants only within South Africa.

3.5.4 Research Questionnaires

The questionnaire given in Appendix 6 was circulated within the Sasol group of companies to project managers, project engineers and to various engineering and project management firms for feedback. The researcher utilised an opportunity at a Sasol Secunda Refinery Engineering Meeting held early in November 2014 to discuss the objectives of the research project and request participation from the engineers that were at the meeting. Forty five hard copies of the questionnaire were handed out at the end of the meeting. An electronic copy of the questionnaire was later circulated to the meeting attendees.

A further 75 emails sent out by the researcher to project managers and engineers within the research target group requesting participation in the research project and submission of the feedback via email or at the specific collection points; hard-copy completed questionnaires were left with secretaries that had been requested to provide support before the questionnaires were sent out.

The researcher did not utilise one-on-one or group interviews to collect data required from the questionnaire. The majority of the respondents completed the questionnaires in isolation; however 13% of the respondents made contact with the researcher for clarification on certain questions.

The research questionnaires that were collected from the submission stations and via email by the morning of the 31st of December 2014 at the Secunda Refinery were utilised for the purpose of the data analysis as discussed later in Chapter 4. The information received was used to develop graphs, with a combination of qualitative and quantitative information, that were later used to test the hypothesis developed earlier in the research.

The questionnaire was structured to ensure that information regarding key areas of the research would be tested while also ensuring that it was linked to the research questions and objectives.

Questionnaire: Part 1

Questions 1 to 9 were structured to gain insight into the project size (magnitude), typology, complexity and strategic importance. These questions were utilised in the research to ensure that projects that are similar in nature, size, complexity and strategic importance are grouped and reviewed as a group in order to draw a mean that is accurate based on the project typology as defined in the research.

Questionnaire: Part 2

Questions 10 to 13 were utilised to get information on the types of resources involved in the project and the magnitude of the resources involved in the project.

Questionnaire: Part 3

Questions 14 to 17 focused on gathering information on the activities and/or deliverables that were completed during the four phases of the project life cycle by the four different resource types for the particular project.

Questionnaire: Part 4

Questions 18, 19 and 20 were structured to obtain qualitative and quantitative feedback from the respondents on the amount of hours or LOE required per resource for the four different resource types for the four phases of the project life cycle.

Questionnaire: Part 5

The last set of questions, namely question 21 and 22, were included to understand if external factors or risks influenced the project during the project life cycle and how this was managed and lastly if the project was considered a success.

The minimum number of questionnaires considered for both internal distribution and distribution external to Sasol, was 50.

3.5.5 Participant Observation

Participant observation as a quantitative method was also utilised and provided very valuable information towards refining the research hypothesis. As the researcher was also a participant in the Sasol Synfuels Projects Department. At the time of this research, the researcher had 10 years of experience as a project engineer within the power utility and petro-chemical industry in South Africa. Thus the researcher’s observations on the following projects was utilised as part of the data in the data collection phase of the research process:

- Venturi Absorber Rebuild Project.
- Replacement of the Coke Cutting Tool Project.
- Construction of a 2.2 Million Litre Tank Project.
- Sectional Replacement of Sulphen Storage Tanks Project.
- Boiler Re-build Project.

This research method entailed the observations and deductions noted by the researcher based on unstructured discussions with project team members and colleagues external to the projects. The observations and participation in the different project teams over a period of 12 months, where the level of effort per resources, the specific resources and deliverables were evaluated against the other projects within the Secunda Refinery. The Secunda Refinery was noted to be the ideal community to undertake the study into the daily activities of the project teams based at this site. In order to ensure the areas observed would add value to the research project, the following criteria were used in eliminating observations that were not to be considered in the research data analysis:

- Project team being observed needed to be structured with appointments and clearly documented or perceived roles and responsibilities.
- Observations on external projects were limited to projects in the initiation, planning or closure phase due to the assumed large number of activities in the execution phase.
- Projects had to be small and technical in nature as defined in this dissertation.
- Only projects within the Power Station and Sulphur plant environment were observed.
- Projects assumed to have a significant number of external resources were not considered for observation.

Both the perceptions and actual effort required from particular resources were noted, as well as the deliverables required per phase and the impact of external factors on the different resources. The setting of the site, what was observed by the researcher and the discussions between the researcher and multiple participants were noted in field notes, the information noted was assumed to be objective and subjective. The participants to the study which formed part of the researcher’s project team were aware of the study and the fact that the researcher would utilise the observations for the dissertation. However participants from other projects and within the refinery were not aware of the observations being noted for the purpose of this research.

The aspects that were key for the observations conducted were:

- Perception in terms of level of effort required per resource from the project team.
- Level of effort per resource observed by the researcher from other projects.
- The criticality of the different resources on projects.
- Critical deliverables based on project success or failure.

This information was recorded as field notes which were later interpreted into findings; these findings were then summarised into qualitative and quantitative information.

The details pertaining to the analysis of the observation, the criteria used to select the observation group, how the process of recording the observations and the process of analysing the information are discussed further in the dissertation under Section 4.3.1.

Information from archived projects and from previous project managers that the participant had worked with regarding the LOE, man-hours and the distribution of the man-hours was also represented in a graphical model which was used to define the research hypothesis on the LOE and the different project life cycle models. This information and the interpretation thereof will be discussed extensively in Chapter 4.

In undertaking participant observations, it is impossible for the researcher to be totally detached from the research process even when desired. Instead of seeing this as a concern it has been identified in this research project as a benefit and will be utilised as unstructured information under the participant observation method. This idea is also referred to in literature as reflexivity.

Reflexivity is defined by Horsburgh (2003, p. 308) as the active knowledge or understanding by the researcher that their actions and decisions will inevitably impact upon the meaning and context of the experience under investigation. Therefore, the researcher realises and accepts that they are an integral part of the world being investigated; thus neutrality or objectivity regarding the data collection, analysis and interpretation is not possible.

3.6 Research Site

The research site for the dissertation was limited by the researcher's ability to access what many organisations consider to be confidential information, namely the resource loading at different phases of the project. Project management and engineering consulting firms also consider this information to be of strategic importance as organisations that execute projects successfully with the optimal number of resources can be more profitable than those that do not use resources efficiently.

However, due to the volume of small projects executed within the different business units or companies within Sasol, the availability of information internally was not a concern. The following Sasol business units formed part of the research site:

- Sasol Synfuels is located in Secunda, Mpumalanga. The site consists of two power stations and refineries on the same site. The site employees more than 15 000 people. In terms of production, the site produces 800 megawatts of electricity and imports 600 megawatts of electricity continuously in order to produce 7,4 million tonnes of numerous types of products ranging from petrol to fertilisers per annum. The average annual budget for small projects within Synfuels is five hundred million rand.
- Sasol Technology is located both in Secunda, Mpumalanga and Rosebank, Gauteng. This Sasol business unit is focused on developing new technologies for Sasol and executing projects for the Sasol group internationally in countries such as Mozambique, Nigeria, Canada and the United States of America to name a few.
- Sasol South Africa based in Randburg, Alberton and Germiston, Gauteng focuses on retail and wholesale business in South Africa. The projects related to the construction of retail sites and commercial sites are managed within this business unit.

Two consulting organisations that provide project management and engineering services also formed part of the research site for the dissertation. The names of the organisations will not be disclosed as anonymity was guaranteed when gatekeeper approval was requested. The two consulting firms however, render a service to the Sasol group.

The research site was also limited to projects executed within the boundaries of South Africa, particularly Mpumalanga province and specific to the petro-chemical industry.

3.7 Description of Participant Group

Defining the participant group and the sample size for a research project is a very important step as it is neither practical nor effective to strive to study an entire population group. Many researchers, therefore, have previously opted for random samples. In terms of sample size many researchers believed that the larger the sample size the better the research feedback as the sampling error was assumed to decrease with size. However, more recent literature shows that the benefit of a large sample size does not surpass the benefits associated with defining an optimum sample and key parameters that are important to the sample group. An optimum sample is defined by Marshall (1996) as one that adequately answers the research question(s).

Literature (Marshall, 1996 p. 523) shows that there are three main sample strategies, namely convenience, judgement and theoretical samples. Convenience sample is mainly focused on the ease of access to the participants; this technique can be the least rigorous and can lead to poor results. This method is generally seen as not credible or representative. The judgement sample is commonly utilised by researchers as the researcher selects the most productive sample to respond to the research questionnaire. This sampling method can be very informative but the researcher needs to be well informed on the research topic to ensure this sampling method is well utilised to allow valuable feedback from the research process.

The theoretical sampling method requires an iterative process in that it entails the building of interpretative theories from the data received and later elaborating on theories built. Therefore participants will be selected or defined based on their ability to provide relevant data on the area or subject under research. Analysis of the feedback from the research questionnaires or interviews will also give guidance in the future sample group, this approach is part of theoretical sampling (Horsburgh, 2003, p. 311).

The sampling method utilised for this research was a combination of judgement sampling and theoretical sampling. The participant group was not restricted by gender, race or age as is the case with many quantitative research studies which generally focus on a specific group. The specific group for this research was restricted to the parameters defined below.

- The participants needed to have an engineering or project management background or qualification.
- The participants' experience within the industry or projects had to exceed a period of three years.
- The feedback from the questionnaires would not be restricted to a particular field; however, the projects needed to be executed within the petro-chemical industry.
- The participants had to be working for Sasol or either one of the project and engineering consulting forms.

- The age, gender, race or nationality of the participant was not a restricting parameter for participation.
- The participation was also restricted only to English-speaking individuals.

The size of the participant group was not limited as the research objective was based on obtaining a large volume of information that would be utilised to evaluate the hypothesis and define the graphical models. The participant group was therefore limited to 120 participants. However, the time available for the research was the limiting factor as data collection, analysis and interpretation were very time consuming.

3.8 Methods of Data Collection

The data that was utilised for the research process was categorised into two, namely structured and unstructured i.e. historical data, surveys, participant observation and questionnaires. The raw data obtained from the different research processes was collected, organised and processed into Microsoft Excel and Word.

3.8.1 Structured Data

Structured information on resource loading at different phases of the project life cycle was sourced from the following organisations:

- Consulting Engineering and project management firms.
- Sasol project and engineering groups:
  - Sasol Technology project managers for small projects.
  - Sasol Synfuels project managers and project engineers for small projects.
  - Sasol South Africa Energy project managers and project engineers for small projects.

Data on technical, business, sponsor and project management resources required from start to closure phase in terms of man-hours or effort level was requested and treated as confidential for the purposes of this research project.

3.8.2 Unstructured Data

Unstructured data refers to information that was obtained during the research process from participant observations and feedback from the research questionnaires from the participants. Field notes from the participant observation were expanded into descriptive narratives. The narratives were then developed into MS Word documents with date stamps as the referencing method. The information was categorised and recorded utilising a hardcopy filing system and later transferred to Microsoft Excel.

The observations were conducted on projects that were planned and executed within the Sasol Secunda Refinery complex, specifically the power station and the sulphur plant. The observations were conducted on project department personnel, engineers, management and operations personnel from the January 2014 to 15th of December 2014. The recording of the unstructured data was limited to weekly notes. The activities pre and post the execution phase of the construction of a 2.2 million litre tank provide a significant volume of information utilised in developing the model presented later in the dissertation.

3.9 Data Analysis

In order to complete the analysis of the information, the raw data that was available had to be structured in a manner that would allow efficient analysis of the information. A systematic approach was developed which entailed the following steps:

- Quantitative information on the resource loading hours was reviewed to ensure the information was relevant to projects only considered for the purpose of this research.
- The information on the resources hours was turned into an average to ensure anonymity and confidentiality.
- The qualitative and quantitative information was later developed into graphs to indicate the average LOE per resource and the key deliverables for the project life cycle.
- The qualitative information was obtained from two main sources, namely the participant observations and the research questionnaire.
- The quantitative feedback from the questionnaires was also checked for validity to the research topic. All valid feedback was then filed according to the project life cycle phase.
- The information was also converted into an average measure and converted into graphical representation.
- The participant observation feedback was also structured into graphical models based on previous projects.

The key focus of the data analysis process while maintaining confidentiality and anonymity was to search for differences, similarities, themes, areas of development, areas of future research and new ideas or themes during the continuous research process. Testing the hypothesis while also adjusting where necessary in order to define a graphical model from the research process was also key.

Ultimately the final outcome of the research process was to define a graphical model that would give an indication of the project life cycle, project life cycle phases, key project deliverables per phase and the LOE required per resource for the project life cycle.

3.10 Assumption and Risks

The graphical representations that would be developed for the purpose of the research would consider certain assumptions and risks which would clearly be defined with the graphs. Some of the assumptions and risks can be summarised as follows:

- All projects information utilised for the data collection phase is assumed to be correct and accurate.
- The information provided is assumed to be in line with the project limits in terms of budget, schedule and scope.
- The respondents are assumed to be competent and well experienced in project management.
- Exclusion for factors to allow for efficiency, effectiveness and other undefined risks are not included.
- Scope creep or additional scope was not considered in the model.
- The project resources are assumed to be competent.
- A risk of under- or overestimating resources should be considered and a correction factor is recommended as seen later in the dissertation.
- The model to be developed does not include legal and organisational governance deliverables as these are assumed to be clearly defined in other documents or tools.

3.11 Ethical Considerations

Due to the sensitivity and confidentiality of the information that was required for the research process, a formal request to conduct the study, as seen in Appendix 5, was sent to a group of desired participants for the research project. Consent to continue with the research and send out the research questionnaire was given by the following organisations:

- Sasol Technology.
- Sasol South Africa Energy.
- Sasol Synfuels.
- Two project management and engineering consulting firms.

The gatekeeper approvals were obtained and filed as seen in Appendix 7 as proof that the management representatives were aware of the research and did consent at the time of the research.

The participants were assured of anonymity and confidentiality, as this was clearly stated in the introduction of the research questionnaire. Furthermore participation in the research process was also clearly indicated as voluntary in the questionnaire. However, due to the number of questionnaires sent out for the research, participant consent was not documented but assumed for questionnaires that were returned for the purpose of the research.

Lastly ethical clearance (Appendix 8) was also obtained from the University of KwaZulu-Natal to conduct the research for the purpose of completing the dissertation.

3.12 Review of Another Engineering Model

The use of models in the petro-chemical industry is not a new phenomenon. Models such as the pump curve model continue to be utilised extensively in industry. Especially as the pump may have been man's fourth invention following the wedge, lever and the wheel (Ajayi and Mofikoya, 2012, p.795).

A theoretical model of a pump curve and one specific to a particular pump will be discussed later in Section 4.4. The key basis of this section is to provide an objective view of how a similar model to the level of effort model that was developed during this research process continues to be utilised in the petro-chemical industry.

3.13 Research Limitations

This section of the dissertation will provide a brief description of some of the critical limitations experienced during the research process. Firstly, the number of respondents to the study was a potential concern as the information that was requested from the questionnaire was very extensive and a significant amount of time was required to complete the questionnaire. Secondly, some respondents believed the information was confidential to a certain extent as it could potentially impact future pricing in terms of hours required from the different resources at different project phases.

Furthermore, the competency and experience of the respondents were also a limitation as the questionnaire required feedback where certain individuals could either have limited exposure or knowledge on the matter. This had the potential of diluting the accuracy of the feedback with invalid information. Lastly as the questionnaires were circulated by email, one of the key limitations was the inability of the researcher to engage the respondents on a one–on-one before the completion of the research questionnaire. The hard copies of the questionnaires were only handed over to respondents for completion, the respondents and the researcher did not engage in one-on-one discussions.

3.14 Conclusion

This chapter of the research dissertation introduced the research design that was utilised to address the research questions and achieve the research objectives. A quantitative research methodology was defined and adopted for the purpose of the research. The research method utilised for this particular research was limited to historical research, case studies, research questionnaires and participant observation.

The hypothesis statement, null hypothesis and detailed hypothesis statement were clearly defined and introduced in this chapter. The hypothesis in summary states that the LOE for critical resources varies significantly depending on the phase of the project for small-sized projects. The hypothesis was further defined graphically into models indicating the LOE required per resource for the project life cycle. This hypothesis was developed prior to commencement of the research process.

The data obtained from structured and unstructured sources discussed in this chapter was used to further refine the hypothesis, test the hypothesis and further develop the hypothesis. The data analysis process was clearly defined, and with the aid of Microsoft Excel the research information was stored, refined, evaluated, analysed and illustrated in graphical models as will be discussed in the next chapter.

The research site consisted of three main sites, namely Sasol Synfuels Secunda, Sasol Technology South Africa and Sasol South Africa Energy Projects. The focus was mainly on South African projects for the research questionnaires sent out for feedback. The research participants were not limited or restricted by race, gender or age but rather by their competence, experience and working experience within the petro-chemical industry.

The research questionnaire was structured into five parts which ensured that feedback from the participants would include feedback specifically on the following:

- Insight on the project size, complexity and strategic importance.
- The types of resources involved in the project.
- The activities and deliverables completed per phase.
- Qualitative and quantitative feedback on resource LOE.
- External factors that influenced the project.

The limitations for the research project were documented and well understood by the researcher as describes in Section 3.13 of the dissertation. The aspects that could influence the research findings from the limitations such as lack of feedback from respondents and ensuring strict confidentiality of the feedback were managed closely in ensuring the research process would be completed as planned.

Lastly the approval from gatekeepers and the University of KwaZulu-Natal was critical for the research process. Consent from gatekeepers, participants and the university was requested via a formal letter requesting permission to conduct the research, detailed consent in the introduction of the research questionnaire and a detailed ethical clearance application. The formal approvals from the university ethics committee and the gatekeepers to undertake the research process were completed and are attached to this research dissertation.

CHAPTER FOUR

Results and Discussion

4.1 Introduction

This chapter of the research dissertation will focus on presentation of the results after the analysis of the data obtained from the numerous sources as per the research methodology discussed in the previous chapter. The results from the respondents will be presented by means of quantitative graphs and qualitative feedback summarized in tables in order to give a collective or cumulative presentation as to maintain confidentiality while also providing in-depth feedback from the research process.

The results will also be discussed in detail in this section of the dissertation while re-visiting the research questions and objectives discussed in Chapter 1. The literature reviewed in Chapter 2 will also form part of the discussion of the results.

The discussion will clearly indicate the information that supported the research hypothesis while also highlighting the key areas of misalignment. The hypothesis will also be reviewed and areas of agreement and misalignment will be shown.

The discussion will be centred around the research objectives and questions as findings and recommendations centred around the objectives and the questions are critical and will form the basis for Chapter 5, in order to clearly define the outcomes, lessons and contributions of this research project. The discussions associated with the objective that ties to the feedback from the questionnaires will be discussed later in this chapter after the analysis and representation of the feedback from the respondents.

4.1.1 Objectives One and Two

The first two objectives for the research were focused around developing a hypothesis for critical resources for a small project from start to finish, specifically on the LOE required per phase. The research process defined in Chapter 3 of the dissertation made possible the answering of the research question linked to these objectives. A detailed analysis of literature highlighted numerous project life cycles for small projects. The following project life cycles have been adopted by many scholars and organisations:

- Four-phase project life cycle
- Six-phase project life cycle
- Eight-phase project life cycle

These three models are very similar and in essence can be seen as an evolution from one to the next. In simple terms, the eight-phase project life cycle model is an evolution of the six phase cycle. The six phase project life cycle similarly is the evolution of the four phase project life cycle. As shown in Chapter 2 these models are similar and merely include additional phases to allow firstly for better governance of pre-project initiation, post-project initiation, and prior to project closure. The inclusion of additional phases such as the pre-feasibility phase allows the project team to develop the project in smaller stages rather than when there are few phases. In the inclusion of additional phases the project governance and deliverables are better managed and certain key documents are developed into more detail as the project develops from one phase to another. This is key for large-scale projects as pre-feasibility, for example, can identify key concerns that can have a financial impact in the development of a feasibility package for a particular project.

In the project management of specific types of projects, for example small size projects with a low complexity; the four-phase project management cycle has proven adequate and does yield success across many organisations.

However, the research process did highlight new concepts and areas of incongruence regarding project life cycle models. There is a small group of organisations and project managers specifically within the engineering sector that have also adopted a two phase project management life cycle. The first phase as highlighted in Section 2.11.1, being a combination of an initiation and planning phase. The second and last phase is a combination of a detailed planning phase, execution and project closure.

The Engineering Council of South Africa recognises a five-phase project life cycle referred to as the stages of services (Republic of South Africa, 2014, p. 40), namely:

- Inception
- Concept and Viability
- Design Development, Documentation and Procurement
- Contract Administration and Inspection
- Close out

Another new concept introduced by Westney (1992, p. 9) is that any project management technique can be adopted and projects can be managed according to the conventional approach. In so doing so projects can be addressed more adaptively and embrace change during the planning and development process which could exploit available efficiencies and become more innovative by nature.

A more radical approach which is believed to be in line with complexity theories such as those defined in literature associated with complex adaptive systems indicates projects to fall within the definition of a complex adaptive systems that require dynamic thinking. The literature further elaborates that no particular model, actions or guidelines can guarantee a particular outcome for a complex adaptive system.

Irrespective of the conflicting project life cycles models that have been documented and researched, there is still common agreement about the four, six and eight-phase project life cycle. The most commonly utilised and adopted model for small and less complex projects is the four-phase project life cycle as observed in the literature review, case studies and participant observation undertaken during the research process. The four phases of this model are primarily focused on the specific scope and deliverables required per phase.

The four phases are project initiation or start, project definition or planning, project execution and project closure or delivery, in that particular order of sequencing.

In defining or developing the hypothesis for small projects the project life cycle model adopted was critical as this would form the basis for the scope or deliverables required at different milestones of the project which would have a direct correlation on the LOE required from the resources.

In further developing the hypothesis, the research process assisted in obtaining information on the definition and specification of critical resources within the project management environment. The literature clearly highlighted that resources are not limited to individuals or groups of individuals but can be inclusive to include tangible and intangible items such as knowledge, materials, structures, tools and so forth.

However, there is common agreement derived from literature, case studies and participant observation in terms of key or critical resources required for projects and these have been defined as follows:

- A project manager who is responsible for the management of the project, resources, schedule, cost, quality and overall success of the project.
- The customer, client or business, which will utilise the project's product.
- The performing organisation, which is the organisation whose employees are mostly doing the physical work of the project.
- The project team, which is the group of individuals doing work on the project.
- The sponsor, who is the individual or group that provides funding for the project.

There are some very valuable new concepts that have also emerged from the research process, specifically around critical resources, which go as far as to say resources need to be defined in a way that allows for effective management of the project and that the role of the project manager and his competencies are the critical issues when evaluating the concept around resources for a project.

After detailed analysis and review of the different sources of information optimal or critical list of resources, the resources were grouped and limited as follows: project manager, technical resources, business resources and sponsor resources. The performing resources were excluded from the research process as these resources and their effort level tend to vary significantly depending on the scope of the project. The performing resources are also not defined in the front-end loading of a project but are rather defined by the contractor or service provider early in the execution phase of the project. The research associated with the definition of these resources or effort levels can be considered for future research.

The concept of LOE is one that is relatively new within the project management environments and it was a key concept to the research conducted. This concept is simply defined in Chapter 2 as a quantifiable count and measure of definable labour units required to arrive at the completion of a phase of a particular project schedule.

Literature on the definition or calculation of LOE for project resources is very limited currently as there are currently numerous computer programs utilised by organisations and project managers to define quantitative resource plans.

In terms of the LOE required from the technical resources throughout the project life cycle, the Engineering Council of South Africa gives an indication of the LOE per phase based on the recommended percentage of payment for the technical resources per phase. This detail is given in Table 4-1.

Table 4-1: Summary of Project Deliverables according to ECSA

Adapted from: Republic of South Africa, 2014, p. 40

Project Phase (Stage of Service)	**Typical Percentage Points for Each Stage**
Inception	5
Concept and Viability	15
Design Development & Documentation and Procurement	40
Contract Administration and Inspection	35
Close out	5

There is very recent literature from the International Community of Project Managers that was very useful in defining the LOE required from a resource and was discussed in detail in Section 2.9. These guidelines together with the representation given in Section 2.7 and knowledge of the researcher based on previous projects aided in defining the LOE at different phases for different resources for small projects. The assumptions and information from literature related to LOE will later be compared to the feedback from the questionnaire.

In evaluating all the aspects related to projects and project management as defined earlier in this section it was important to also acknowledge that the project deliverables are also dependent or influenced by numerous factors including those discussed earlier. The project deliverables as discussed in Section 2.7 can be defined as the work or product located at the end of a hierarchy of activities, which can be a product, equipment or documentation.

These deliverables are generally determined by the client, the organisational governance and the project life cycle model adopted. The definition of deliverables and milestones is key in that it directly influences whether the project is termed a success or not. Prior to concluding the discussion regarding project deliverables, the concept of project success will be explored, as this can influence the project deliverables.

This concept of project success or project success factors was discussed in Section 2.10 of the dissertation. This concept is not similar to project management success which is centred around the successful management of the project diamond, i.e. cost, quality, schedule and scope, but rather is centred around the measures that have been specified in the definition of a project being a success or not.

These measures were highlighted in detail in Table 2-1 and include adherence to the project mission, client acceptance of the final product and provision of timely and accurate data to key stakeholders.

The list of key deliverables for critical resources in small projects within the petro-chemical industry is directly influenced by project success factors and the definition of victory for small projects. It then becomes clear what the list of key deliverables for the critical resources in small projects within the petro-chemical industry should include. Research by Westland (2006) gives insight into the deliverables for the four-phase project life cycle acceptable by the project management fraternity. These deliverables are summarised per phase in Table 4-2. These are not indicated per resources.

Table 4-2: Summary: Project Deliverables according to Literature

Adapted from: Westland, 2006, p. 221

	Project Phases			
	Initiation Phase	**Planning Phase**	**Execution**	**Closure**
Deliverables	Develop Business Case	Develop Project Plan	Build/Contract/Fabricate Deliverables	Perform Project Closure
	Complete Feasibility Study	Create Resource Plan	Monitor and Control	Review project completion
	Establish Terms of Reference	Create Financial Plan	Cost Management	
	Appoint Project Team	Create Quality Plan	Quality Management	
	Set up Project Office	Create Risk Plan	Risk Management	

Deliverables	Project Phases			
	Gate review and Sign-off	Create Acceptance Plan	Acceptance Management	
		Create Communication Plan	Communication Management	
		Create Procurement Plan	Procurement Management	
		Contract Suppliers	Issue Management	
		Gate review and Sign-off	Change Management	
			Time Management	
			Gate review and Sign-off	

The list of deliverables for small projects can be extremely detailed as seen in Table 4-3 beyond what has been defined in Table 4-2. The information highlighted in Table 4-3 was based on the feedback and analysis of the different sources of information utilised for the quantitative research process as defined earlier under research methodology.

Appendix 2 gives a detailed list of deliverables as observed during the participant observation research process. The deliverables are indicated per phase for the three types of projects currently executed in Sasol Synfuels, namely complex renewals or capital projects, in-house/EPC Renewals and lastly in-house renewals. The magnitude and type of projects as defined earlier specific to this research can be categorised as in-house renewals according to the Sasol Synfuels Project Management Procedure.

However, the questionnaire feedback regarding deliverables required per project life cycle phase will be discussed later in more detail in Section 4.3. This feedback will also be reviewed, analysed and included in the final discussion of results and development of the model as per the objectives of the research project.

Table 4-3: Summary: Project Deliverables According to Research Process

	Project Phases			
	Initiation Phase	**Planning Phase**	**Execution**	**Closure**
Deliverables	Develop Business Case	Develop Project Plan	Build/Contract/Fabricate Deliverables	Perform Project Closure
	Develop Business Plan	Create Resource Plan	Monitor and Control	Review project completion
	Complete Feasibility Study	Create Financial Plan	Cost Management	Post Audit Report
	Appoint Interim Project Team	Create Quality Plan	Quality Management	Performance Certified
	Develop Preliminary and Conceptual Engineering Proposals	Create Risk Plan	Risk Management	Close out of all governance documents
	Develop Project Execution Philosophy	Create Acceptance Plan	Acceptance Management	Optimise business and product
	Develop Project Execution Strategy	Create Communication Plan	Communication Management	Post Audit Report
	Establish Terms of Reference	Create Procurement Plan	Procurement Management	Performance Certified
	Develop Basic Development Charter	Contract Suppliers	Issue Management	Project Close-out Report

<table>
<tr><th rowspan="6">Deliverables</th><th colspan="4">Project Phases</th></tr>
<tr><td>Planning Phase</td><td>Execution</td><td>Closure</td><td>Initiation Phase</td></tr>
<tr><td>Develop Level 1 Schedule</td><td>Update Project Estimate</td><td>Change Management</td><td>Ensure Governance</td></tr>
<tr><td>Develop Very Rough Order of Magnitude Estimate</td><td>Develop Final Business Case</td><td>Time Management</td><td>Optimise business and product</td></tr>
<tr><td rowspan="2">Gate review and Sign-off</td><td>Finalise Basic Engineering Package</td><td>Start-up Assistance</td><td>Optimise facility, safety, reliability and integrity</td></tr>
<tr><td>Execution Funds Approval</td><td>Ensure Technical Integrity</td><td>Project Governance</td></tr>
<tr><th rowspan="5">Deliverables</th><td rowspan="5"></td><td>Develop Level 2 Schedule</td><td>Develop Level 3 Schedule</td><td>Corporate Governance</td></tr>
<tr><td rowspan="4">Gate review and Sign-off</td><td>Ensure Governance</td><td rowspan="4">Gate review and Sign-off</td></tr>
<tr><td>Final product or running entity</td></tr>
<tr><td>Project Close-out review plan</td></tr>
<tr><td>Gate review and Sign-off</td></tr>
</table>

The literature, case studies and participant observation discussed were all used in further developing the hypothesis model in order to address the requirements of the objectives of this research project.

The research hypothesis for this research therefore states, as defined earlier in Chapter 3, that there are four-phases for small projects which are project initiation or start, project definition or planning, project execution and lastly project closure or delivery. The LOE required per resource per phase is very dynamic and varies significantly throughout the project life cycle. The four key resources being the project management resources, technical resources, business resources and sponsor resources.

The information obtained from the participant observation research process also indicated clearly the changes in the effort level from the different resources involved within the project as the project moves from one phase to another. The resources were identified as follows:

- Project Management
- Technical or Engineering
- Operations
- Strategy and Business

Figure 4-1 clearly indicates the changes in the level of involvement or LOE, as termed in this research, for the four resource types as the project moves from one phase to another as defined by the Sasol Synfuels Project Management Procedure. The letters indicated in the figure give an indication of which resource is Responsible (R), Accountable (A), Consulted (C), Supports (S) and Informed (I). Appendix 3 gives a graph indicating the level of involvement per resources for complex projects as an indication of the changes or variations in terms of responsibilities for the different resources depending on the typology and complexity of a project.

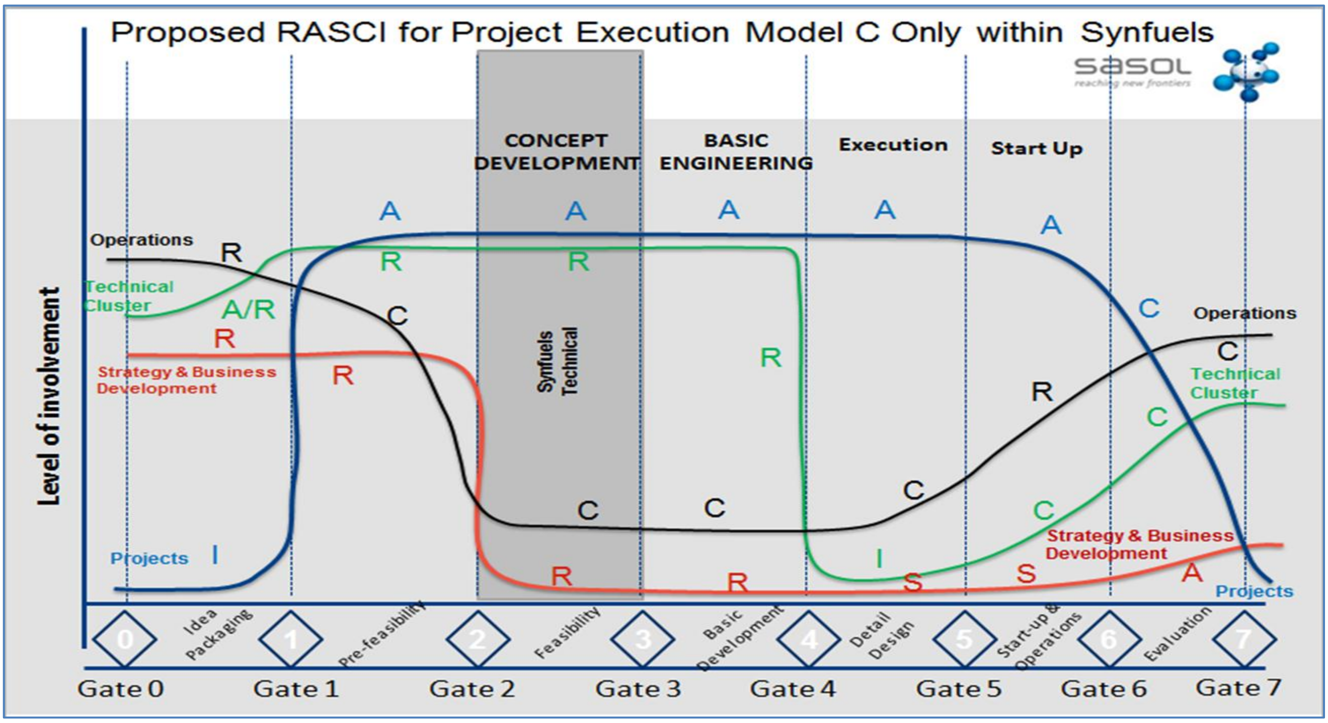


Figure 4-1: Sasol In-house Renewal Project Level of Effort

Adapted from: Synfuels Projects, 2013, p. 32

The research hypothesis is defined taking into consideration the different research methods utilised for this research project and is further defined in Table 4-4 and graphically in Figure 4-2 in terms of the effort level required per resource at the different phases of the project life cycle.

Table 4-4: Hypothesis Maximum Effort Level per Resource

Resources	Project Life Cycle Phases (Maximum Effort Level Per Resource %)			
	Initiation	Planning	Execution	Closure
Project Management	20	16	40	20
Technical Resources	40	50	15	5
Business Resources	10	10	5	25
Sponsor Resource	10	30	10	45

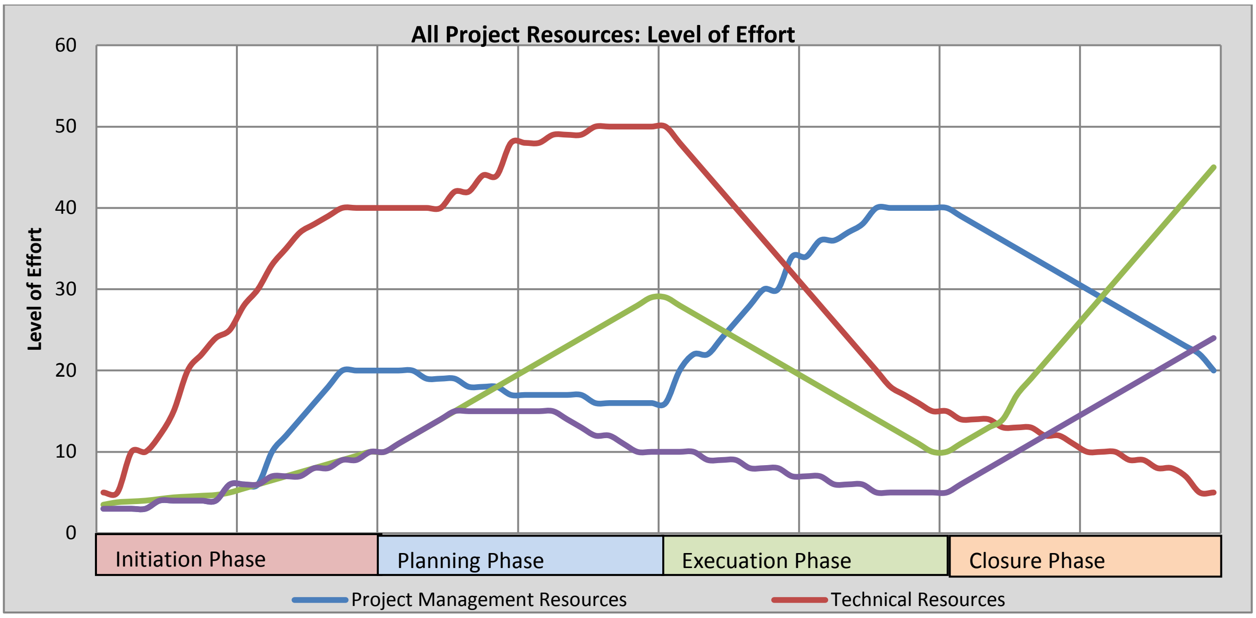


Figure 4-2: Research Hypothesis Graphical Presentation

Later in the dissertation the feedback from the research questionnaires will be analysed and evaluated against the current literature specifically on four concepts, the definition of key resources, the LOE required, the deliverables and the project phases. The representation of the hypothesis will be evaluated graphically later against the respondent feedback to clearly indicate the gap or alignment between the hypothesis and the quantitative feedback.

The research objectives also include a discussion regarding the areas of alignment or congruency from current literature to the hypothesis.

Table 4-5: Summary of Research Findings

Area of Review	Literature Review	Hypothesis	Case Study	Summary
Project Life Cycle	Aligned to four, six and eight-phase model	Defined around the four-phase model	Support for four and six-phase models	Significant alignment observed through the research process with very minor conflicting ideas

Area of Review	Literature Review	Hypothesis	Case Study	Summary
Project Phases	Initiation, Planning, Execution and closure phases	Initiation, Planning, Execution and closure phases	Start, Detailed, Execution and Termination	The naming convention is different; however, in essence there is also alignment in terms of the objectives for the different project phases
Critical Resources	Project Manager, Customer, Performing Organisation, Project Team and Sponsor	Project Manager, Technical, Business and Sponsor Resources	Project Manager, Customer, Engineering and Sponsor resources	Significant alignment observed in terms of critical resources for projects. New ideas that conflict the idea of critical resources however, are developing and are gaining support within research
Deliverables	Extensive list of deliverables documented well in research literature	Hypothesis provided a summary of deliverables which in principle are similar to research literature	The deliverables are well understood and tend to vary depending on project complexity and organisational governance	Alignment on key deliverables for the different phases. This is a subject that is well documented and understood in industry. Organisational governance gives stringent requirements with gatekeepers specific to deliverables for different types of projects

Area of Review	Literature Review	Hypothesis	Case Study	Summary
Level of Effort	Methodology defined by International Community of Project Manager	Aligned to participant observation	Not documented	The concept of level of effort is one that has not be well research or documented by scholars. The focus in the industry is mainly on actual LOE measurement for resources rather than a providing a tool to assist with defining LOE at the beginning of a project for front end loading.

4.2 Research Results in Terms of the Objectives

This section will present data collected and discuss the associated relevance and alignment to the literature reviewed in Chapter 2. Concepts that were identified and any incongruence with the feedback and the literature will be explored.

The structured approach that was followed was based on the objectives for the dissertation and later the presentation of the results and then concludes with a summary of key findings and an updated hypothesis to conclude the chapter.

4.2.1 Objective Three

The third objective of the research project centers on the development of a graphical model to give an indication or guidance in terms of the resources required and level of effort for the different phases of the project life cycle for small projects within the petro-chemical industry. In essence this allows for a graphical representation of the key aspects observed from the literature reviewed and the data analysis completed for the purpose of this research project. The graphical representation can be utilised for front-end loading on projects or be further refined by other scholars in the future. Project managers will have the opportunity to utilise the graphical model when planning to execute small projects within the petro-chemical industry in South Africa.

The graphical model will be defined later in the dissertation after analysis of the data obtained from the questionnaires and the participant observations.

4.3 Data Analysis

Data analysis for a quantitative research project required the researcher to evaluate the information from three distinct perspectives, namely literally, reflexively and interpretively. Analysis using these three methods added value towards reviewing the information and the results specifically because the researcher's sample for quantitative research was generally small. A detail breakdown of the number of respondents will be provided later in this section.

The data was analysed primarily from the deductive approach utilising the questionnaires to group the information and then looked for areas of alignment and areas of differences. The information was then reviewed together with case studies, historical research, latest literature and participant observations to further develop, adjust and test the hypothesis and develop the graphical model as per the research objective deliverables.

4.3.1 Participant Observation

The number of projects that were utilised in terms of participant observation for the purpose of the research was limited to five over a period of twelve months.

The information was then categorised based on it being qualitative or quantitative as discussed earlier in Section 3.5.1. The software programs that were utilised were, Microsoft Excel and Word. Microsoft Excel was utilised to develop the level of effort graphs, calculate averages in terms of level of effort based on the raw data from multiple resources and verification of the data. Microsoft Word was utilised to structure the information obtained from the field notes into the descriptions narrative, expanded field notes, draw mind maps and define common concepts such as definition of critical resources, key deliverables, perception of resource effort level.

The qualitative and quantitative results will be shown later in this chapter in graphical and table form with only key information highlighted. The calculations and the raw data used in developing and defining the graphs are included in Appendix 9 for detailed review and analysis.

The information provided in Table 4-6 is the calculated averages for the level of effort per resources at different phases of the four phase project life cycle model as per the five main projects observed during participant observation research process as discussed earlier in Section 3.5.5. The background information utilised to calculate the averages is provided in Appendix 9. The quantitative measures indicated in terms of level of effort per resource, per phase for the five projects were obtained during open ended discussions with the different project teams. The information was not based on hard measures such as a resource plan or actual effort level measures conducted by the project team but rather based on the project team's experience, perception and the discussion.

Table 4-6: Average Level of Effort per Resource: Observations Feedback

Average Measures from all Projects				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	18%	36%	26%	19%
Planning	26%	40%	17%	17%
Execution	52%	22%	16%	10%
Closure	40%	20%	31%	9%

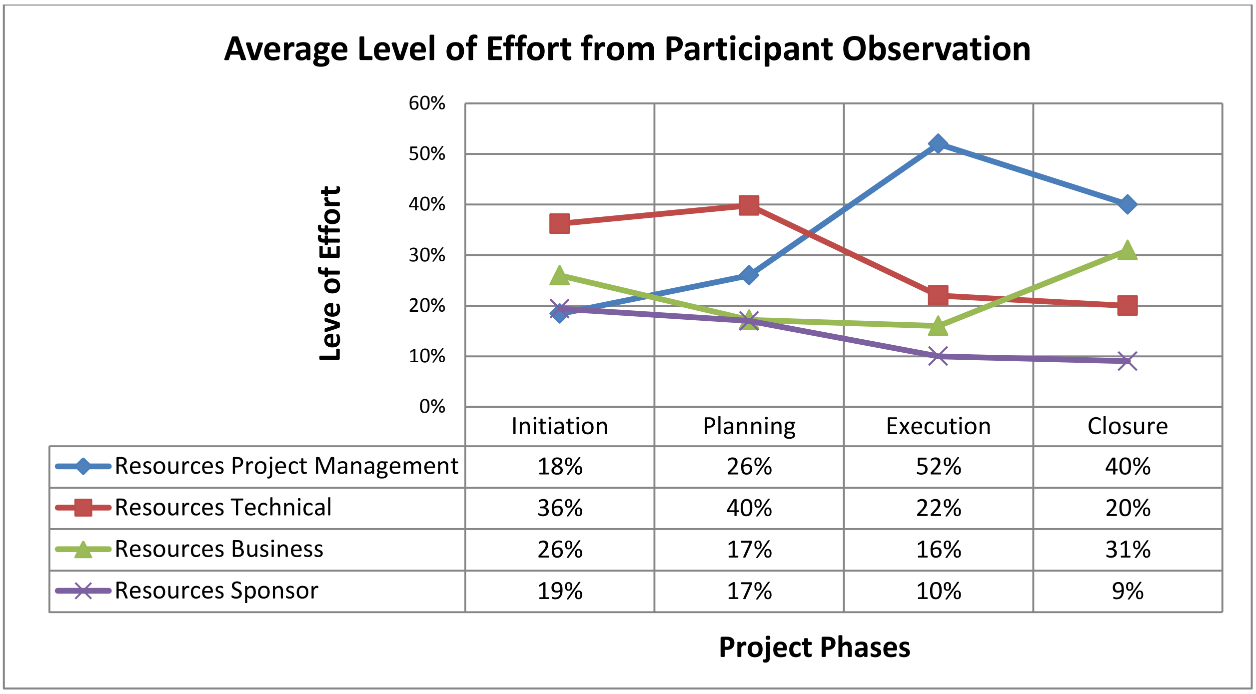


Figure 4-3: Participant Observation Feedback: Average Level of Effort

4.3.2 Research Questionnaires

The research questionnaire in Appendix 6 was utilised to obtain feedback from engineers and project managers within Sasol and externally from consultants that undertake projects for Sasol and other organisations within the petro-chemical industry. The detail of the departments and consultant that provided consent in terms of the feedback required for the research project is given in Appendix 7.

The research questionnaire was circulated to over 120 participants; however, only 53 responses (44%) were received back from the group, both internal to Sasol and engineering consultants, were considered for the purpose of the research project. The percentage of responses from the questionnaires was not as originally expected; however, the quality and quantity of the feedback obtained was acknowledged to be a good representation of the research group.

This section of the dissertation provides a summary of the qualitative and quantitative feedback received from the research group. The detail of the feedback can be found in Appendix 10. The information was evaluated from a qualitative and quantitative point of view. Table 4-7 gives an indication of the spread of the information.

Table 4-7: Grouping Of Questionnaire Feedback Data

Research Questionnaire Feedback	Qualitative Review (Summation Of The Details)	Quantitative Review (Graphical Representation)
Project Typology, Complexity and Schedule		x
Project Deliverables per Phase	x	
Project Resource Loading: Total Hours	Details were not provided by all respondents.	
Project Resource Loading: Percentage		x
Project Success		x

4.3.3 Interpretations of Questionnaire Results

The data obtained from the questionnaires as discussed in the previous section was analysed and summarised into key areas as per the research objectives to highlight the feedback from the research process. The results will be summarised as follows in this section of the dissertation:

- Project typology, complexity and schedule
- Project deliverables
- Level of effort per resource

The summary of results from the questionnaires, participant observations and literature reviews will then be critically compared later in this section to clearly indicate areas of alignment and misalignment.

In order to prevent dilution and misrepresentation of the research data and results, the misalignments identified from the three different research processes specifically pertaining to the level of effort measures will not be addressed by means of averaging the information or utilising the mean of the various data points. The researcher's experience and knowledge of the project management environment was utilised in adjusting the difference from the different research sources to provide input towards the final graphical model that would be presented as a deliverable in line with the research objectives. It was however, imperative to focus on providing a model that can be utilised further in research or in industry specifically regarding the level of effort required per resource for the different phases and the deliverables required per phase.

The graphs shown in Figure 4-4 provide detail regarding the feedback from the research questionnaire on the type of project that the feedback was based on. The majority of the projects, as can be seen from the graphs were technical in nature making up 89% of the projects feedback. This was a positive deduction as the research objective was to address projects that are technical in nature. The complexity of the projects noted from the questionnaire was mainly of a medium and low nature with the split at 68% and 23% respectively. This again was in line with the research objectives in terms of project complexity.

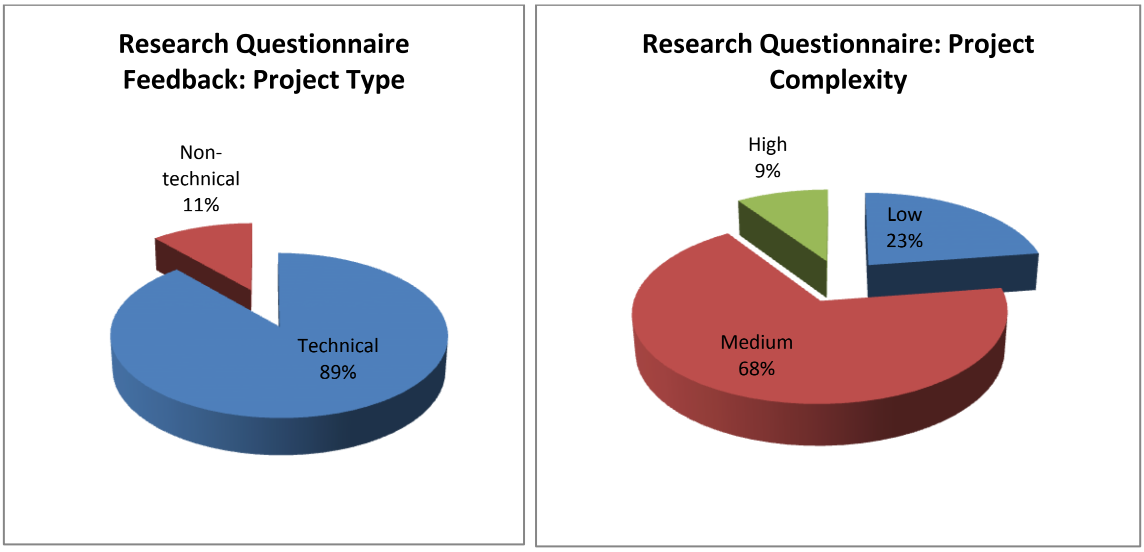


Figure 4-4: Questionnaire Feedback: Project split based on Type and Complexity.

In terms of project total end-of-job budget and schedule the feedback received from the questionnaire is seen in Figure 4-5. In terms of the information seen here 51% of the projects had a budget in line with the criteria specified for this research project and 76% of the projects had a schedule in line with the research criteria. The information received from the research questionnaires was therefore in line with the research requirements in terms of specific projects that would be considered in developing the model as per the research objectives.

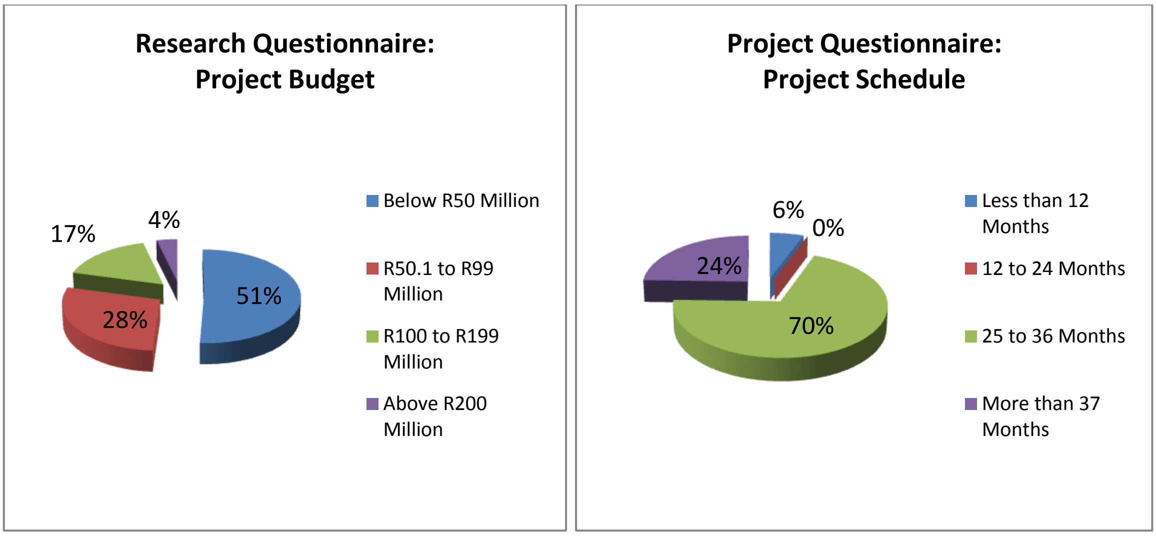


Figure 4-5: Questionnaire Feedback: Project split based on Budget and Schedule.

The qualitative information that was important for the model in defining the critical project deliverables for the model obtained from the research questionnaires is summarised in Table 4-8, where the information was evaluated and presented according to the key resources and the four-phase project life cycle model.

Table 4-8: Feedback on Critical Project Deliverables: Questionnaire Feedback

Project Phase	Resources	Research Questionnaires Feedback
CONCEPT PHASE	Technical Resources	• Feasibility Study Report • Technical Justification Report • Scope of work for concept design • Tender evaluation • Concept Design • Review of previous failures and maintenance strategies • Registration of the required modification • Preliminary schedule for technical scope • Obtain existing system technical information • Technology selection for the project
	Project Management	• Develop level 1 project schedule • Develop a Potential Deviation Analysis

Project Phase	Resources	Research Questionnaires Feedback
	Resources	• Develop a resource plan • Ensure all the governance documentation is completed as per schedule • Manage interfaces between different disciplines •
	Sponsor Resources	• Evaluate the need for the project • Develop and maintain organisational project budgets • Ensure project governance • Provide funding for concept phase of the project • Appoint a project manager
	Business Resources	• Develop the business case • Evaluate the concept design and the technology selection • Inform the rest of the business on the project progress
PLANNING PHASE	Technical Resources	• Update schedule for technical scope • Basic Design • Managing the completion of technical activities • Ensure procurement and fabrication of long lead items • Completing engineering studies such as HAZOP (Hazard and Operability) and RAM (Reliability Availability and

Project Phase	Resources	Research Questionnaires Feedback
		Maintainability) studies
	Project Management Resources	• Develop level 3 project schedule • Define project team • Develop project critical factors • Ensure the project is accommodated in the outage/shut-down plan • Arrange the project communication and meeting guidelines • Apply for project execution phase funds • Approval of contracts for the project
	Sponsor Resources	• Providing alignment and support between the project team and the business • Support address project risks • Provide funding for the project • Ensure project governance • Review the project schedule and scope of work

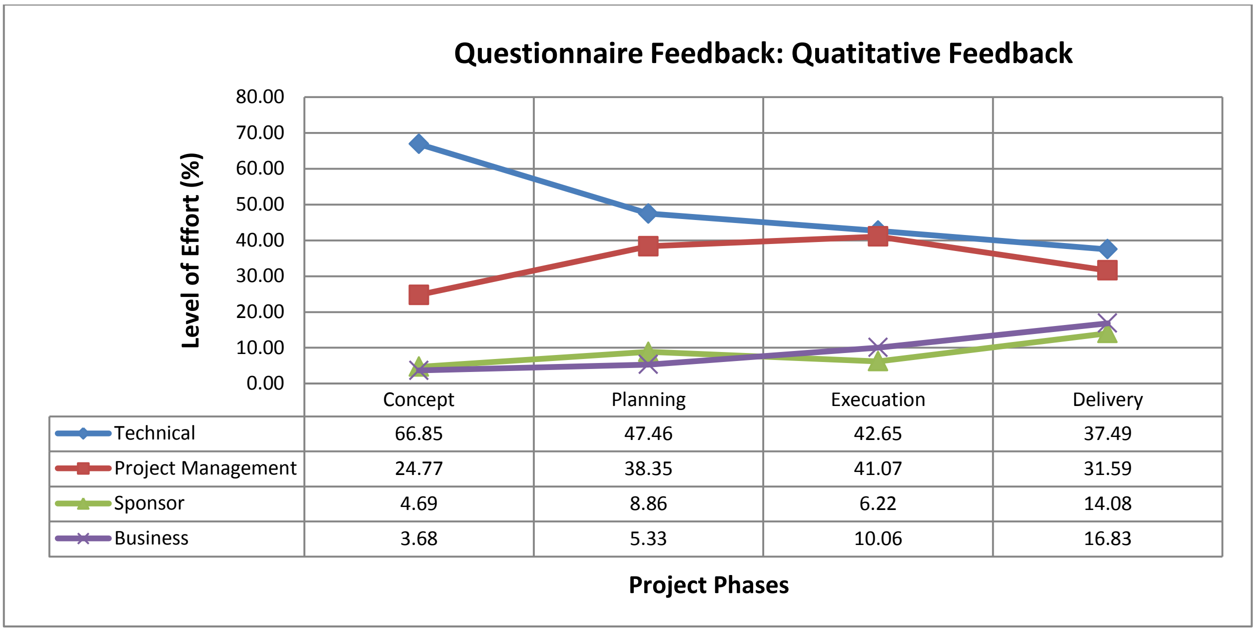
Project Phase	Resources	Research Questionnaires Feedback
	Business Resources	• Provide input to the design based on operational requirements • Participate in engineering studies such as HAZOP and RAM studies
EXECUTION PHASE	Technical Resources	• Detailed Design • Developing scope of work for tendering purposes • Tender evaluations • Placing contracts for resources and materials required for the project. • Support in ensuring quality control measures • Inspections and sign-off on work completed • Interface management between different engineering disciplines • Pre-commissioning report
	Project Management Resources	• Update project schedule (Level 4 Schedule) • Appoint service providers and contractors for the execution scope • Management and reporting on project triangle • Ensuring all required resources and equipment is available for the project

Project Phase	Resources	Research Questionnaires Feedback
		• Approval of milestone payments • Site inspections and sign-off on work completed
	Sponsor Resources	• Ensure project governance • Provide funding for execution phase of the project • Hold the project manager accountable for project triangle measures
	Business Resources	• Develop operating procedures. • Participate in design reviews based on operational experience
DELIVERY PHASE	Technical Resources	• Review of end-of-job documentation • Updating of internal documents • Close out of change management process • Ensuring operation of the equipment or system is as per original requirements
	Project Management Resources	• Final reports for the project • Project close out • Gather information from project resources to provide feedback

Project Phase	Resources	Research Questionnaires Feedback
		• Manage the project triangle
	Sponsor Resources	• Review final project reports • Ensure governance • Ensure all business documentation has been updated • Approval to commission the system/project
	Business Resources	• Commission and operate the new product or system • Assessing the impact of the project on business

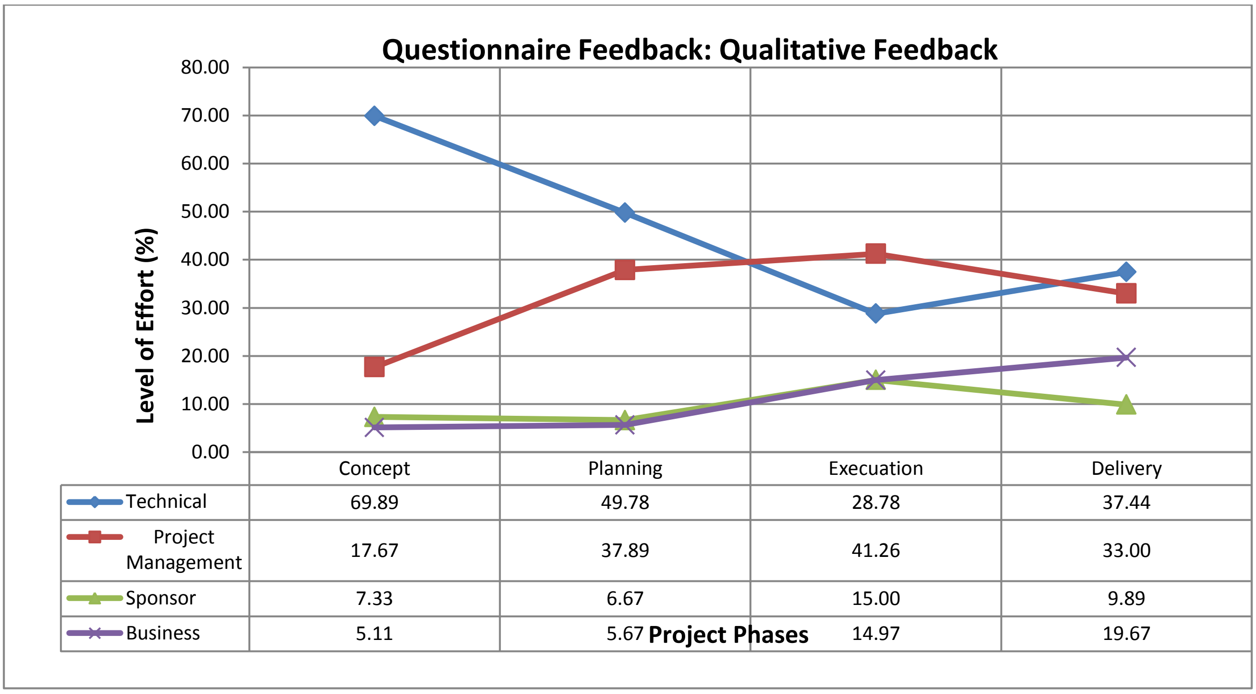
The graphs given in Figure 4-6 and Figure 4-7 give the representation of the level of effort feedback from the research questionnaires. The graphs are separated as some of the respondents provide the data in terms of hours booked per resource and others provided a percentage value for the level of effort. This can be observed from questions 18 and 19 of the research questionnaire in Appendix 6.

The sensitivity and volume of the quantitative data was a concern for respondents as only 16% of the respondents provided detailed data on hours worked. Irrespective of the low response rate on this question, the information obtained was still utilised with the information that was provided as a percentage in order to utilise as much data as possible for the model to be proposed.



	Concept	Planning	Execuation	Delivery
Technical	66.85	47.46	42.65	37.49
Project Management	24.77	38.35	41.07	31.59
Sponsor	4.69	8.86	6.22	14.08
Business	3.68	5.33	10.06	16.83

Figure 4-6: Level of Effort: Questionnaires Feedback (Resource Actual Hours)



	Concept	Planning	Execuation	Delivery
Technical	69.89	49.78	28.78	37.44
Project Management	17.67	37.89	41.26	33.00
Sponsor	7.33	6.67	15.00	9.89
Business	5.11	5.67	14.97	19.67

Figure 4-7: Level of Effort: Questionnaires Feedback (Resource Percentage Hours)

The combined qualitative and quantitative information obtained from the research questionnaires was also compared against the participant observation information as shown previously in Section 4.3.1. Table 4-9 provides a comparison of this information. As can be seen there were significant discrepancies between the level of effort measure from the questionnaires and that recorded from the participant observation feedback. This discrepancy was noted but due to the time limitations, it was not investigated further for this research project. This discrepancy can be better understood or examined should a research project be considered that will primarily focus on a quantitative evaluation of the level of effort based on actual level of effort tracking information.

Table 4-9: Summary of Feedback: Level of Effort.

Project Phase	Project Management Resources		Technical Resources		Business Resources		Sponsor Resources	
	Participant Observation	Research Question-naire	Participant Observation	Research Question-naire	Participant Observa-tion	Research Question-naire	Partici-pant Observa-tion	Research Question-naire
Concept	18%	18%	36%	70%	26%	5%	19%	7%
Planning	26%	38%	40%	50%	17%	6%	17%	7%
Execution	52%	42%	22%	29%	16%	15%	10%	15%
Delivery	40%	33%	20%	37%	31%	20%	9%	10%

The information was then analysed and presented in a manner that shows its agreement or conflict with the original hypothesis for the research. The information was then utilised to modify the hypothesis or to develop future investigations that may be required to prove or disprove the research hypothesis. The graphical patterns drawn were then explained individually and cumulatively in order to provide results that have meaning, experience and views. The gaps between the research information and the hypothesis exist mainly because the hypothesis is not as dynamic as level of effort in industry. The level of effort model thus by its nature will always have gaps, which are mainly due to the nature of projects, the dynamic nature of resources, the environment projects are executed in and the tools used in projects that can require more or less effort from a resource.

Accepting that these gaps exist is more important than understanding why they exist. As in projects these gaps are managed by means of various tools, skills from the project team and other support functions that tend to be specific to each project.

All the qualitative information from all the avenues utilised for this research project, among others, historical data, literature review, participant observation and questionnaires in closing out the research objectives are summarised in Table 4-10.

Table 4-10: Summary of All Research Qualitative Findings

Area of Review	Other Research Methods	Participant Observations	Research Questionnaires
Project Life Cycle	Significant alignment observed through the research process with very minor conflicting ideas. The main project life cycle models being: • Four phase • Six Phase • Eight Phase	Exposed to four-phase and eight-phase project life cycle models	The research questionnaire was developed in line with the four-phase project life cycle model which is utilised mainly for small projects within the chosen research environment
Project Phases	The naming convention was observed to be different from one source to another; however, in essence there is also alignment in terms of the objectives for the different project phases.	The four phases observed by the participant for the projects evaluated were namely: • Feasibility Phase • Basic Development Phase • Execution Phase • Start-up Phase	The questionnaire was developed in line with the phases utilised within the selected research environment, namely: • Concept Phase • Planning Phase • Execution phase • Delivery phase

Area of Review	Other Research Methods	Participant Observations	Research Questionnaires
Critical Resources	Significant alignment observed in terms of critical resources for projects. New ideas that conflict the idea of critical resources, however, are developing and are gaining support within research.	The following resources were identified as critical from the participant observation: • Project Management Resources • Technical Resources • Business Resources • Sponsor Resources	The research questionnaire was developed with four main resource groups, in order to align to the research environment, these resources were namely: • Project Management Resources • Technical Resources • Business Resources • Sponsor Resources
Deliverables	Alignment on key deliverables for the different phases. This is a subject that is well documented and understood in industry. Organisational governance gives stringent requirements with gatekeepers specific to deliverables for different types of projects.	The phase deliverables were clearly defined for the projects as they were directly influenced by the organisational governance and requirements.	An extensive list of deliverables was obtained from the 53 research questionnaires received from the respondents. There was alignment in terms of the feedback obtained. The feedback as extremely detailed as it was specific to particular projects.

Area of Review	Other Research Methods	Participant Observations	Research Questionnaires
Level of Effort	Level of effort is shown in literature as an indication but without detail required for front-end loading.	The organisational guideline, experience and observation on previous projects were utilised in define the level of effort for the projects considered.	The research questionnaire provided extremely valuable information on the detail required to develop the level of effort models. The information from the different respondents was aligned.

All the quantitative findings from the research process are summarised in Figure 4-8 and Table 4-11 which provide the recommended figures to be utilised in defining the level of effort for the four critical resource groups in project management for the simplistic four-phase project life cycle model. The model and how it will add value in the front-end loading of projects and towards the body of knowledge will be explained in detail in Section 4.5.

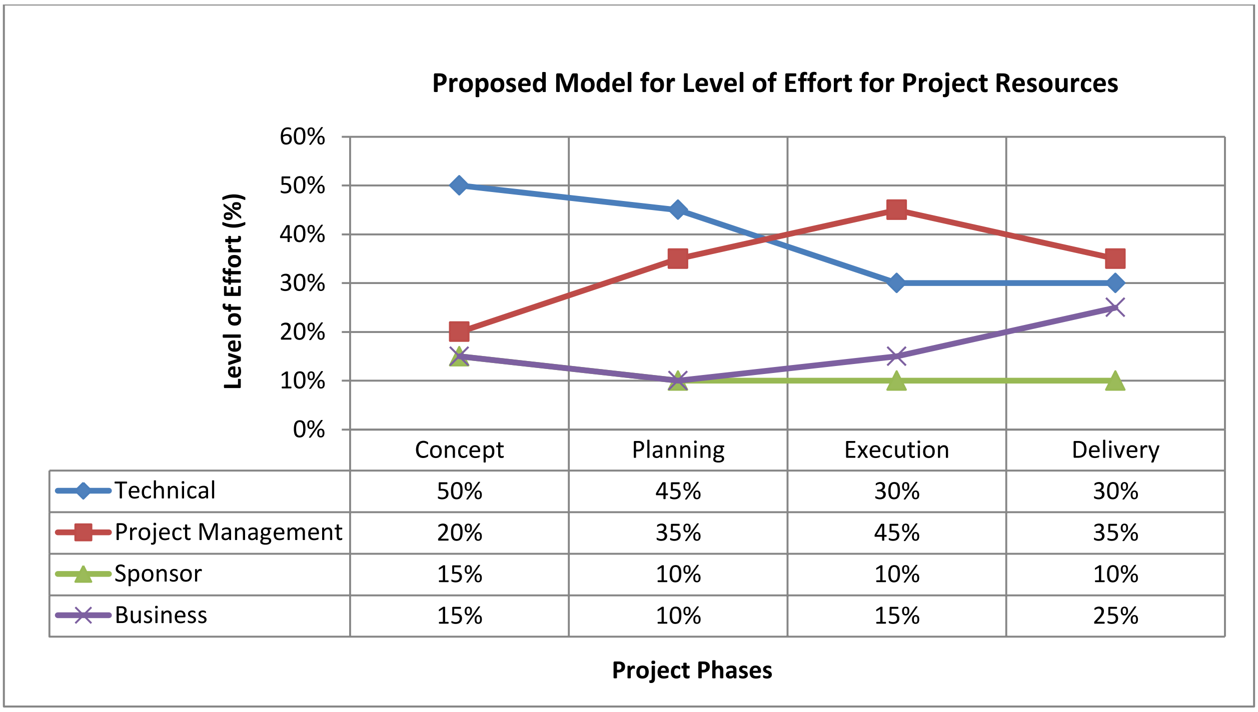


Figure 4-8: Research Proposed Model: Level of Effort Graph

Table 4-11: Summary of All Research Quantitative Findings

Project Phase	Project Management Resources (LOE)		Technical Resources (LOE)		Business Resources (LOE)		Sponsor Resources (LOE)	
	Hypothesis	**Proposed Model**	**Hypo-thesis**	**Proposed Model**	**Hypo-thesis**	**Proposed Model**	**Hypothesis**	**Proposed Model**
Concept	20%	20%	40%	50%	10%	15%	10%	15%
Planning	16%	35%	50%	45%	10%	10%	30%	10%
Execution	40%	45%	15%	30%	5%	15%	10%	10%
Delivery	20%	35%	5%	30%	25%	25%	45%	10%

The comparison of the original hypothesis to the proposed model based on the research process undertaken for this research project indicates a very small margin in terms of the values indicated for the level of effort for the four critical resources from concept to delivery phase.

This clearly indicates there was more alignment rather than conflict between the hypothesis detailed in Section 3.4 of this dissertation, with the exception of a few values as indicated in Table 4-11 above.

4.4 Another Engineering Model

The use of a model as a tool within the technical environment is not a new phenomenon and has been adopted and utilised extensively within the petro-chemical industry. A common tool utilised within the mechanical engineering fraternity, including organisations such as Sasol, is the pump and performance curves used in industry to give detail on the performance of a pump.

This model is included in the dissertation as a good example of how a simple model such as the pump curves model is being utilised within the engineering industry. The section serves to provide some background on how this model works as a foundation before the proposed level of effort model is explained in detail in Section 4.5.

These curves are used during design activities for pump selection and for fault finding on running pumping systems. Figure 4-9 gives a theoretical illustration of what is commonly referred to in industry as pump curves for centrifugal pumps.

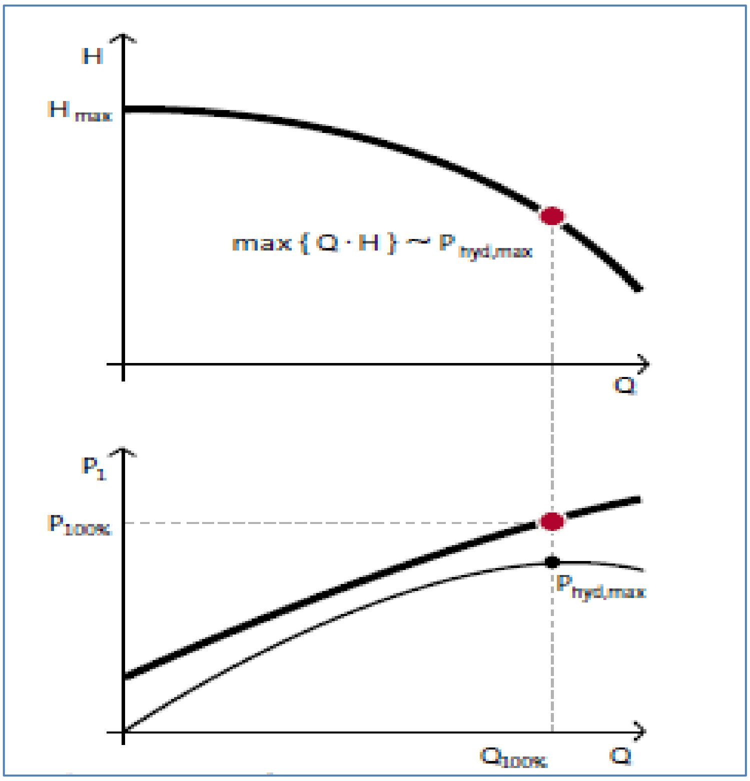


Figure 4-9: Engineering Model: Theoretical Pump Curves Model

Adapted from: Grundfos Research Technology, c.2014, p. 56

These theoretical curves are developed to give more detail in terms of the pump performance for every pump before it is supplied to the market. These curves are then termed pump performance curves and will entail the following information on a particular pump as per in-service tests conducted before entry into the market:

- Head (H)
- Flowrate (Q)
- Power Consumption (P)
- Pump Efficiency (η)
- Net Positive Suction Head(NPSH)

Figure 4-10 gives an indication on how this information can be read from a particular pump performance pump curve. Table 4-12 gives a summary of the information read from the graph based on a required flow rate of 70 m^3/h.

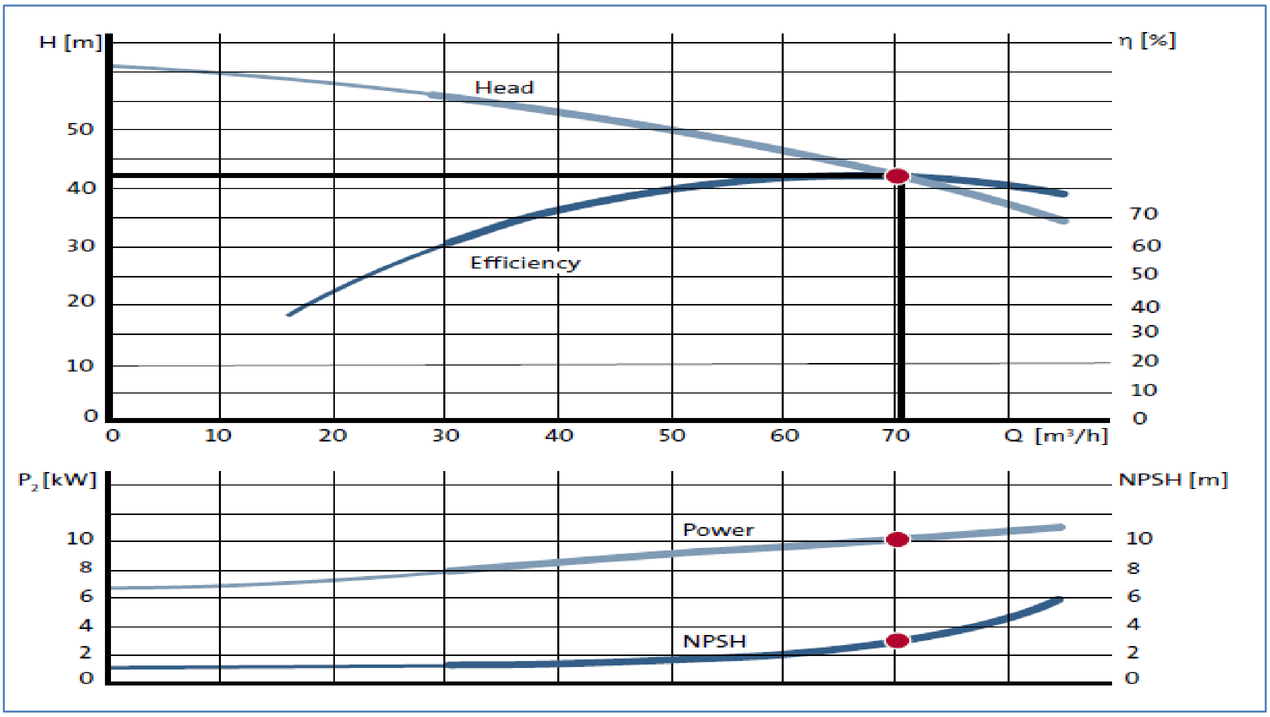


Figure 4-10: Typical Pump Curves for Centrifugal Pump

Adapted from: Grundfos Research Technology, c.2014, p. 30

Table 4-12: Pump Information Obtained from Performance Curve

Description Value	**Value**
Head	42 m
Power Consumption	10 kW
Pump Efficiency	85%
Net Positive Suction Head	3 m

As seen in Appendix 11 this information can vary significantly depending on the shape of impeller. An example of how the pump curves are issued in industry with a pump (KSB pump) on delivery to the end user is also attached in Appendix 11.

The pump curves clearly indicate the benefits of a model that can be used in industry, as these curves are used in projects during detailed engineering of pumping systems, during analysis or fault finding on pump performance during normal operation and other situations. The final model that will be defined in Section 5 of this dissertation as per the research objective will function as highlight in this section in providing a measure of the deliverables, level of effort and the resources required per phase for small projects.

4.5 Proposed Level of Effort Model

Before concluding this chapter that primarily focused on the data and results from the different research processes, it is critical to ensure that the proposed model on the level of effort is illustrated, articulated and documented well. This is imperative as it will not only ensure alignment in the understanding of the proposed model but also ensure the value addition is realised in industry by engineers and project managers that will utilise the proposed model for the front-end loading required for small projects within the petro-chemical industry in South Africa.

A detailed summary of the level of effort, resources, deliverables and the project life cycle phases as given on the schematic of the model is given in Appendix 12, and can be utilised once a good understanding of the model has been achieved. The information to be presented in this section of the dissertation will provide a more detailed explanation of the model; however, the explanation or details will be provided as per the four-phase project life cycle model.

It is advisable to highlight to anyone willing to utilise the level of effort model of the type of project the model can be used for in defining the deliverables, level of effort and resources types required during front-end loading. These boundaries are:

- Projects that are technical in nature.
- Projects that are defined as having a medium to low complexity.
- Projects with a project schedule not longer than 36 months.
- Projects with a budget less than 50 million rand.

4.5.1 Level of Effort Model: Concept Phase

In terms of the level of effort model, the concept phase is the phase when a project is identified and issued to a particular resource for planning. This resource does not necessarily have to be the resource that will execute, manage or report on the project. At this particular point the feasibility and planning that is required for most projects has not been conducted.

As the model is defined for technical projects from the model given in Appendix 12, the recommended level of effort for the technical resource is highlighted to peak at a maximum of 50%. The model was developed to be dynamic across the project life cycle phases; however, the model does not show variation or change in terms of the level of effort required from the start of the particular phase to the end of the particular phase.

In other words the model clearly recommends planning for a constant level of effort of 50% for the technical resource, 20% for the project resource and 15% for the sponsor and another 15% for the business resource. It does not provide guidance in terms of the ramp up or ramp down rate for the particular resource.

The model allows for a plan in terms of resource effort level that is dynamic at a higher level, the requirement to develop the level of effort ramp up or ramp down rate was believed to be a requirement for more complex and larger projects as this can have an impact on a large pool of resources.

In the model's definition or recommendation in terms of the level of effort required for the critical resources, it was also extremely important for the model to give guidance over and above the legal requirements and the particular organisational requirements of the deliverables that should be actioned and completed within a particular project phase. In essence once the model has specified the level of effort for a particular resource, at a particular phase; it goes further and defines what these resources need to deliver in order to move from one phase to another.

The model therefore provides recommendations as follows:

- Plan for a maximum level of effort of 50% for technical resources to focus on the following deliverables:
    - Technical Justification
    - Feasibility Study
    - Registration of modification
    - Concept Design
    - And others as per the proposed list of deliverables given in the model
- Plan for a maximum level of effort of 20% for project management resources to focus on the following deliverables:
    - Develop a level one project schedule.

  - Manage interfaces between disciplines.
  - And others as per the proposed list of deliverables given in the model.
- Plan for a maximum level of effort of 15% for sponsor resources to focus on the following deliverables:
  - Evaluate the need for the project.
  - Provide funding for the concept phase of the project.
  - And others as per the proposed list of deliverables given in the model.
- Plan for a maximum level of effort of 15% for business resources to focus on the following deliverables:
  - Develop the business case for the project.
  - Evaluate the concept design and the technology selection.
  - Inform the rest of the business on the project progress.

4.5.2 Level of Effort Model: Planning Phase

The second phase of the project life cycle model as proposed by the level of effort model is the planning phase and sometimes referred to as the definition phase of the project. According to the model proposed this section will follow after the concept phase; however, as indicated on the model the deliverables from one phase to another do not overlap. The deliverables do build on each other but they do not overlap.

Thus it is critical to note that the deliverables noted per resource under the concept phase will need to be completed and signed off before official completion of the concept phase of the project can be acknowledged. The model, however, does not limit when the deliverables need to be completed, a resource can therefore work on the planning phase deliverables while the project is still in concept phase, provided the prescribed pre-requisite deliverables have been completed.

As highlighted in Section 4.5.1 the model does not provide detail on the ramp up or ramp down rates, but provides a recommendation in terms of the maximum level of effort that will be required from the particular resource. In the planning phase the technical resource level of effort reduces from 50% to 45%, the level of effort for both the sponsor and business resource reduces from 15% to 10% and lastly the project management resource increases up to 35%.

The model therefore provides recommendations as follows:

- Plan for a maximum level of effort of 45% for technical resources to focus on the following deliverables:
    - Updated project schedule for the technical scope.
    - Engineering studies, such as RAM, HAZOP.
    - Basic Design.
    - And others as per the proposed list of deliverables given in the model.
- Plan for a maximum level of effort of 35% for project management resources to focus on the following deliverables:
    - Develop a level three project schedule.
    - Apply for project execution phase funds.
    - And others as per the proposed list of deliverables given in the model.
- Plan for a maximum level of effort of 10% for sponsor resources to focus on the following deliverables:
    - Approval of project scope and schedule.
    - Provide funding for the planning phase of the project.
    - And others as per the proposed list of deliverables given in the model.
- Plan for a maximum level of effort of 10% for business resources to focus on the following deliverables:
    - Provide input to the design base.
    - Evaluate the basic design and the technology selection.
    - Participate in engineering studies such as HAZOP and RAM.

4.5.3 Level of Effort Model: Execution Phase

The next phase after the planning phase is generally accepted and known in industry and literature as the execution phase of the project life cycle model. It was indicated clearly early in the dissertation that the level of effort model would not include the resources required for the physical construction, fabrication or installation of the project. The resources are limited to the technical, sponsor, business and project management resources and the model should be utilised taking note of this critical point.

As highlighted for the planning phase the deliverables that are specified per resource for the execution phase need to be concluded before the project can officially move from the execution phase to the delivery phase. The level of effort required from the resources again changes as the model is dynamic and considers the different requirements for each resource at different phases. The technical, project management, sponsor and business resources maximum level of effort recommended changes are as follows: 45% to 30%, 35% to 45%, remains constant at 10% and lastly from 10% to 15% respectively

The model therefore provides recommendations as follows:

- Technical resources to focus on the following deliverables:
    - Detailed Design
    - Tender Evaluation
    - Pre-commissioning reports
    - And others as per the proposed list of deliverables given in the model
- Project management resources to focus on the following deliverables:
    - Develop a level four project schedule.
    - Approval of milestone payments.
    - Managing and reporting on project triangle.
    - And others as per the proposed list of deliverables given in the model.
- Sponsor resources to focus on the following deliverables:
    - Ensure project governance.
    - Hold the project manager accountable for project triangle.
    - And others as per the proposed list of deliverables given in the model.
- Business resources to focus on the following deliverables:
    - Develop operating procedures.
    - Participate in design reviews.
    - Commissioning process.

4.5.4 Level of Effort Model: Delivery Phase

The final phase as per the level of effort model is called the delivery phase but is also known in industry as the closure or hand-over phase. The official completion of this phase and the required deliverables are generally managed more strictly in industry. Once the project has officially passed this phase the project team has handed over the project and is no longer responsible for the equipment, product or system subject to special contractual or warrantee-related issues.

At completion of this phase the project stops being a project and becomes part of normal operation. In this phase the detailed analysis required to determine whether the project was a success or failure is also concluded. The change in the level of effort for the project management, sponsor, business and technical resources changes as follows, 45% to 35%, constant at 10%, 15% to 25% and constant at 30% respectively for the resources.

The model therefore provides recommendations as follows:

- Technical resources to focus on the following deliverables:
    - Review and sign-off on end-of-job documentation.
    - Close-out change management process.
    - And others as per the proposed list of deliverables given in the model.
- Project management resources to focus on the following deliverables:
    - Final reports for the project.
    - Manage the project triangle.
    - And others as per the proposed list of deliverables given in the model.
- Sponsor resources to focus on the following deliverables:
    - Review final project reports.
    - Provide approval to commission the project.
    - And others as per the proposed list of deliverables given in the model.
- Business resources to focus on the following deliverables:
    - Commission and operate new system or plant.
    - Assess the impact of the project on the business.

4.6 Conclusion

In this chapter, multiple sources of data were utilised in defining a model that can be utilised to define the level of effort required per resource at different phases of the project. The data was categorised mainly into three categories for the purpose of the data analysis. The three main categories were:

- Data from previous projects observed by the participant.
- Data obtained from the research questionnaires.
- Concepts and literature noted from the literature review process.

The main areas of evaluation during the research process are summarised below:

- The different types of project life cycles.
- The different types of project phases.
- The critical deliverables at different phases of the project.
- The key resource types for the project.
- The level of effort required per resource at different phases of the project.

In evaluating these areas the information was mainly aligned to the hypothesis, literature reviewed and the research process undertaken for the project. The areas of alignment were mainly on the project life cycles, project phases and deliverables per phase.

The definition of key resources was not totally aligned to the hypothesis and literature as the hypothesis provided four main resources and literature highlighted multiple ideas which vary from the project manager being the only critical resources to a list similar but longer to that specified in the hypothesis for critical resources. In terms of the research questionnaires, the participants were not requested to give input on the critical resources as the questionnaire was developed based on four critical resources as defined in the hypothesis. The feedback received from the questionnaire, however, did not conflict with this idea as resource loading feedback was aligned to the resources defined in the hypothesis.

The research questionnaires were circulated to a significant group that included respondents both internal and external to Sasol. The feedback was based on project detail provided from mainly technical projects. Specifically 89% of the projects were technical, 68% of which were of a medium complexity. Three-quarters of the projects that feedback was provided for were completed within a period of 24 to 36 months, half of which had a total project budget of less than 50 million rand. This is important to highlight for the research findings as it is in line with the research objective of developing a model for small projects which are generally defined in industry in terms of project complexity, budget and schedule.

Similarities and areas of misalignment were highlighted in tabular form in detailing the summary of the investigations for the following key research requirements:

- Project life cycles observed and utilised.
- The definition and associated understanding of project phases.
- Critical resources as defined in industry and literature for projects.
- Key deliverables defined at different project phases.
- The definition and understanding of the concept defined as the level of effort.

Both in industry and in the literature reviewed, the areas of alignment were well documented and understood except the concept of level of effort, which is not well documented or understood. Thus the need for this research project which focused on further defining the concept of level of effort and obtaining research data as discussed in Chapter 3 which was utilised in this section after detailed data analysis to further develop the definition of the concept and the magnitude of effort required from four critical resources based on industry experience from the numerous research participants. After the analysis and evaluation of the numerous streams of information, a schematic representation of the information is provided in Figure 4-11, which clearly provides a representation of the level of effort required per resource as per the deliverables required for the phase per particular resource. This model was developed based on the limited feedback based on small projects within the petro-chemical industry in South Africa.

The response from the questionnaires, at 44% should not be concerning as multiple methods of research were utilised and the responses were well aligned towards the values given in the final model. In conclusion, based on the extensive research process undertaken for the research project the concept of level of effort has been addressed and highlighted in the detailed model indicated in Appendix 12. The benefits, further developments and contributions of this model are discussed in the next chapter.

It was, however, very encouraging to note the alignment or how small the variances were for the proposed level of effort measures obtained from the research questionnaire feedback versus the original hypothesis level of effort measures as indicated earlier in this section. In essence there was clear alignment between the hypothesis and the feedback from the research process.

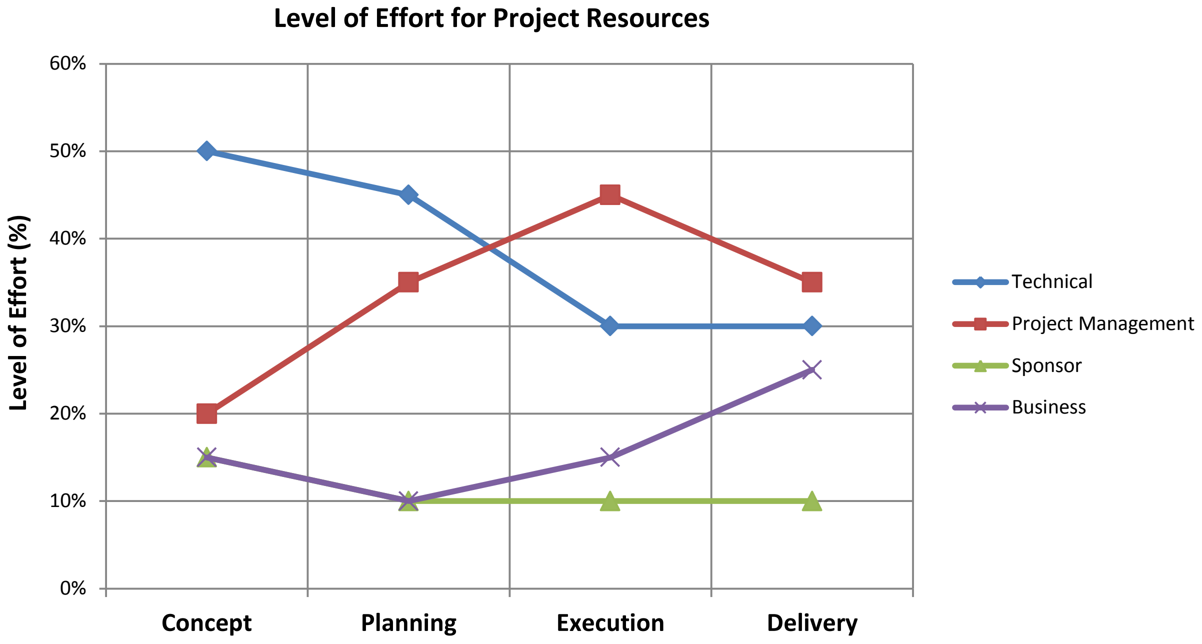


Figure 4-11: Level of Effort Graph

Table 4-13: Key Deliverables per Resource

Resources Deliverables	Concept Phase	Planning Phase	Execution Phase	Delivery Phase
Technical Resource	Feasibility study & concept design report	Basic design report	Detailed design and pre-commissioning Report	Compile and review end-of-job Documentation
Sponsor Resources	Evaluate the need for the project and provide funding	Ensure governance and review scope and schedule	Provide funding and hold project manager accountable	Review final documentation and approve for commissioning
Business Resources	Develop business case and inform business of projects	Provide operational requirements in the design	Develop operating procedures	Commission and operate the new system
Project Management	Develop project resources requirements and Plan	Develop the project diamond (cost, schedule and scope)	Reporting on and managing the project diamond	Provide final documentation and close the project

The proposed level of effort model is therefore a tool that can be used in industry by project managers and engineers. In order to ensure the tool is utilised effectively and there is alignment in terms of understanding the information shown on the model as depicted in Appendix 12, the limitations of the tool were discussed earlier in the section, one of the limitations being that the proposed model does not provide an indication of the required ramp up or ramp down rate in terms of the level of effort for a particular resource from the start of the phase to the end of the particular phase. The proposed level of effort model provides a recommendation on the maximum level of effort required for a particular resource at a particular phase to ensure completion of the critical deliverables. Legal and governance requirements have not been included on the model as no guidance should be provided in terms of organisational governance or legal requirements as these requirements are generally well documented in legislature and company policies. The assumption is legal and internal organisational governance is always the foundation to any project front-end loading. The deliverables specified do not include specific governance requirements that may vary from one organisation to another. However, these deliverables are mandatory to officially move from one phase to another in terms of the level of effort model.

The model clearly can benefit and provide a guideline that is dynamic from one phase to another in terms of specifying or planning the required level of effort for project resources. The deliverables specified in the model are not all-inclusive but rather are critical deliverables for the particular resources which can assist with front-end loading on projects within the petrol chemical industry that are technical in nature, have a complexity that is not greater than medium, with an end-of-job budget of not more than 50 million and finally a project schedule not longer than 36 months.

The use of schematics or graphs to extrapolate or obtain information based on a constant in industry has been used and continues to be used extremely well in the engineering environment. An example of a pump curve discussed earlier in this section clearly proves a graphical model can be utilised with much success in industry. Therefore the use of the model to define the level of effort and the deliverables required for a project can add value in the industry.

CHAPTER FIVE

Conclusion and Recommendations

5.1 Introduction

This section of the dissertation will provide a summary of the conclusions from the research processes followed for the research project, namely:

- Literature reviewed
- Participant observation feedback
- Research questionnaires feedback

The information obtained from the numerous research processes was analysed and evaluated in Chapter 4 of the dissertation. The conclusions from the data analysed will also be presented as a summary to the research project in this section. The final model to be proposed to scholars and industry for managing critical resources on small projects within the petro-chemical industry and the associated level of effort at the different phases of the project life cycle will also be presented in this chapter.

In conclusion, the recommendations will also be included in this section which will be presented in this chapter to ensure that the knowledge base is further developed by others in the future. The recommendations will be provide in two sections, firstly recommendations based on the learning observed from the current research project and lastly recommendations for future studies.

5.2 Conclusions

A large number of small projects are executed annually by numerous organisations within the petro-chemical industry, these projects vary from changes in organisational structures, information technology changes, construction, manufacturing and procurement of equipment or creation of new organisations to state a few. The management of these projects is critical as organisations typically define the scope, quality, schedule and cost for these projects based on future earnings, profitability, clients and organisational growth from the success of these projects.

The successful execution of these projects is therefore crucial for many organisations and continues to become even more crucial as organisations that have developed systems to manage projects successfully tend to be in a position to sustain themselves into the future and have a competitive advantage over their competitors.

This research investigated the current systems, models, ideologies and tools currently utilised and documented specifically for small projects. Small projects are often seen as noncritical mainly because of the end-of-job budget allocated to the project and the impact each project has on the organisation. However, small projects as a whole for most organisations utilise a substantial budget and have the potential to impact the profitability or sustainability of an organisation in the very long term.

The research has defined the different project life cycles model and their associated project phases, specifically those that have been adopted by other researchers and project managers in industry. The project phase deliverables were also extensively researched in order to understand and define the activities required from the various resources in order to complete the project.

The resources or stakeholders involved in the project at different project phases were defined based on literature, industry research and case studies. The focus was mainly on defining the resources and understanding the level of effort required from the different resources at the different phases of the project life cycle.

The concept of level of effort was not extensively documented in literature as most of the literature evaluated only provided a high-level definition of the concept. The graphs and models provided in literature did not provide sufficient detail but rather an indication of how dynamic this measure is during project execution. During the research process this concept of level of effort was defined for various resources and a guideline provide by the the International Community of Project Managers.

It was clear the reason why this concept has not been documented or investigated extensively in industry or literature was mainly because many organisations and scholars prefer to focus on defining resources more quantitatively rather than providing a combination model on resources. The tools recommended for quantitative resource planning in projects is a matter that is well understood and preferred in industry.

In order to obtain data from industry regarding the hypothesis, questionnaires were circulated to a pool of 120 participants within the petro-chemical industry and processed, analysed and presented into mathematical graphs that were compared against the research hypothesis.

The focus of this research was primarily to define the hypothesis that states that the level of effort for critical project resources varies significantly depending on the phases of the project life cycle for small projects as defined earlier in the research. The hypothesis was defined or illustrated by means of graphs that were tested against the research data and literature.

The opposing or conflicting literature that was evaluated was also discussed and areas of future investigation will be highlighted for scholars to test and research at a later stage, in this section.

The contribution of the research project is a model that defines the level of effort for resources at different project life cycle phases based on the deliverables required per phase which can later be utilised in industry for effective and efficient resource management on small projects, as given in Figure 5-1 on page 108.

The model alone as provided in Figure 5-1 on page 108 is not sufficient as a conclusion The method by which the tool or model is to be utilised in defining the deliverables and maximum level of effort required for each phase of the project life cycle during front-end loading of the project is extremely important. The researcher has therefore defined, step by step, how the information provided in the model is to be interpreted. The utilisation of a graphical model is not a new thing but as with the pump performance graphs illustrated in Chapter 4, the LOE Model can be adopted in industry provided it is provided with a clear method statement or guideline that will ensure successful utilisation of the information.

The LOE model is intended to be utilised for small projects within the petro-chemical industry that meet the following criteria:

- Projects with no more than a medium complexity interpretation.
- Projects with a project schedule not longer than 36 months.
- Projects with a budget less than 50 million rand.

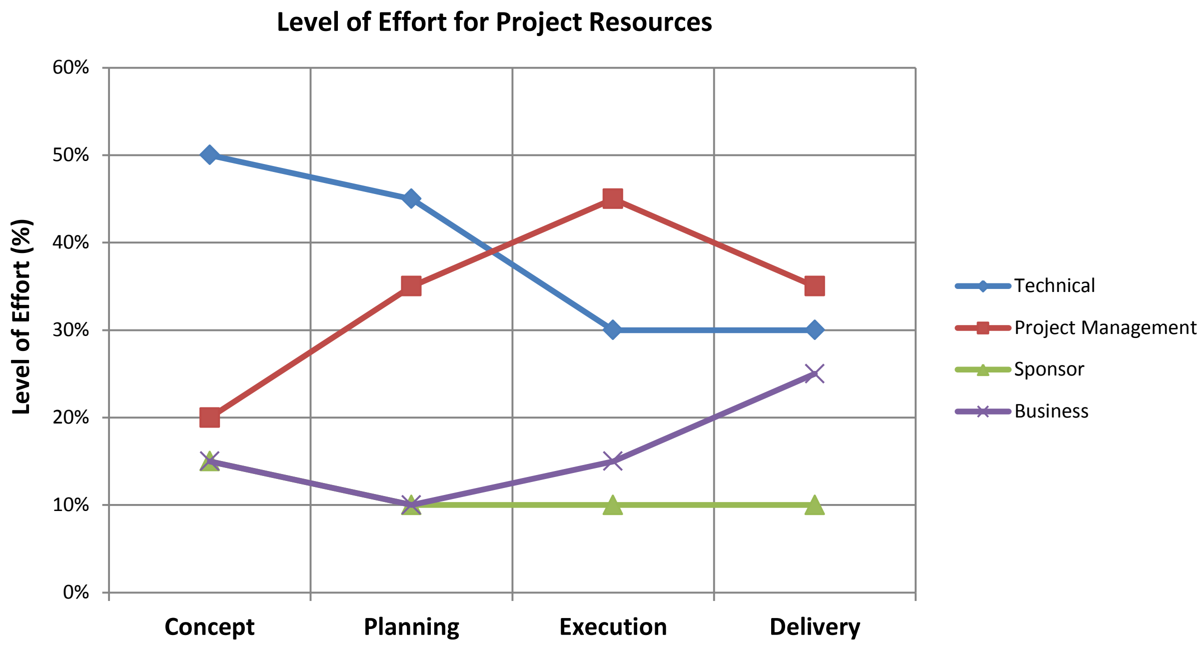


Figure 5-1: Level of Effort Graph

Table 5-1: Key Deliverables per Resource for Project Life Cycle Model

Resources Deliverables	Concept Phase	Planning Phase	Execution Phase	Delivery Phase
Technical Resource	Feasibility study & concept design report	Basic design report	Detailed design and pre-commissioning Report	Compile and review end-of-job Documentation
Sponsor Resources	Evaluate the need for the project and provide funding	Ensure governance and review scope and schedule	Provide funding and hold project manager accountable	Review final documentation and approve for commissioning
Business Resources	Develop business case and inform business of projects	Provide operational requirements in the design	Develop operating procedures	Commission and operate the new system
Project Management	Develop project resources requirements and Plan	Develop the project diamond (cost, schedule and scope)	Reporting on and managing the project diamond	Provide final documentation and close the project

Once a project is assumed to be within the margins of a small project the model can be utilised to develop a plan in terms of the level of effort per resource as noted in Table 5-2.

Table 5-2: Resource Plan Based on Level of Effort as per Model

Project Phase	Level of Effort			
	Project Management Resources	**Technical Resources**	**Business Resources**	**Sponsor Resources**
Concept	20%	50%	15%	15%
Planning	35%	45%	10%	10%
Execution	45%	30%	15%	10%
Delivery	35%	30%	25%	10%

The detailed model given in Appendix 12 provides detail into the key deliverables per resource per phase. For example, the following are defined as the key deliverables for the project management resources for the concept phase:

- Develop level 1 project schedule.
- Develop a potential deviation analysis.
- Develop a resource plan.
- Ensure all the governance documentation is completed as per schedule.
- Manage interfaces between different disciplines.

In the example highlighted above from the model, 20% of the effort required from the resources at concept phase will be focused on project management deliverables as given in the list above, or defined in another way, 20% effort is required from the project management resource to ensure completion of the deliverables given above.

The proposed level of effort employs terminology that is utilised with the project management environment. Therefore before the proposed level of effort model can be utilised, some aspects of the model were discussed in Chapter 4, such as understanding and ensuring alignment in terms of the project life cycle phases, and what type of work is required at different phases and when the project officially moves from one phase to another.

The limitations of the model were also discussed as the level of effort model does not offer a resource ramp up or ramp down rate. The model allows one to plan for the maximum level of effort required per resource type. The model is dynamic in that the level of effort changes from one phase to another, however the level of effort ramp up or ramp down rate within a particular phase is not defined as this was believed to be a requirement for more complex and larger projects.

The model provides a recommendation in terms of the maximum level of effort that is required for a particular resource at a particular phase to ensure completion of the critical deliverables. The deliverables specified do not include legal or governance requirements that may vary from one organisation to another. However, they are mandatory to officially move from one phase to another in terms of the level of effort model. The researcher's assumption was that legal and internal organisational governance requirements are always the foundation to any project's front-end loading process. As highlighted earlier in the dissertation, it was also critical to reinforce that the proposed model does not provide input or guidance in terms of the level of effort required from resources that are required for construction, fabrication or installation activities. The level of effort guideline is limited to the technical, project management, sponsor and business resources for the four phases of the project life cycle model.

The proposed level of effort model as discussed earlier does not provide an all-inclusive list of deliverables but rather a summary of critical deliverables and puts more emphasis on the dynamic nature of the level of effort required from the four critical resource types from one phase to another. Extensive research is available and documented in terms of the deliverables required per project phase. Many organisations have very detailed procedures that provide guidelines in terms of the deliverables required per phase. However, there was a significant gap both in industry and literature pertaining to the concept of level of effort. The concept of level of effort, the nature of the level of effort, and recommendations as documented in this dissertation will provide value in this particular field of knowledge.

The information presented in the research in terms of the definitions and methodology that can be utilised in the definition of the level of effort is sound and well referenced. The model, however, being qualitative and quantitative, can be explored further by undertaking a more extensive quantitative view or also considering expanding the research site to other industries and not limiting the projects to be considered by type, complexity, schedule or budget constraints.

In concluding the research project dissertation, it is important to confirm that the research questions and objectives were addressed as highlighted at the definition of the research project. The research objectives and questions as seen earlier in Chapters 1 and 2 are related. The model given in Figure 5-1 and in detail in Appendix 12 addresses the first and the third research questions which focused on how to present the changes in the level of effort for different resources at different phases of a project. The proposed level of effort model and the values associated with the level of effort per resource answer these questions and third objective defined for the research project.

The second question of the research project primary questioned validity and alignment in terms of current literature and research data obtained specifically on the level of effort, project phases, project deliverables and project resources. As discussed earlier in Chapter 4, a detailed summary of the areas of alignment and misalignment were indicated and it was clear that there is much alignment or similarity both in literature and the research site on the areas investigated during the research process.

The first two objectives of the research mainly concerned the definition and review of a hypothesis which would be evaluated against the literature and research data that was obtained for the research site. Chapters 3 and 4 provide extensive detail on the hypothesis defined, the null hypothesis and the evaluation of the hypothesis against research feedback from questionnaire, literature reviewed and the participant observation. The areas of alignment between the hypothesis and the research data were significant with very minimal concern in terms of the detail in the original hypothesis that was presented with the research project.

The research project as defined in this dissertation report has addressed the areas of investigation as initially planned. The research has yielded good results and model that has the potential to contribute positively to the literature and the industry.

5.3 Contribution of this Research

The research project can contribute to the literature data base for future scholars and provide a tool to industry for the front-end loading on projects. Previous research conducted regarding the concept of level of effort was very limited and this research project will add to the body of knowledge.

Research conducted previously provided a qualitative graph for the level of effort as given in Chapter 2 but the graph provided no indication in terms of magnitude. It merely provided a schematic interpretation of a dynamic curve that changes with the project phases based on the resources required at different phases, referred to by other scholars as level of involvement. This research project has given more detail in quantifying the variance in level of effort for different resources across the project life cycle.

This research project therefore has contributed a set of quantitative mathematical graphs with qualitative information on critical resources and key deliverables for small-sized projects within the petro-chemical industry in South Africa. The model will assist in defining a dynamic project team, which will increase or decrease in size for different phases of the project life cycle. Section 2.9 of the dissertation also provides a guideline that a project manager or engineer can utilise in testing these graphs or developing a level of effort for different resources required in projects.

Such a tool can assist in giving organisations, engineering and project management firms the opportunity to effectively utilise the resource pool available to the company on various projects, and it can further be utilised as an optimisation tool for skills required at different phases of the project life cycle on multiple projects.

5.4 Recommendations

The model that has been developed and detailed in Appendix 12 can be utilised by engineers or project managers managing small projects within the petro-chemical industry at conceptual phase of a project. The model can be used at conceptual phase for projects to assist with defining or understanding the following better:

- Budget estimate for resources required on projects.
- Resource planning across multiple projects.
- Highlighting concerns on resources overloaded.
- Project scheduling or planning synchronised to resource availability.
- Defining key deliverables.

The model should, however, be utilised with a safety margin or correction factor as the model is generic in its nature, proposal is to utilise a correction factors as defined in the Table 5-3 when defining the level of effort per resource. The correction factors were calculated based on the various marginal differences noted from the quantitative information obtained from the research questionnaires. These correction factors were also defined based on the researcher's understanding of the marginal differences in the information and experience within the project management environment.

Table 5-3: Recommended Correction Factor per Project Phase

Project Phase	**Correction Factor**
Concept	2.5%
Planning	5%
Execution	5%
Closure	2.5%

The research project was very specific in defining the model as a model to be utilised within the petro-chemical industry on small projects. However, the model can be utilised in other industries with caution but would recommend the model be developed further to include medium- and large-scale projects. The next section will provide more detail into future studies recommended specifically after completion of this research project that other scholars can consider for study.

5.5 Recommendation for Future Studies

The research project was conducted as a quantitative research project specifically focused on small projects within the petro-chemical industry. After developing the model for the level of effort for key resources at different phases of the project life cycle, the following list of recommendations should be considered for future studies:

- Develop the model produced from this research project further by undertaking a more extensive quantitative research method.
- Develop the model further to include projects in other industries and for medium- and large-scale projects.
- Evaluate the concept of critical resources in project management further to understand further the types of resources that can be defined as critical.
- Explore the conflicting ideology that states project life cycle models should be dynamic and specific to a project rather than defined as per the current focus of the four, six and eight phase project life cycles.
- Investigate the concept of CAS within the project environment.

BIBLIOGRAPHY

Abdou, A. c.2012. Introduction to Project Management: *United Arab Emirates University* [Online], Available at: http://www.engg.uaeu.ac.ae/departments/units/gra/lec/Project%20Management%20techniques%2011-12_%20Dr.%20Alaa%20Abdou%20I.pdf [Accessed: 23 July 2014]

Adams, J.R. and Barndt, S. E. 1988. Project management handbook: Behavioral implications of the project life cycle Von Nostrand Reinhold, New York.

Ajayi, K.T. and Mofikoya, D.K.2012. Study of Pumps in Multiple Sonnections, *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)*, vol.3, Issue 5, pp. 795-800.

Ansoff, H. I. 1984. *Implanting strategic management.* Prentice-Hall International. Englewood Cliffs, NJ.

Archibald, R.D., Di Filippo, I. and Di Filippo, D. c.2011. The Six-Phase Comprehensive Project Life Cycle Model Including the Project Incubation/Feasibility Phase and the Post-Project Evaluation Phase [Online], Available at: http://www.iil.com/downloads/Archibald_Di_Filippo_ComprehensivePLCModel_FINAL.pdf [Accessed: 19 July 2014].

Business Dictionary. 2015. *Level of Effort* [Online], Available at: http://www.businessdictionary.com/definition/level-of-effort-LOE.html [Accessed: 19 June 2015].

Blake, S.B. 1978. Managing for responsive research and development. Freeman, San Francisco.

BRITISH STANDARDS INSTITUTE. 2002. BS 6079-1: *Guide to Project Management*. British Standards Institute, London.

Brooks, F. P. 1975. The mythical man-month: Essays on software engineering.: Addison Wesley, New York.

Burke, R. 2004. *Project management: Planning and control techniques.* 4th ed. Blue Weaver Marketing and Distribution, Cape Town.

Chan, S. 2001. Complex Adaptive Systems [Online], Available at: http://web.mit.edu/esd.83/www/notebook/Complex%20Adaptive%20Systems.pdf [Accessed: 5 September 2014].

Choy, L. T. 2014. The Strengths and Weaknesses of research Methodology: Comparison and Complimentary between Qualitative and Quantitative Approaches, *IOSR Journal of Humanities And Social Science*, vol. 19, Issue 4, pp. 99-104.

Cooke-Davies, T. 2002. The “Real” Success Factors on Projects, *International Journal of Project Management*, vol. 20, pp. 185 -190.

Chapman, C. and Ward, S. 1997. *Project risk management*. John Wiley & Sons Ltd., West Sussex

Frame, J.D. 1995. *Managing projects in organizations.* 2^{nd} ed. Jossey-Bass Publishers, San Francisco.

Gupta, S. and Dokania, N.K. 2013. Challenges and Implementation of Effort Tracking Systems, *International Journal of Engineering Research & Technology*, vol.2 Issue 10, pp. 2272 – 2280.

Grundfos Research Technology. c.2014. *The Centrifugal Pump* [Online], Available at: http://www.grundfos.com/content/dam/Global%20Site/Industries%20%26%20solutions/Industry/pdf/The_Centrifugal_Pump.pdf [Accessed: 11 November 2014].

Horsburgh, D. 2003. Evaluation of Qualitative Research, *Journal of Clinical Nursing*, vol. 12, pp. 307–312.

Huang, H., Shiu, J. and Chen, T. 2011. The Project Scheduling and Decision Mechanism Based on the Multi-Resource Leveling, *EPPM, Singapore*, pp.117-126.

Ireland, V., Gorod, A. and White, E. W. 2013. *Project Perspectives: The Annual Publication of International Project Management Association* [Online], Available at: http://ipma.ch/assets/re-perspectives_2013.pdf [Accessed: 23 July 2014]

Izadpanah, H., Arbabi, H. and Kord, B. 2012. The Reality of Project Management Office for Construction Organization in the Oil, Gas and Petrochemical Industry of Iran, *Research Journal of Applied Sciences, Engineering and Technology*, vol. 4, no. 15, pp. 2515 –2522.

Khalili, H.A. and Maleki, A. 2011. Project Risk Management Techniques in Resource Allocation, Scheduling and Planning, *World Academy of Science, Engineering and Technology*, vol. 5, pp. 196–200.

KSB. 2005. Selecting Centrifugal Pumps [Online], Available at http://za.grundfos.com/content/dam/Global%20Site/Industries%20%26%20solutions/Industry/pdf/The_Centrifugal_Pump.pdf [Accessed: 11 November 2014].

Lewis, J.P. 1998. *Mastering Project Management*. McGraw-Hill, New York.

Lynch, B. 2003. Critical Chain Project Management: Coming to a Radar Screen Near You!, *The Journal of Information Technology Management*, vol. 16, no. 3, pp. 1 – 35.

Marshall, M.N. 1996. Sampling for Qualitative Research, *Family Practice*, vol. 13. no. 6, pp. 522–525.

Meziane, M.E.L., Meziane, K. E. I. and Liang, Y. c.2010. A Study of Petrochemical Project Management and Design Practices in Petrochemical Firms in China, Hubei

Changjiang Petrochemical Equipment Co., LTD (CJPCE) as Study Case, *Asian Journal of Business and Management Sciences*, vol. 1, no. 7, pp. 68–81.

Milton, N. 2005. *Knowledge management for teams and projects*. Chandos Publishing, England.

Mikulskiene, B. 2014. *Research and Development Project Management.* Mykolo Romerio universitetas, Vilnius

Mochal, T. 2014. Ten Steps to Estimate Effort on Your Project [Online], Available at: http://www.theicpm.com/blog/item/4706-ten-steps-to-estimate-effort-on-your-project [Accessed 5 September 2014]

Mohamed, N.L. and Mohamed, K.J. 2012. Project Management Phases of a SCADA System for Automation of Electrical Distribution Networks, *IJCSI International Journal of Computer Science Issues*, vol. 9, issue.2, no.2, pp. 157-162.

Munk-Madsen, A. c.2005. *The Concept of 'Project': A Proposal for a Unifying Definition* [Online], Available at: http://www.metodica.dk/pers/Define032.pdf [Accessed: 20 July 2014]

Nigatu,T. 2009. *Qualitative Data Analysis* [Online], Available at: http://www.slideshare.net/tilahunigatu/qualitative-data-analysis-11895136 [Accessed: 10 August 2014].

Patton, M.Q., Cochran, M. 2002. *A Guide to Using Qualitative Research Methodology* [Online], Available at: http://fieldresearch.msf.org/msf/bitstream/10144/84230/1/Qualitative%20research%20methodology.pdf [Accessed: 9 August 2014].

Project Management Institute. 2000. *A guide to the project management body of knowledge (PMBOK Guide).* 2000 ed. Project Management Institute Inc., Pennsylvania.

Project Management Institute. 2008. *A guide to the project management body of knowledge (PMBOK Guide).* 4th ed. Pennsylvania USA: Project Management Institute, Inc.

Project Management Knowledge. 2014. *Effort* [Online], Available at: http://project-management-knowledge.com/definitions/e/effort/ [Accessed 5 September 2014].

Ramakrishnan,N.2015. Analysis of Effort Prediction as an Influencing Parameter of Success in Software Development Projects, *International Journal of Advanced Research in Computer Science and Software Engineering*,vol. 5, Issue 2, pp. 498- 500.

Remington, K., Zolin, R. and Turner, R. 2009. *A Model of Project Complexity: Distinguishing Dimensions of Complexity from Severity* [Online], Available at: http://eprints.qut.edu.au/29011/1/c29011.pdf [Accessed: 9 September 2014]

Republic of South Africa. 2014. Government Gazette Guideline for Services and Processes for Estimating Fees for Persons Registered in Terms of the Engineering Profession Act, 2000, (Act 46 of 2000), Vol. 546,No. 38324, pp. 40–43.

Sage Publications. 2012. *Qualitative Data Analysis* [Online], Available at: http://www.sagepub.com/upm-data/43454_10.pdf [Accessed 9 August 2014].

Sasol Limited. 2012. *Business Development and Implementation Model* [Online], Available at: http://intwww.sasol.com/sastech/BDI/bdifrontpage.htm [Accessed: 19 June 2014].

Selaru, C. 2012. Resource Allocation in Project Management, *International Journal of Economic Practices and Theories*, vol. 2, no. 4, pp. 274–282.

Shenhar, A.J, Dvir, D. and Shulman, Y. 1995. A Two Dimensional Taxonomy of Products and Innovations, *Journal of Engineering and Technology Management*, vol. 12, pp. 175-200.

Slusarczyk, A. and Kuchta, D. 2011. The New Approach for Project Activities Classification and its Application in the Critical Chain Buffer Management Method, *Institute of Organization and Management*, vol. 1, pp. 142-162.

Slevin, D.P. and Pinto, J.K. 1987. *Balancing Strategy and Tactics in Project Implementation* [Online], Available at: http://www.iei.liu.se/fek/utbildning/kurskatalog/723g18/articles_and_papers/1.107456/PintoSlevin1988.pdf [Accessed: 5 September 204].

Synfuels Projects. 2013. *Procedure: Project Management (SAX 10029304)*, Secunda: Sasol (Pty) Ltd.

Taylor, D. 2014. The Literature Review: A Few Tips on Conducting It [Online], Available at: http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review [Accessed 12 August 2014].

Turner, J.R, Huemann, M. and Keegan, A. 2008. *Human resource management in the project-oriented organization*. PMI Book Service Center, Atlanta.

Turner, J.R. and Muller, R. 2005. The Project Manager's Leadership Style as a Success Factor on Projects: A literature Review, *Project Management Journal*, vol. 36, no. 1, pp. 49-61.

Williams, C.2007. Research Methods, *Journal of Business& Economics Research*, vol.5, no.3, pp.65-72.

Williams, T.M, 1999. *The Need for New Paradigms for Complex Projects* [Online], Available at: http://ieg.ifs.tuwien.ac.at/~aigner/projects/planninglines/evaluation/Project_Management/papers/williams99complexity.pdf [Accessed: 9 September 2014]

Welman, J.C. and Kruger, S.J. 1999. Research methodology for business and administrative sciences. Thomson, New York:.

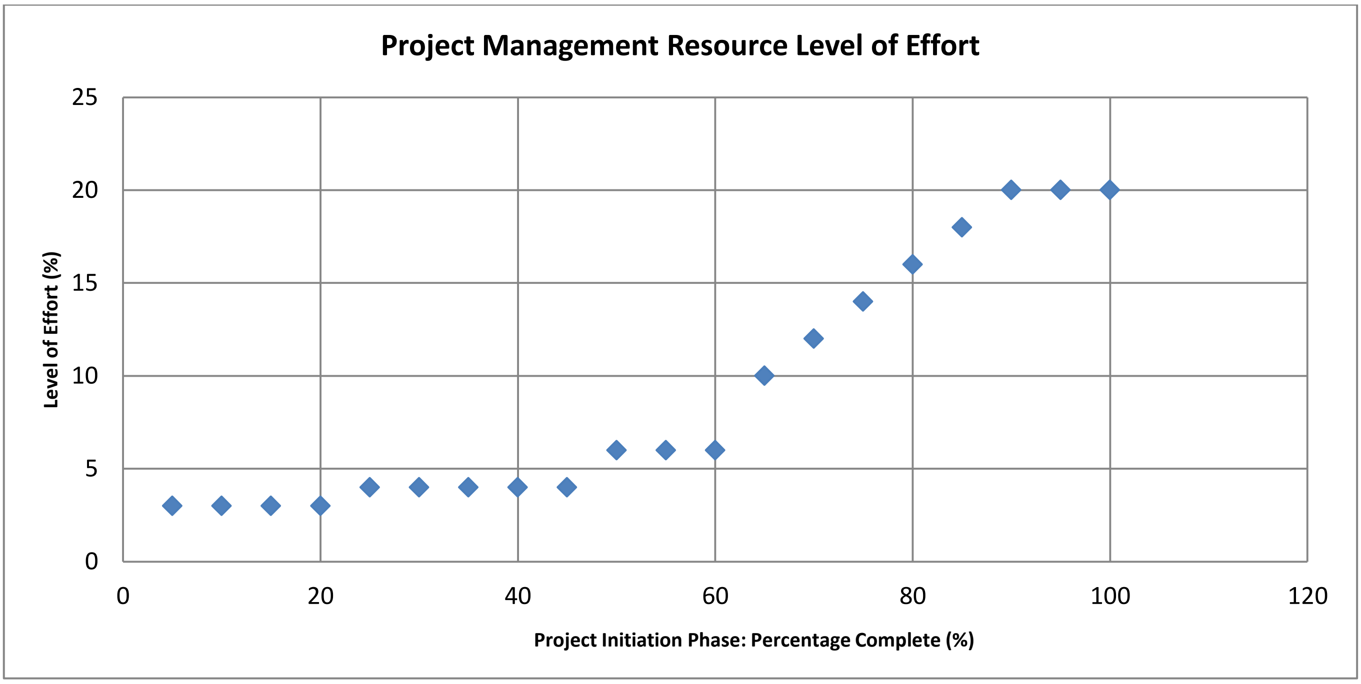
Westland, J. 2006. *Project management life cycle*. Kogan Page, London.

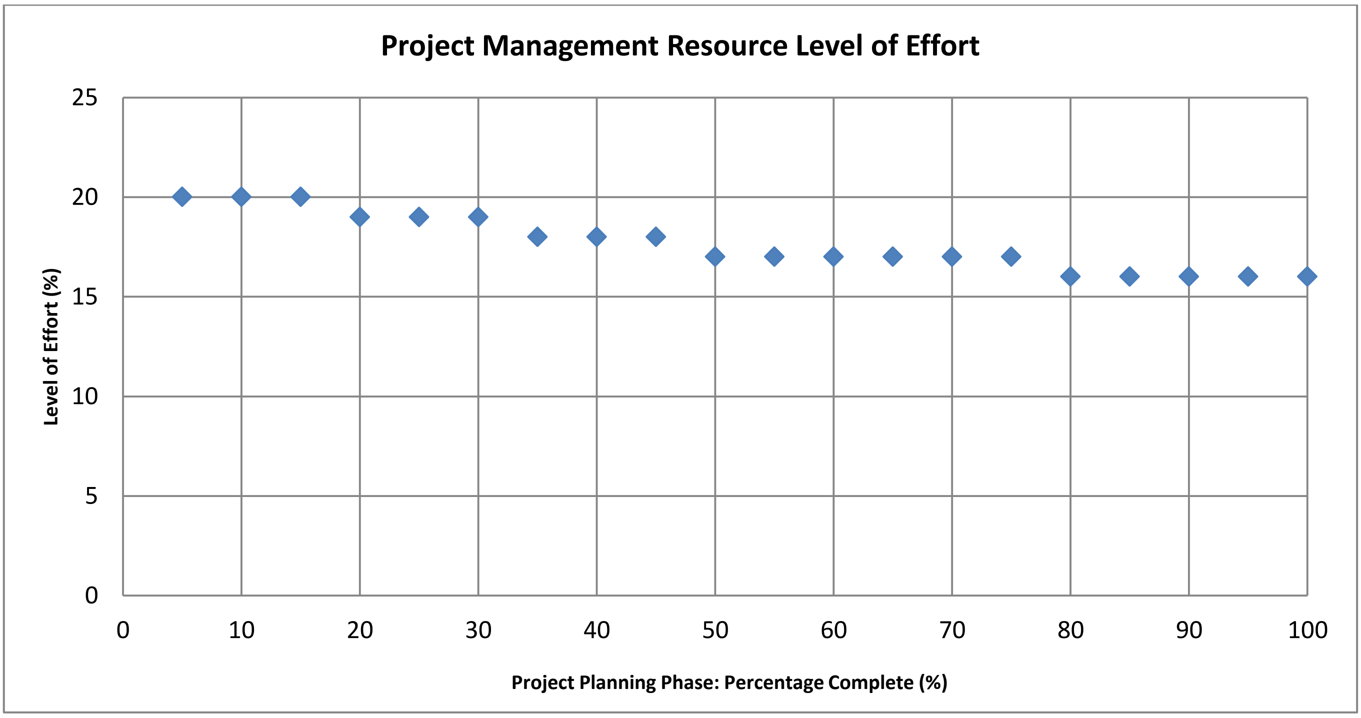
Westney, E.R. 1992. *Computerized management of multiple small projects*. Marcel Dekker Inc., New York.

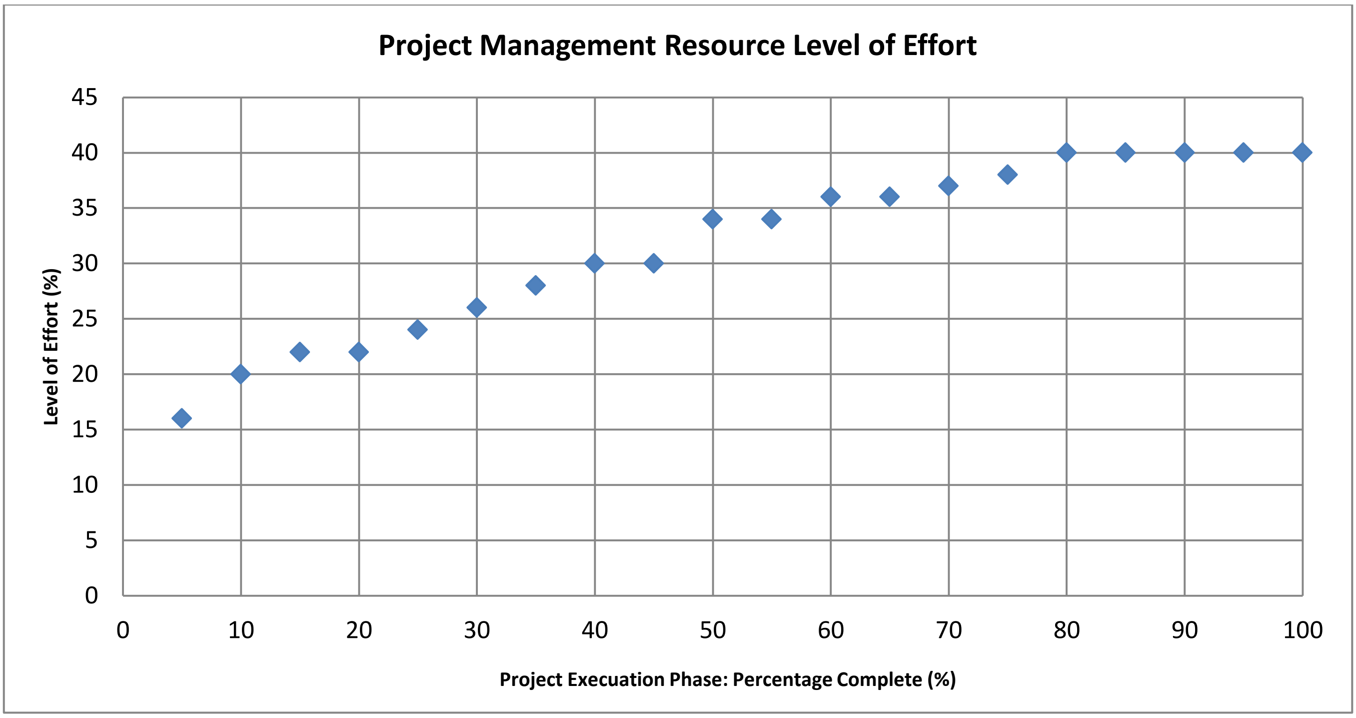
Wheelwright, S.C. and Clark, K.B. 1992. *Revolutionizing product development*. The Free Press New, York.

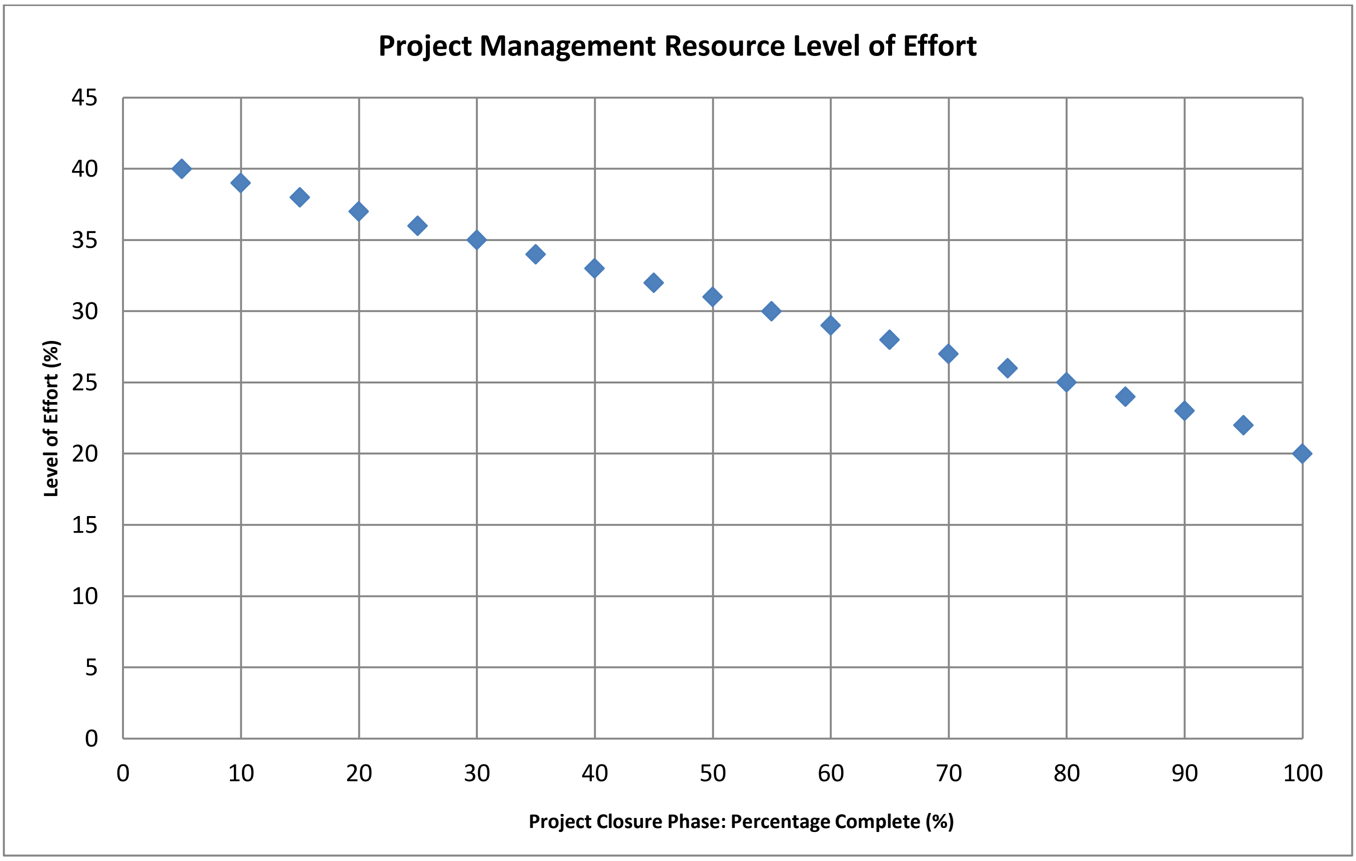
APPENDICES

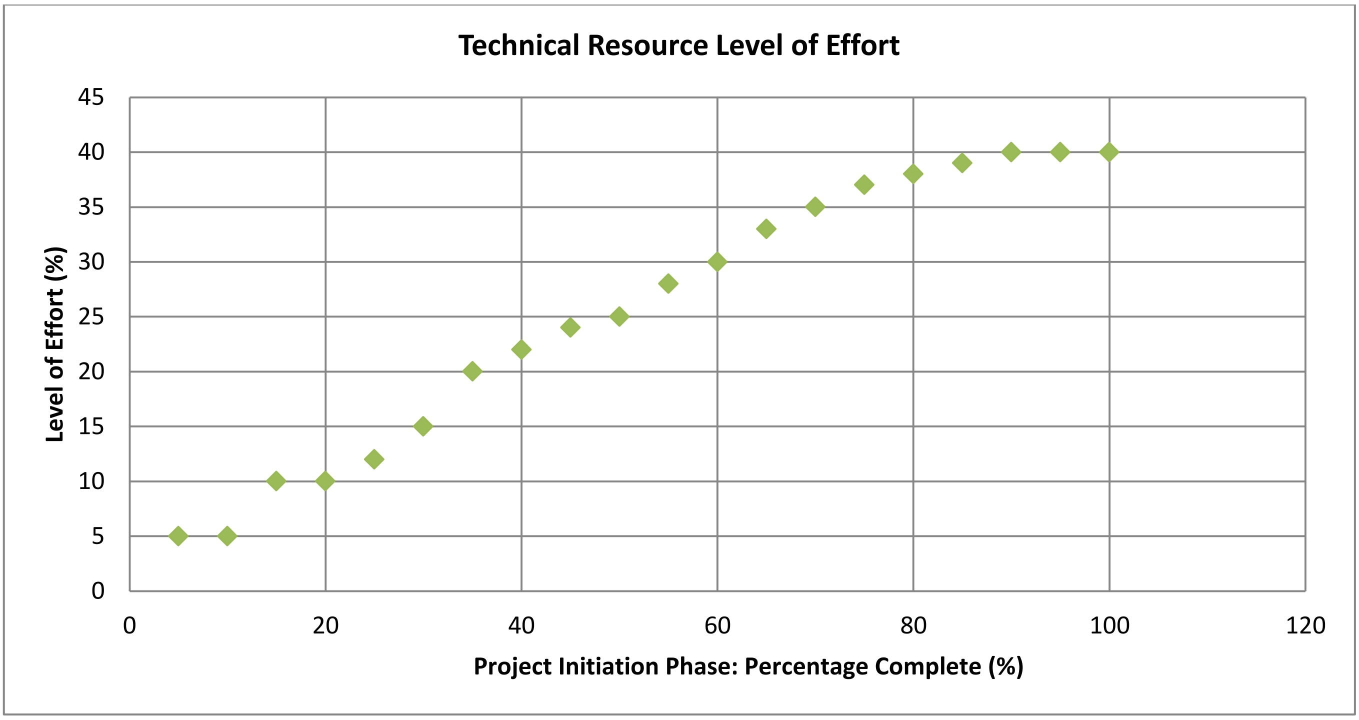
APPENDIX 1: LEVEL OF EFFORT HYPOTHESIS GRAPHS

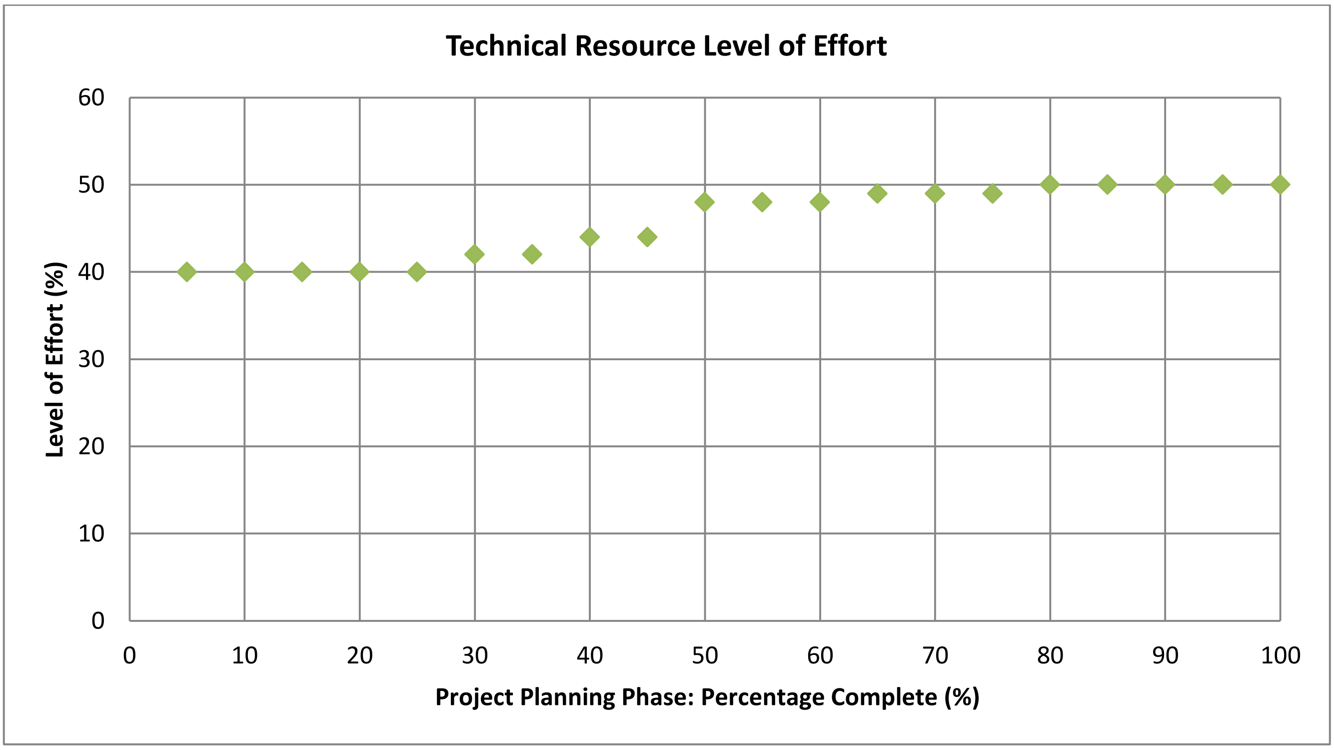


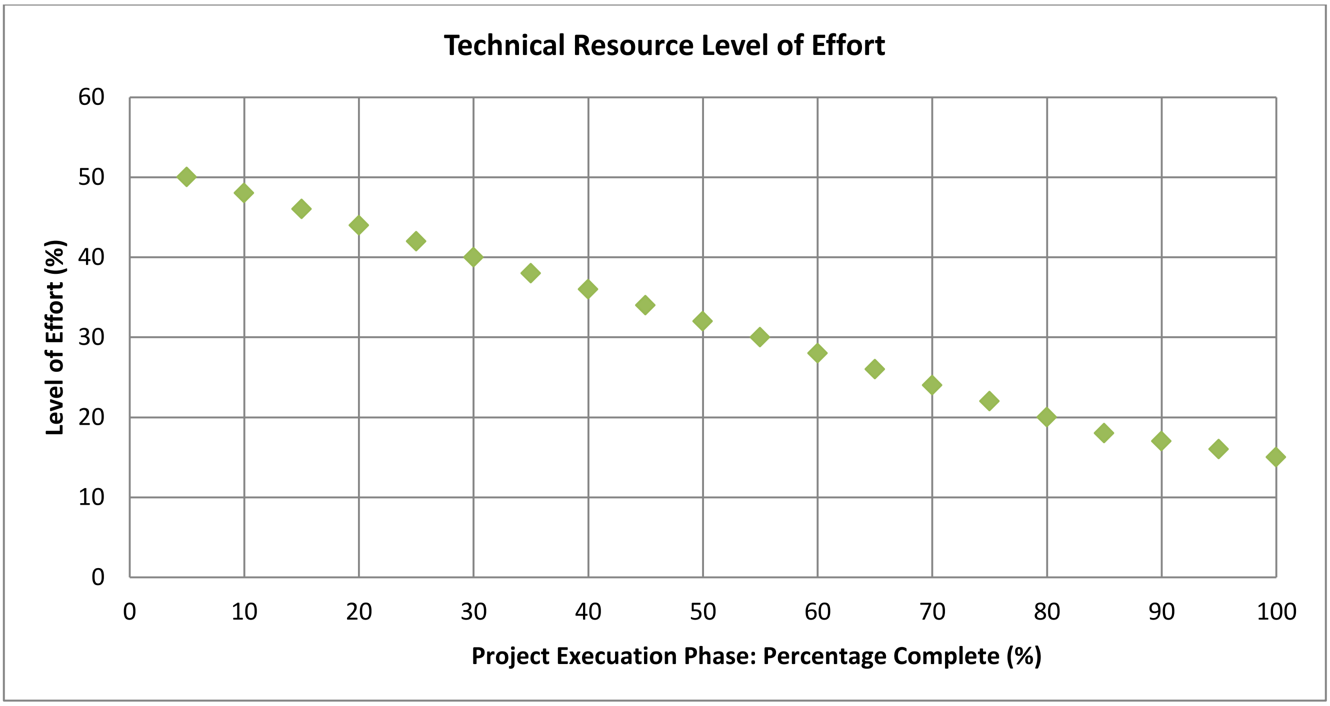


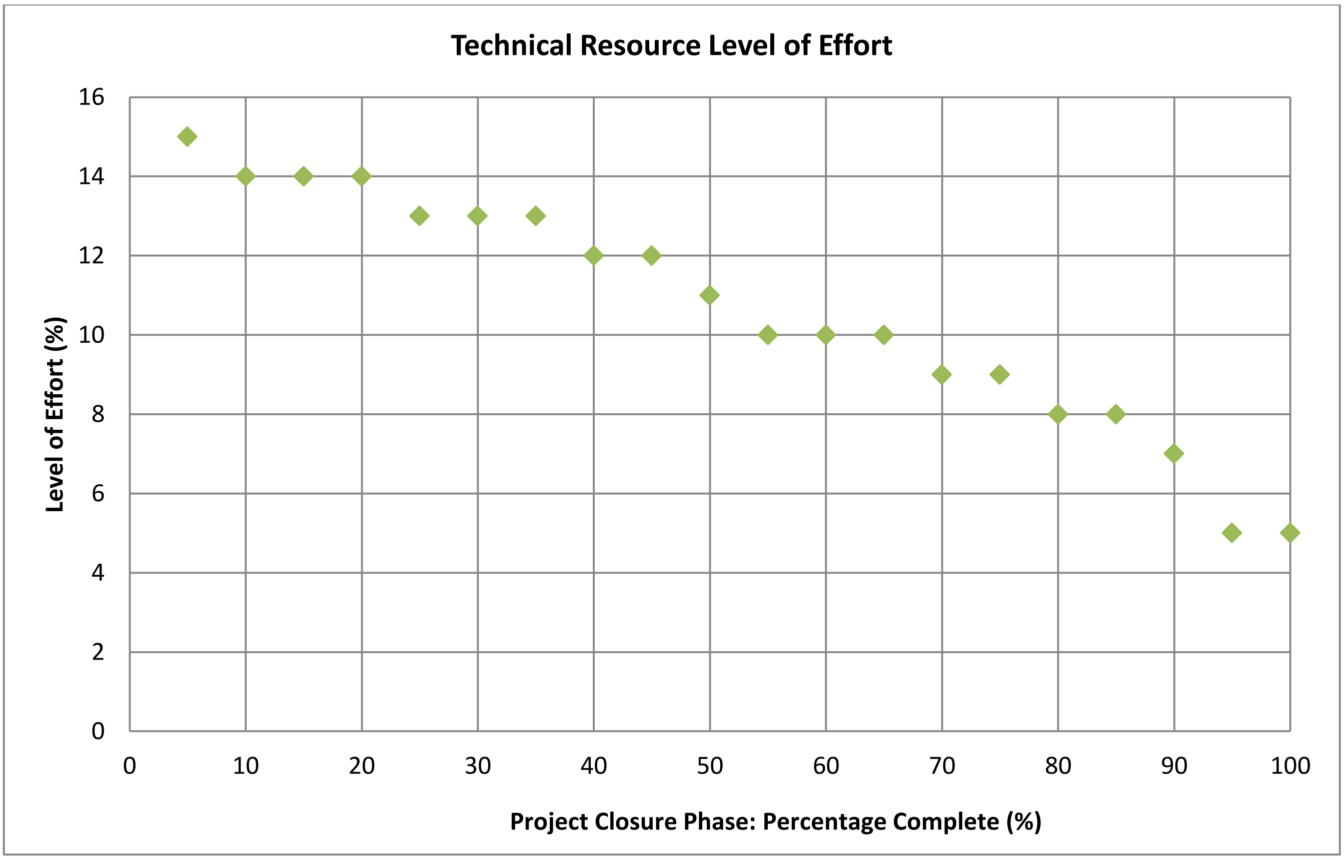

Project Management Resource Level of Effort
Level of Effort (%)
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Project Execuation Phase: Percentage Complete (%)

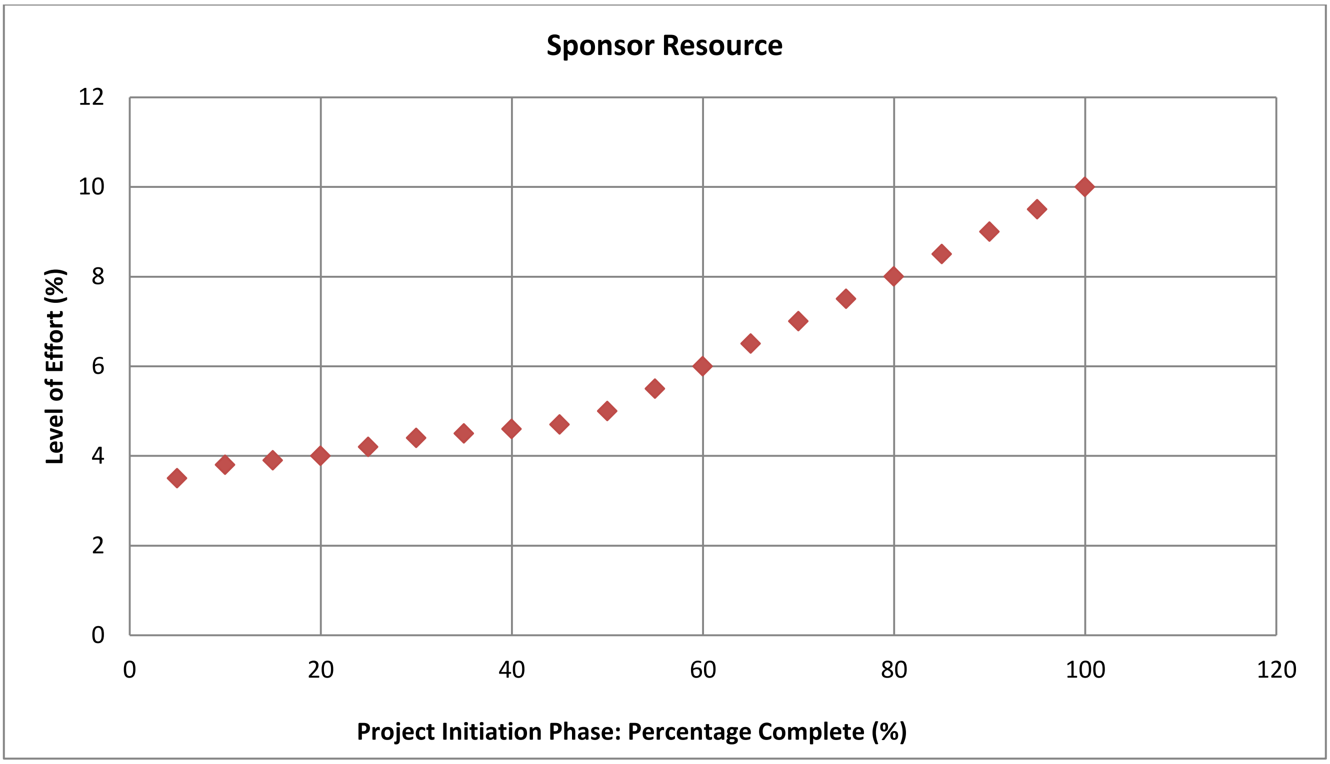

Project Management Resource Level of Effort
Level of Effort (%)
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Project Closure Phase: Percentage Complete (%)

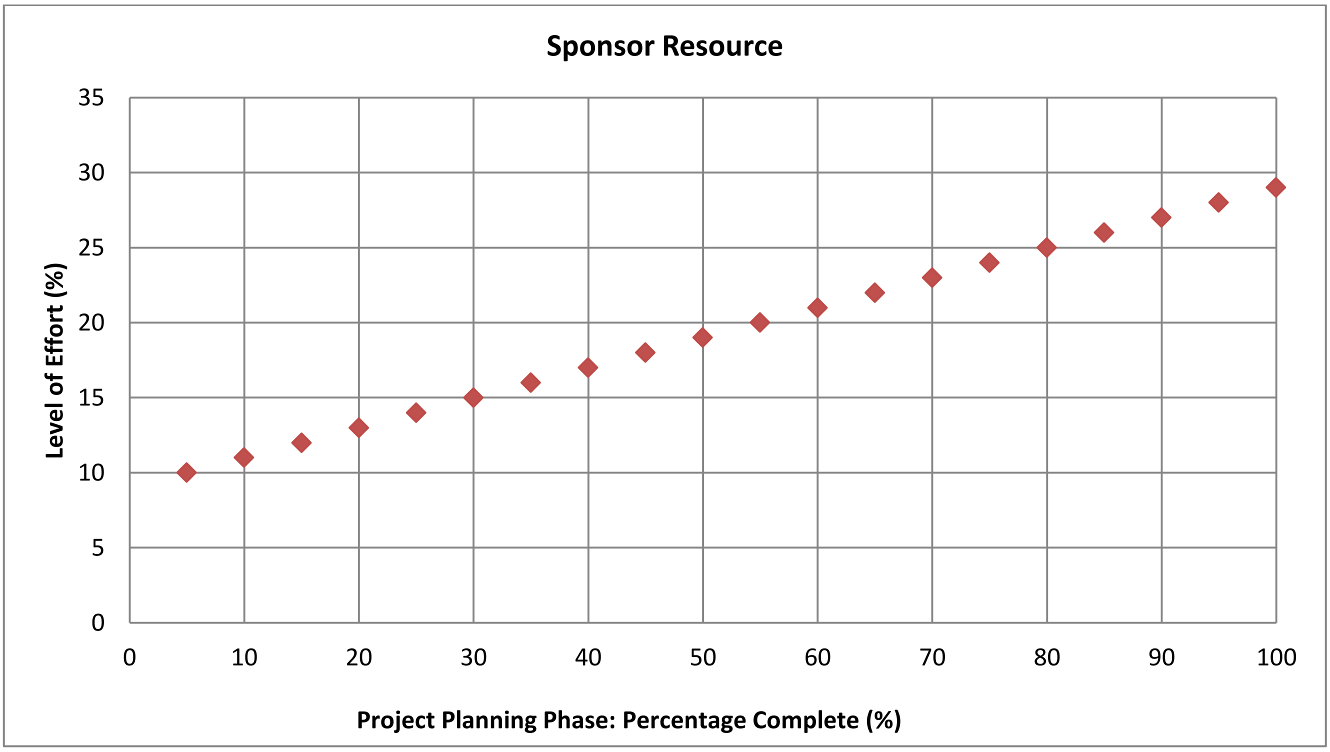

Technical Resource Level of Effort
Level of Effort (%)
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
Project Initiation Phase: Percentage Complete (%)

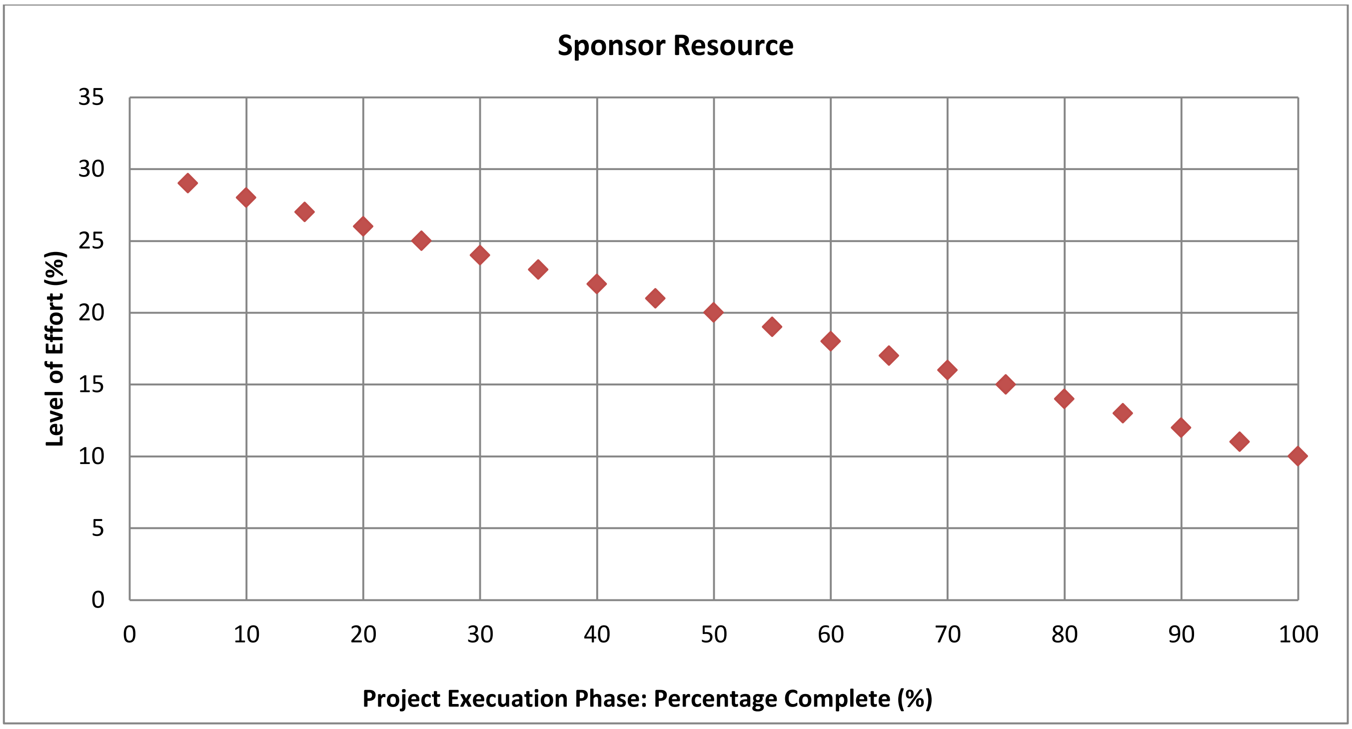

Technical Resource Level of Effort
Level of Effort (%)
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Project Planning Phase: Percentage Complete (%)

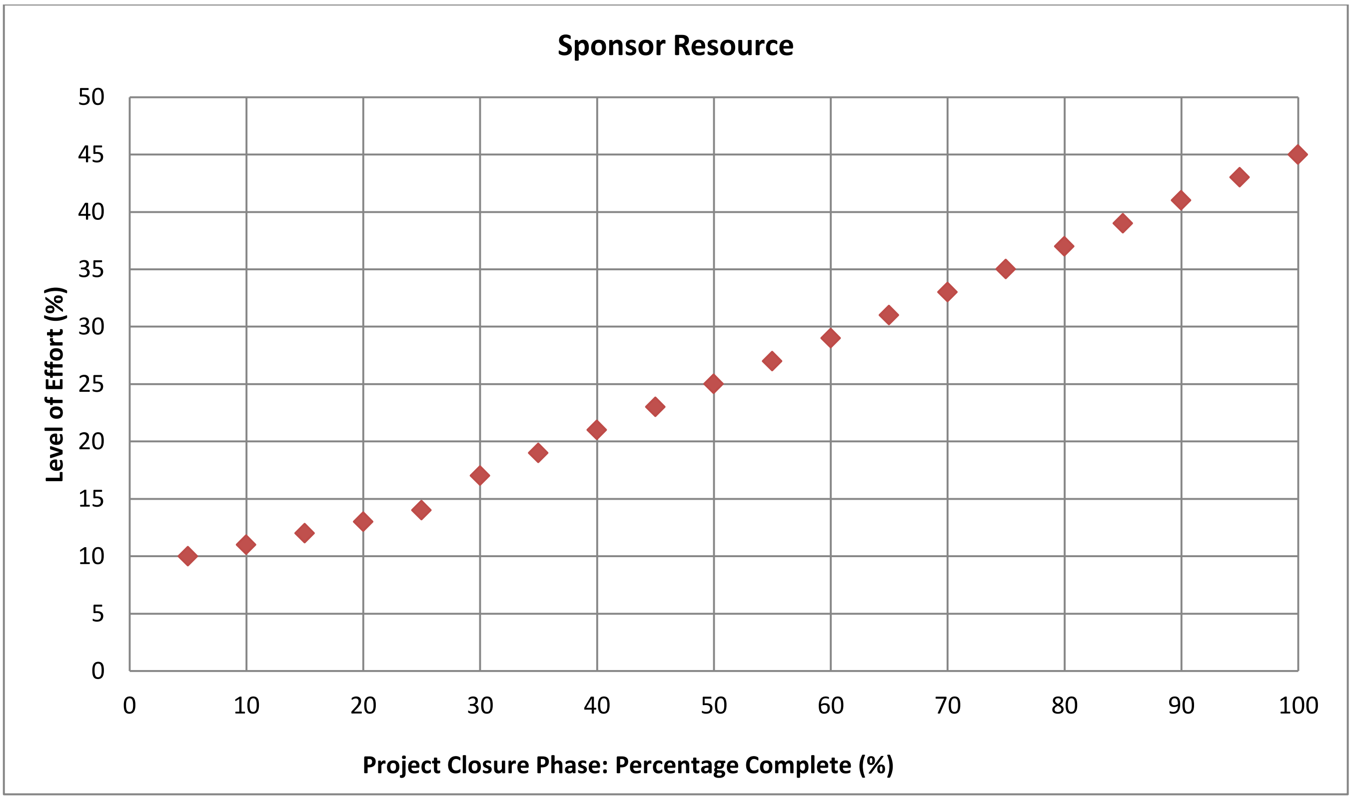

Technical Resource Level of Effort
Level of Effort (%)
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Project Execuation Phase: Percentage Complete (%)

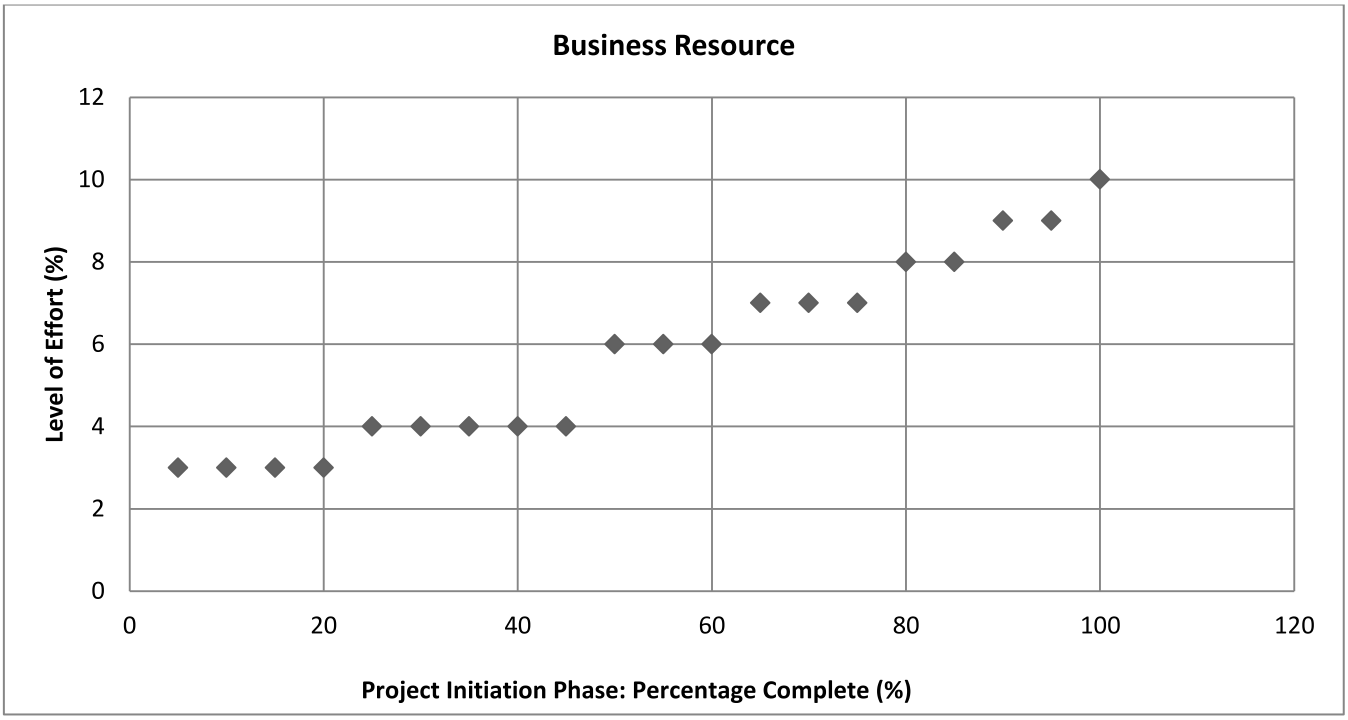

Technical Resource Level of Effort
Level of Effort (%)
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
90
100
Project Closure Phase: Percentage Complete (%)

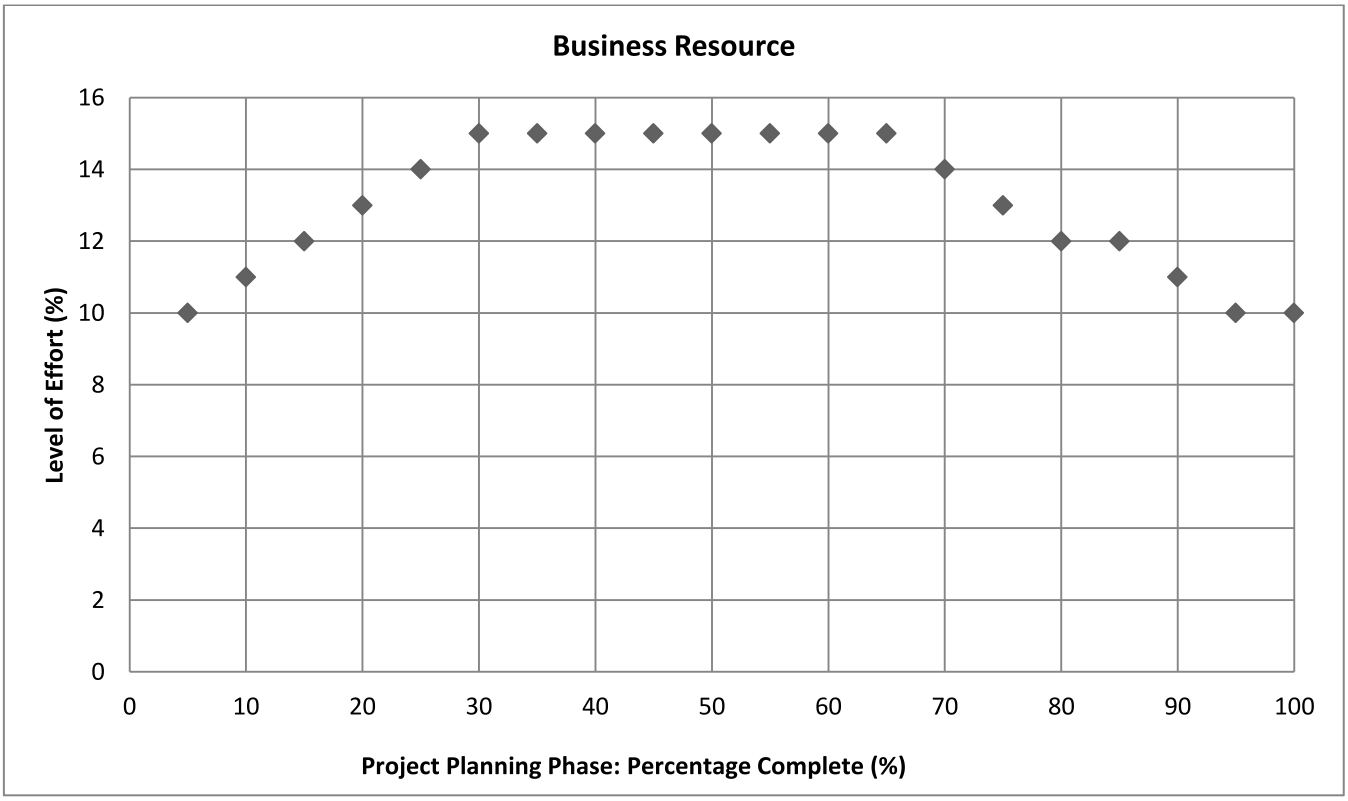

Sponsor Resource
Level of Effort (%)
12
10
8
6
4
2
0
0
20
40
60
80
100
120
Project Initiation Phase: Percentage Complete (%)

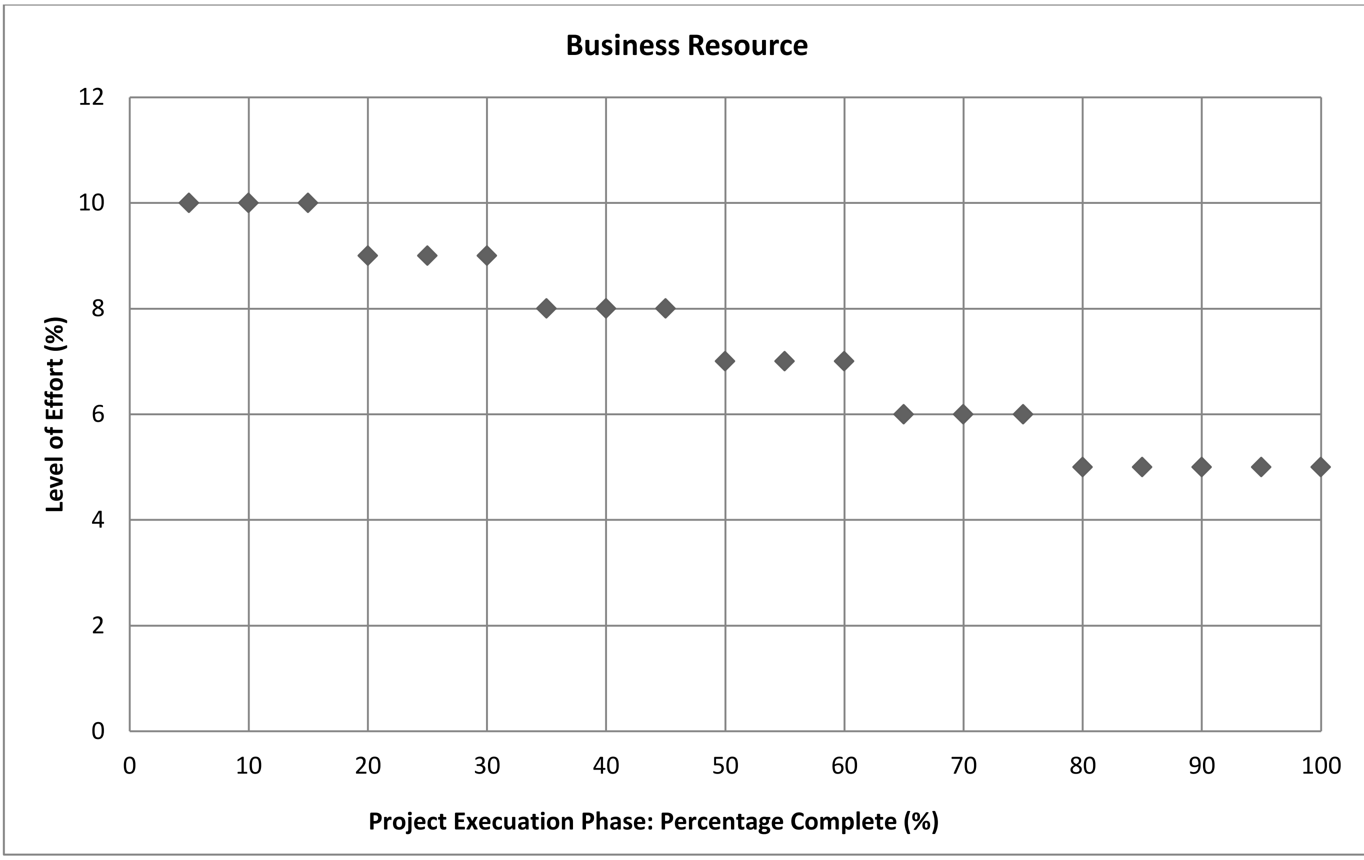

Sponsor Resource
Level of Effort (%)
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Project Planning Phase: Percentage Complete (%)

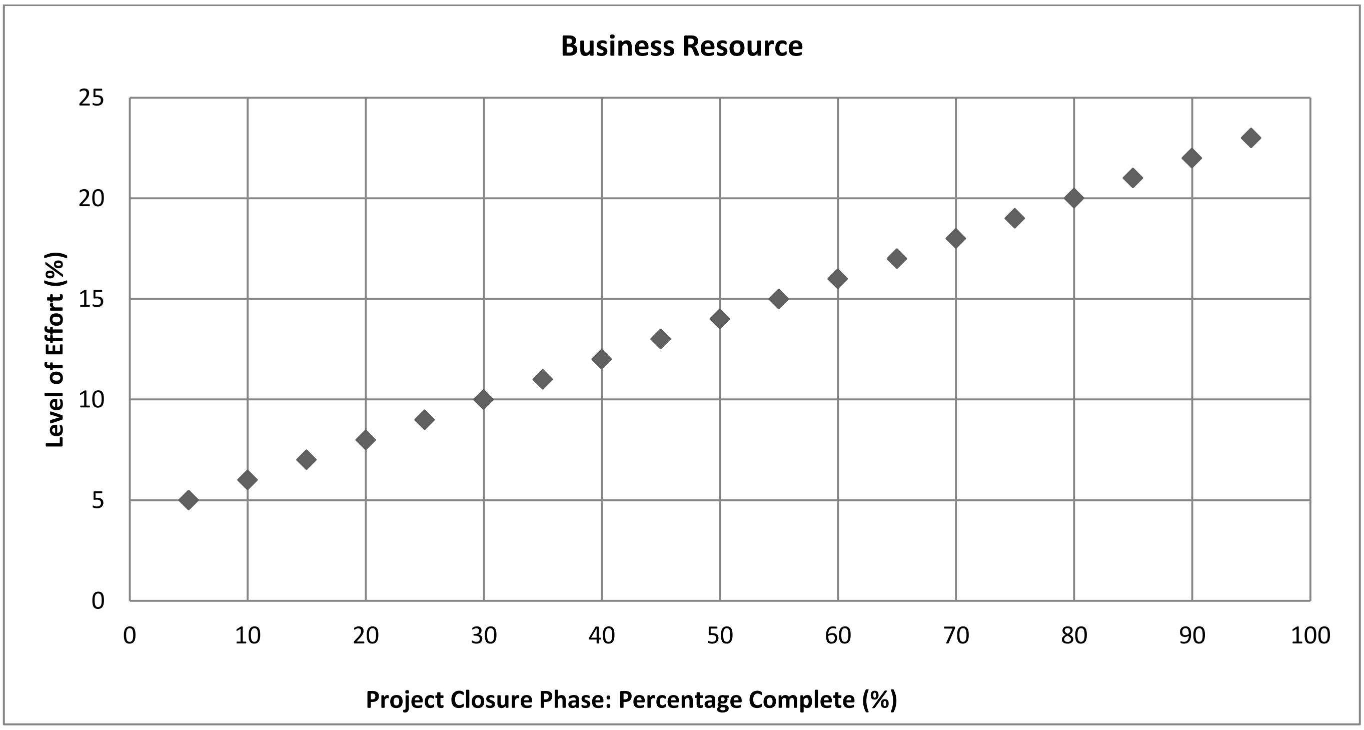

Sponsor Resource
Level of Effort (%)
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Project Execution Phase: Percentage Complete (%)


Sponsor Resource
Level of Effort (%)
50
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Project Closure Phase: Percentage Complete (%)


Business Resource
Level of Effort (%)
0
2
4
6
8
10
12
0
20
40
60
80
100
120
Project Initiation Phase: Percentage Complete (%)


Business Resource
Level of Effort (%)
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
70
80
90
100
Project Planning Phase: Percentage Complete (%)





Adapted from: Synfuels Projects, 2013, p. 34

APPENDIX 2: DETAILED PROJECT DELIVERABLES

Synfuels Projects Mandatory Deliverable List - MODEL A (Complex Renewal/Capital Projects)					
Idea Generation	Pre-feasibility	Feasibility	Basic Development	Execution	Start-up
BU Level 1 Meeting*	Gate 1 – 2	Gate 2 – 3	Gate 3 - 4	Gate 4 - 5	Gate 5 - 6
A. MOM Level 1 Meeting and approval of Prioritisation completed	1. SPD Project Registration/Project Number	16. Management of Change (MOC)	2. Project Charter	16. MOC Form for RFC signed off	16. MOC Closed
B. Opportunity Definition approved	1.1 Project Document Filing Structure Registration	2. Project Charter	3. Level 1 Schedule	3. Level 4 Schedule for Current and Next phase	14. Gate 6 Review Report and Lessons Learnt
C. Resource availability and Plan	2. Project Charter	3. Level 1 Schedule	3.1 Level 4 Schedule for current phase	4. MOM Framing/Alignment	24. Construction Safety File & Audit Report
D. Preliminary Tier Rating	3. Level 1 Schedule	3.1 Level 2 Schedule with major milestones for current and next phase	3.2 Level 3 Schedule for next phase	9. Risk Register	26. Transmittal of Owners documentation on as-builts
Gate 0-1	3.1 Level 2 Schedule with major milestones for current and next phase	4. MOM Framing/Alignment	4. MOM Framing/Alignment	13. MOM Project Status &/or BU Steercom	29. Punch list
E Business Track Deliverables for Gate 1 approval	4. MOM Framing/Alignment	5. Business Case	5. Business Case	14. Gate 5 Review Report	30. Plant accepted by Synfuels as "Ready for Commissioning" (RFC)
E1. Sponsor Appointment Letter	5. Business Case	6. Project Execution Plan	6. Project Execution Plan	15. Capital Expenditure Application	31. Plant accepted by Synfuels as "Ready for Operations" (RFO)
F. Technical Track Deliverables for Gate 1 approval	6. Project Execution Plan	7. Engineering Execution Plan	7. Engineering Execution Plan	19. RFQ Package	32. Plant accepted for Beneficial Operations (BO)
	7. Engineering Execution Plan	8. Feasibility/Concept Package	9. Risk Register	20. Works Information	33. Final Cost and Commercial Closure
	8. Pre-feasibility package	9. Risk Register	10. SDE Estimate for next phase	21. Site Information	
	9. Risk Register	10. SDE for next phase	10. 1 EDJ Estimate (SDE)	22. EPC Contract	
* It may be necessary to present at BU Level 2 Meeting to satisfy ASAM approval	10. SDE for next phase (Gate 2-3)	10.1 EDJ Estimate (OOM)	12. Gate Decision from Synfuels Governance Meeting	23. Commissioning Plan	
	10.1. EOJ Estimate (ROM)	12. Gate Decision from Synfuels Governance Meeting	13. MOM Project Status &/or BU Steercom	24. Safety File checklist approval	
	11. Tier Classification	13. MOM Project Status &/or BU Steercom	14. Gate 4 Review Report	25. Pre-safety Systems Review	
	12. Gate Decision from Synfuels Governance Meeting	14. Gate 3 Review Report	15. Capital Funds Application	26. Owners Documentation (F617/F626)	
	13. MOM Project Status &/or BU Steercom	15. Fund Application	17. Procurement Plan	DOCUMENTATION BY EC	
	14. Gate 2 Review Report	17. Prelim Procurement Plan (Long leads)	18. HAZOP	8. Detail Engineering Package	
	15. Development Funds Application			17. Procurement Plan	
			DOCUMENTATION BY EC	27. Project Quality Plan	
			8. Basic Engineering Package	28. Construction Management Plan	

Adapted from: Synfuels Projects, 2013, p. 35

Synfuels Projects Mandatory Deliverable List - MODEL B (In-House/EPC Renewals)

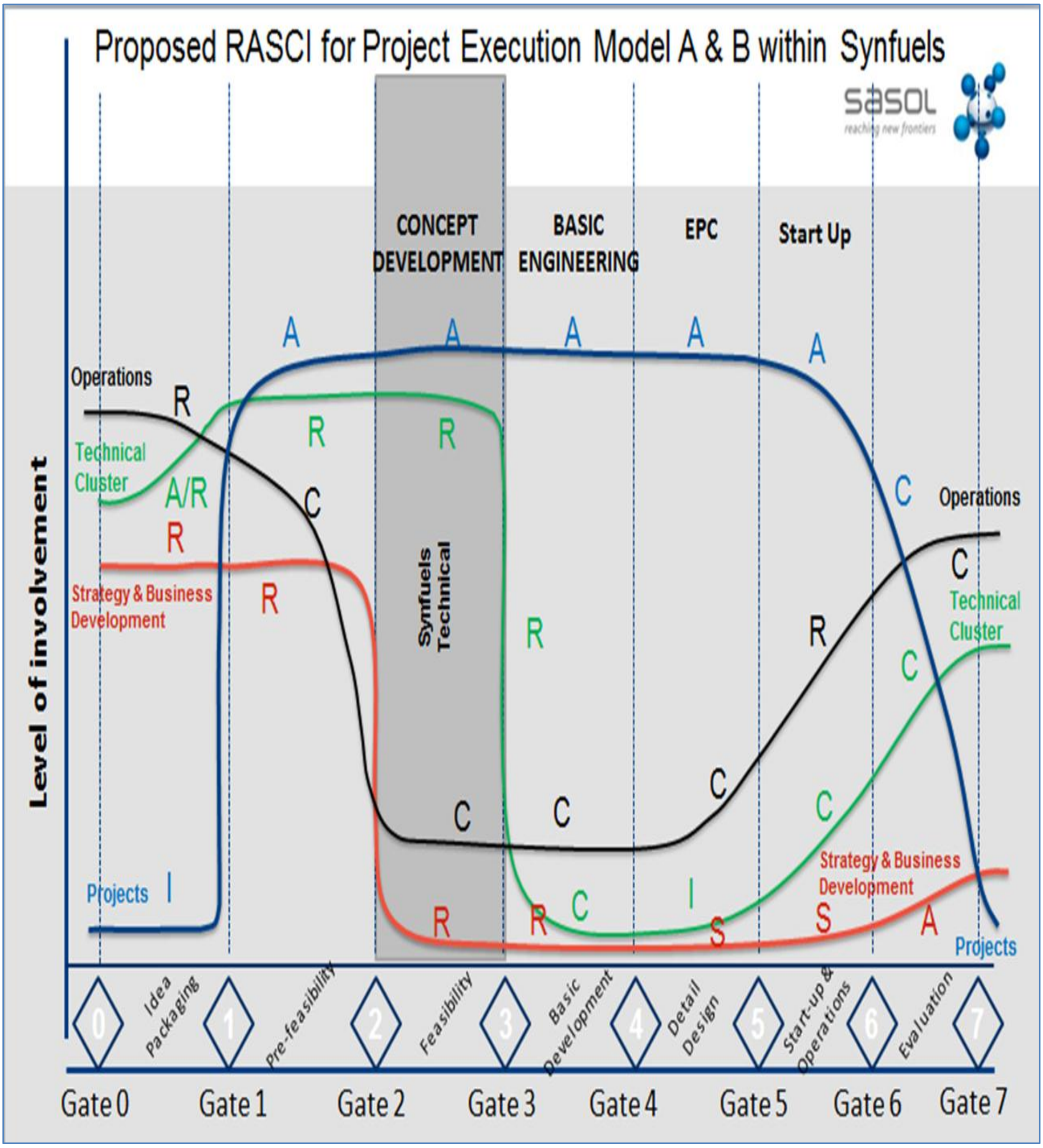
Idea Generation	Pre-feasibility & Feasibility	Basic Development	Execution	Start-up
BU Level 1 Meeting*	Gate 1 – 3	Gate 3 - 4	Gate 4 - 5	Gate 5 - 6
A. MOM Level 1 Meeting and approval of Prioritisation completed	1. SPD Project Registration/Project Number	2. Project Charter	16. MOC Form for RFC signed off	16. MOC Closed
B. Opportunity Definition approved	1.1 Project Document Filing Structure Registration	3. Level 1 Schedule	3. Level 4 Schedule for Current and Next phase	14. Gate 6 Review Report and Lessons Learnt
C. Resource availability and Plan	16. Management of Change (MOC)	3.1 Level 4 Schedule for current phase	4. MOM Framing/Alignment	24. Construction Safety File & Audit Report
D. Preliminary Tier Rating	2. Project Charter	3.2 Level 3 Schedule for next phase	9. Risk Register	26. Transmittal of Owners documentation on as-builts
Gate 0-1	3. Level 1 Schedule	4. MOM Framing/Alignment	13. MOM Project Status &/or BU Steercom	29. Punch list
E. Business Track Deliverables for Gate 1 approval	3.1 Level 2 Schedule with major milestones for current and next phase	5. Business Case	14. Gate 5 Review Report	30. Plant accepted by Synfuels as "Ready for Commissioning" (RFC)
E1. Sponsor Appointment Letter	4. MOM Framing/Alignment	6. Project Execution Plan	15. Capital Expenditure Application	31. Plant accepted by Synfuels as "Ready for Operations" (RFO)
F. Technical Track Deliverables for Gate 1 approval	5. Business Case	7. Engineering Execution Plan	19. RFQ Package	32. Plant accepted for Beneficial Operations (BO)
	6. Project Execution Plan	9. Risk Register	20. Works Information	33. Final Cost and Commercial Closure
	7. Engineering Execution Plan	10. SDE Estimate for next phase	21. Site Information	
	8. Feasibility/Concept Package	10. 1 EOJ Estimate (SDE)	22. EPC Contract	
* It may be necessary to present at BU Level 2 Meeting to satisfy ASAM approval	9. Risk Register	12. Gate Decision from Synfuels Governance Meeting	23. Commissioning Plan	
	10. SDE for next phase	13. MOM Project Status &/or BU Steercom	24. Safety File checklist approval	
	10.1 EOJ Estimate (OOM)	14. Gate 4 Review Report	25. Pre-safety Systems Review	
	11. Tier Classification	15. Capital Funds Application	26. Owners Documentation (F617/F626)	
	12. Gate Decision from Synfuels Governance Meeting	17. Procurement Plan	DOCUMENTATION BY EC	
	13. MOM Project Status &/or BU Steercom	18. HAZOP	8. Detail Engineering Package	
	14. Gate 3 Review Report		17. Procurement Plan	
	15. Fund Application	DOCUMENTATION BY EC	27. Project Quality Plan	
	17. Prelim Procurement Plan (Long leads)	8. Basic Engineering Package	28. Construction Management Plan	

Adapted from: Synfuels Projects, 2013, p. 36

Synfuels Projects Mandatory Deliverable List - MODEL C (In-House Renewals)

Idea Generation	Pre-feasibility & Feasibility	Basic Development	Execution & Start-up
BU Level 1 Meeting*	**GATE 1 - 3**	**GATE 3 - 4**	**GATE 4 - 6**
A. MOM Level 1 Meeting and approval of Prioritisation completed	1. SPD Project Registration/Project Number	2. Update Model C Covering Document (New template and SAS-number)	15. MOC Form for RFC signed off, & final Close-out
B. Opportunity Definition approved	1.1 Project Document Filing Structure Registration	3. Level 1 Schedule	3. Level 4 Schedule for Current Phase
C. Resource availability and Plan	15. Management of Change (MOC)	3.1 Level 4 Schedule for current and next gate	4. MOM Framing/Alignment
D. Preliminary Tier Rating	2. Model C Covering Document (New template and SAS-number)	4. MOM Framing/Alignment	5. Detailed 'Project Execution Plan' (Engineering plan, Quality plan, Procurement plan, Construction plan, Material plan, Communication plan)
Gate 0-1	3. Level 1 Schedule	5. Basic 'Project Execution Plan'	6. Risk Register
E. Business Track Deliverables for Gate 1 approval	3.1 Level 2 Schedule with major milestones for current and next phase	12. Basic Engineering Package	10. MOM Project Status &/or BU Steercom
E1. Sponsor Appointment Letter	4. MOM Framing/Alignment	6. Risk Register	11. Gate 6 Review Report and Lessons Learnt
F. Technical Track Deliverables for Gate 1 approval	5. Feasibility 'Project Execution Plan'	7. SDE for next phase	17. Owners Documentation (F617/F626)
	6. Risk Register	7.1 EOJ Estimate (OOM)	18. Commissioning Plan
	7. SDE for next phase	9. Synfuels Governance committee meeting approval	19. Safety File Checklist approval (8 point)
	7.1 EOJ Estimate (OOM)	10. MOM Project Status &/or BU Steercom	20. SAS542F - Renewal Completion form
* It may be necessary to present at BU Level 2 Meeting to satisfy ASAM approval	8. Tier Classification	11. Gate 4 Review Report	21. Completion Certificates
	9. Synfuels Governance committee meeting approval	13. Fund Application	22. Plant accepted as "Ready for Commissioning" (RFC)
	10. MOM Project Status &/or BU Steercom	14. Procurement Plan	23. Plant accepted as "Ready for Operations" (RFO)
	11. Gate 3 Review Report	16. HAZOP	24. Plant accepted for Beneficial Operations (BO)
	12. Applicable Technical Justification Template per discipline		25. Final Cost and Commercial Closure
	13. SAS542E - Application for Operating Renewal funds		
	14. Prelim Procurement Plan (Long leads)		

APPENDIX 3: LEVEL OF EFFORT FOR COMPLEX PROJECTS



Adapted from: Synfuels Projects, 2013, p. 31

APPENDIX 4: CONSENT LETTER

UNIVERSITY OF KwaZULU-NATAL

Leadership Centre

Master in Commerce: Leadership Studies

Researcher: Mfundo Verby (079 496 2882)

Supervisor: Dhanesh Rampersad (078 801 3411)

CONSENT

I………………………………………………………………………….(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

______________________________ ______________________________

Signature of Participant Date

HSSREC Research Office Contact Details:

Prem Mohun

Research Office: Govan Mbeki Building

Tel 031 2604557

Fax 031 2604609

E-mail mohunp@ukzn.ac.za

APPENDIX 5: REQUEST FOR RESEARCH LETTER

UNIVERSITY OF KwaZULU-NATAL

Leadership Centre

Master in Commerce: Leadership Studies

Researcher: Mfundo Verby (079 496 2882)

Supervisor: Dhanesh Rampersad (078 801 3411)

Subject: Request to Perform Research

I, Mfundo Verby, a Master's student at the University of KwaZulu-Natal hereby request approval to conduct quantitative research within your department or organisation. My research project is entitled "Critical Resource Loading for Small Projects within the petro-chemical industry". The aim of this study is to assess and evaluate the resource effort level required during the different phases of a project life cycle specifically for small projects. Your participation in this survey will enable me to further develop the quantitative graphs on the resource effort levels for deliverables required for the different project phases.

Participation in the research is voluntary. You may refuse to participate from the project at any time with no negative consequences. There will be no monetary gain from participating in this survey group.

The confidentiality and anonymity of the information and responses received will be maintained by me and the University of Kwa-Zulu Natal. You can contact me or my Supervisor should you have any questions or concerns about circulation of the questionnaire within your department or organisation for the purpose of my research. Completion of the questionnaire should not take more than 20 minutes. Kindly confirm approval.

Thank you for your time.

Mfundo Verby (Pr. Eng.)
Email: Mfundo.verby@sasol.com

APPENDIX 6: RESEARCH QUESTIONNAIRE

Research Questionnaire

Research Questionnaire: Critical Resource Loading for Small Projects within the Petro-Chemical Industry during Different Phases of the Project.

Compiled by: Mfundo Verby

Email: Mfundo.verby@sasol.com

Date: April 2014

Information:

This questionnaire is required for information gathering for a Master in Commerce dissertation.

Completing the questionnaire should not take more than 20 minutes.

The objective of the dissertation will be to define the minimum resources, deliverables and level of effort per resource requirements for a small-sized project.

Your participation is voluntary, confidentiality and anonymity will be maintained.

Please tick blocks that are relevant for one project you participated in, directly or indirectly.

1. Project Type

Technical	Nontechnical	other

2. Project Complexity

Low	Medium	High

3. Project Tax Bracket

Maintenance	Renewal	Capital

4. Project Budget

Below 50 Million Rands	Between 50.1 and 99 Million Rands	Between 100 and 199 Million Rands	Above 200 Million Rands

5. Project Schedule

Less than 12 months	Between 12 and 24 months	Between 25 and 36 months	More than 37 months

6. Schedule

Please update the table below to give an indication of the schedule per phase for the project

	Concept	Planning Project	Execution	Delivery
Time Taken per Phase (Months/days/years)				

7. Technology

core	Noncore	Other

8. Strategic Importance

Yes	No

9. Propriety Equipment Involved

Yes	No

- Technical Resource (Electrical/Mechanical/Instrument/Civil/Process/Control Engineering)

Single Discipline	Multidiscipline	If Multidiscipline State Disciplines Below:

10. Project Management Resources

Direct Report	No Direct Report	If Have Direct Reports State The Resource Below:

11. Sponsor Resources

Single Resource	Multiple Resources	If Multiple Resources state below:

12. Business Resources

Single Resource	Multiple Resources	If Multiple Resources state below:

13. Technical Resource

Please list the deliverables that were required from the technical resources for the different phases

13.1 Concept Phase

____

____

____

____

____

____

____

____

____

____

13.2 Planning (Detailed) Phase

13.3 Execution

13.4 Delivery Phase

14. Project Management Resource

Please list the deliverables that were required from the project management resources for the different phases

14.1 Concept Phase

14.2 Planning (Detailed) Phase

14.3 Execution

14.4 Delivery Phase

15. Sponsor Resource

Please list the deliverables that were required from the sponsor resources for the different phases

15.1 Concept Phase

15.2 Planning (Detailed) Phase

15.3 Execution

15.4 Delivery Phase

16. Business Resource

Please list the deliverables that were required from the business resources for the different phases

16.1 Concept Phase

16.2 Planning (Detailed) Phase

16.3 Execution

16.4 Delivery Phase

____

____

____

17. Resource Loading: Total Hours

Please list the number of hours that were required per resource type for the different phases. (Estimation within plus/minus 10% accuracy)

Project Phase	Technical	Project Management	Sponsor	Business
Concept (Idea generation and pre-feasibility)				
Planning (Feasibility and Basic Development)				
Execution (Detailed, Execution and start-up)				
Delivery (Evaluation and operation)				

18. Resource Loading: Percentage

Notes:

Please indicate in terms of percentage the resource allocation for the different resources at different phases, for example: For project definition phase: 30% Technical, 30% project management, 20% Sponsor and 20% Business in terms of the resource hours utilised at a particular project phase. Please ensure the sum per project phase is 100%

Project Phase	Technical	Project Management	Sponsor	Business
Concept (Idea generation and pre-feasibility)				
Planning (Feasibility and Basic Development)				
Execution (Detailed, Execution and start-up)				
Delivery (Evaluation and operation)				

19. Man-hour Raw Data Available

Yes: Please attach copy	No

20. Risks

List the risk that affected the project and discuss how you managed these risks to ensure completion within schedule, scope and cost. Either discuss what was sacrificed Schedule, scope and cost. (Please give overrun/under-run/over expenditure/under expenditure in percentage)

____
____
____
____
____
____

21. Project Success

Would you say the project was a success?

Yes	No

APPENDIX 7: GATEKEEPER APPROVAL

From: Grundling, Uys (UK)
Sent: Thursday, August 28, 2014 11:10 PM
To: Verby, Mfundo (M)
Subject: RE: Request to Perform Research

Good day Mfundo

You can continue with your questionnaire.

Regards

sasol
reaching new frontiers

1 Klasie Havenga, Sasolburg
PO Box 1183, Sasolburg, 1947
www.sasol.com

Uys Grundling
Project Director
Sasol Technology (Pty) Limited

Tel +27 16 960 6256
Fax +27 11 522 3733
Mobile +27 83 637 9841
E-mail uys.grundling@sasol.com

Environmental awareness starts with each of us – think before you print this page

From: Vosloo, Rooies (P)
Sent: Thursday, August 28, 2014 10:37 AM
To: Verby, Mfundo (M)
Subject: RE: Request to Perform Research

You may proceed. Well done with the achievement so far.

Regards
Rooies

sasol
reaching new frontiers

13 Commercial Road
(Kenbert Buildings) Wadeville, 1401
PO Box 123961, Alrode 1451
www.sasol.com

Rooies Vosloo
Manager Engineering Services
Sasol S A Energy

Tel +27 11 865 7818
Fax +27 11 522 2000
Mobile +27 82 554 3503
E-mail pierre.vosloo@sasol.com

Environmental awareness starts with each of us – think before you print this page

From: Odell, Greg (G)
Sent: Thursday, August 28, 2014 9:16 AM
To: Verby, Mfundo (M)
Subject: RE: Request to Perform Research

Hi Mfundo,

Yes you can continue.

Regards,

sasol
reaching new frontiers

PdP Kruger Street, Secunda, 2302
Private Bag X1000,Secunda, 2302
www.sasol.com

Greg Odell
Technical Divisional Manager Mechanical Design and Governance
Sasol Synfuels

Tel +27 17 610 5163
Fax +27 11 522 5842
Mobile +27 84 602 2343
E-mail greg.odell@sasol.com

Environmental awareness starts with each of us – think before you print this page

From: du Toit, Sarel (PJS)
Sent: Thursday, August 28, 2014 7:04 AM
To: Verby, Mfundo (M)
Subject: RE: Request to Perform Research

Mfundo,

You can continue to discuss within my team – please note that no confidential information to be made available at any point.

PS. I assume the engineering team are part of the critical resource assessment.

Regards

sasol
reaching new frontiers

PdP Kruger Street, Secunda, 2302
Private Bag X1000,Secunda,2302
www.sasol.com

Sarel du Toit
Projects
Sasol Synfuels
Tel +27 17 610 3583
Fax +27 11 522 6899
Mobile +27 82 773 2909
E-mail sarel.dutoit1@sasol.com

Environmental awareness starts with each of us – think before you print this page

APPENDIX 8: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

28 October 2014

Mr Mfundo Verby 205527193
Graduate School of Business and Leadership
Westville Campus

Dear Mr Verby

Protocol reference number: HSS/1387/014M
Project title: Critical resource loading for small projects within the Petro-Chemical Industry

Full Approval – Expedited Application

In response to your application received 21 October 2014, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Mr Dhanesh Rampersad
Cc Academic Leader Research: Dr E Munapo
Cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood | Howard College | Medical School | Pietermaritzburg | Westville

APPENDIX 9: DATA FROM PARTICIPANT OBSERVATIONS

Venturi Absorber Rebuild Project				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	20%	25%	40%	15%
Planning	30%	40%	20%	10%
Execution	45%	25%	20%	10%
Closure	35%	15%	40%	10%
Replacement of the Coke Cutting Tool Project				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	17%	46%	15%	22%
Planning	15%	65%	5%	15%
Execution	55%	35%	5%	5%
Closure	45%	25%	25%	5%
Construction of a 2.2 Million Litre Tank for Water Treatment Plant Project				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	15%	50%	10%	25%
Planning	25%	35%	15%	25%
Execution	60%	15%	20%	5%
Closure	45%	15%	30%	10%

Sectional Replacement of the Sulphen Storage Tanks Project				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	20%	35%	25%	20%
Planning	35%	35%	10%	20%
Execution	45%	20%	25%	10%
Closure	30%	20%	40%	10%
Boiler Rebuild Project				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	20%	25%	40%	15%
Planning	25%	24%	36%	15%
Execution	55%	15%	10%	20%
Closure	45%	25%	20%	10%

Average Measures from All Projects				
Project Phase	**Resources**			
	Project Management	**Technical**	**Business**	**Sponsor**
Initiation	18%	36%	26%	19%
Planning	26%	40%	17%	17%
Execution	52%	22%	16%	10%
Closure	40%	20%	31%	9%

APPENDIX 10: DATA FROM RESEARCH QUESTIONNAIRES

Description	Project Type
Technical	47
Nontechnical	6

Description	Project Complexity
Low	12
Medium	36
High	5

Description	Project Budget
Below R50 Million	27
R50.1 to R99 Million	15
R100 to R199 Million	9
Above R200 Million	2

Description	Project Schedule
Less than 12 Months	3
12 to 24 Months	0
25 to 36 Months	37
More than 37 Months	13

Average Resource Hours Results

Project Phases	Technical	Project Management	Sponsor	Business
Concept	66.85	24.77	4.69	3.68
Planning	47.46	38.35	8.86	5.33
Execution	42.65	41.07	6.22	10.06
Delivery	37.49	31.59	14.08	16.83

Average Resources Percentages Results

Project Phases	Technical	Project Management	Sponsor	Business
Concept	69.89	17.67	7.33	5.11
Planning	49.78	37.89	6.67	5.67
Execution	28.78	41.26	15.00	14.97
Delivery	37.44	33.00	9.89	19.67

Project Management					
Project Phase	**Participant Observation**	**Research Questionnaire (Resource Percentages)**	**Research Questionnaire (Resource Hours)**	**Average**	**Adjusted**
Concept	18%	18%	24%	20%	20%
Planning	26%	38%	38%	34%	35%
Execution	52%	42%	41%	45%	45%
Delivery	40%	33%	31%	35%	35%

Technical					
Project Phase	**Participant Observation**	**Research Questionnaire (Resource Percentages)**	**Research Questionnaire (Resource Hours)**	**Average**	**Adjusted**
Concept	36%	70%	66.32%	57%	50%
Planning	40%	50%	47.21%	46%	45%
Execution	22%	29%	42.45%	31%	30%
Delivery	20%	37%	37.09%	32%	30%

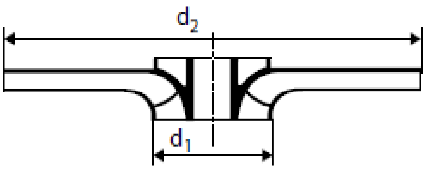
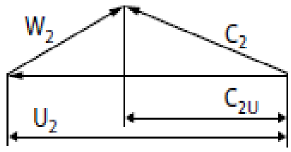
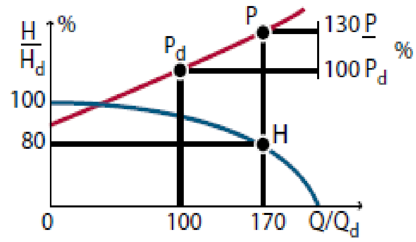
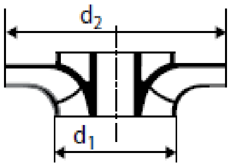
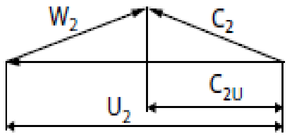
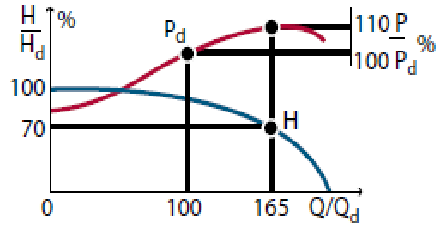
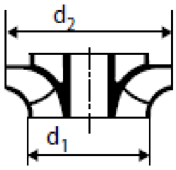
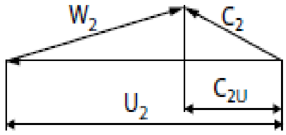
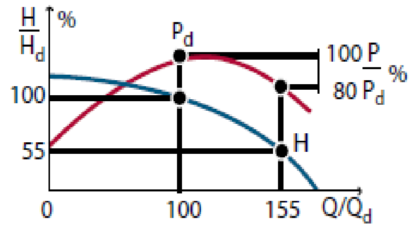
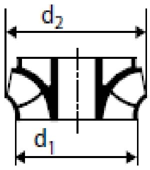
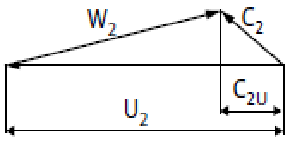
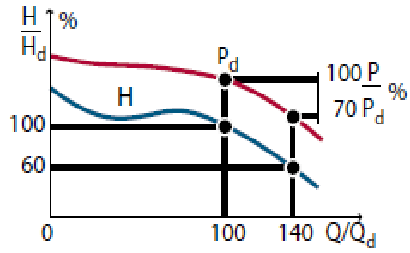
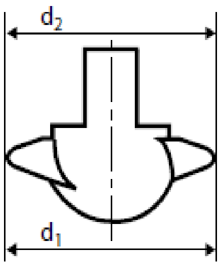
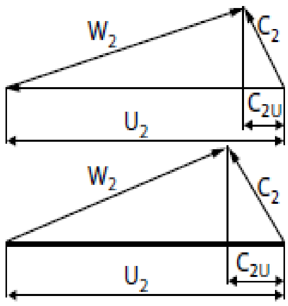
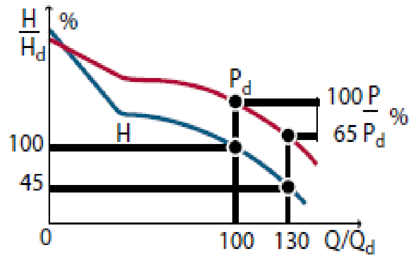
Business					
Project Phase	**Participant Observation**	**Research Questionnaire (Resource Percentages)**	**Research Questionnaire (Resource Hours)**	**Average**	**Adjusted**
Concept	26%	5%	3%	12%	10%
Planning	17%	6%	6%	9%	10%
Execution	16%	15%	11%	14%	15%
Delivery	31%	20%	16%	22%	20%

Sponsor					
Project Phase	**Participant Observation**	**Research Questionnaire (Resource Percentages)**	**Research Questionnaire (Resource Hours)**	**Average**	**Adjusted**
Concept	19%	7%	5%	11%	10%
Planning	17%	7%	9%	11%	10%
Execution	10%	15%	7%	11%	10%
Delivery	9%	10%	14%	11%	10%

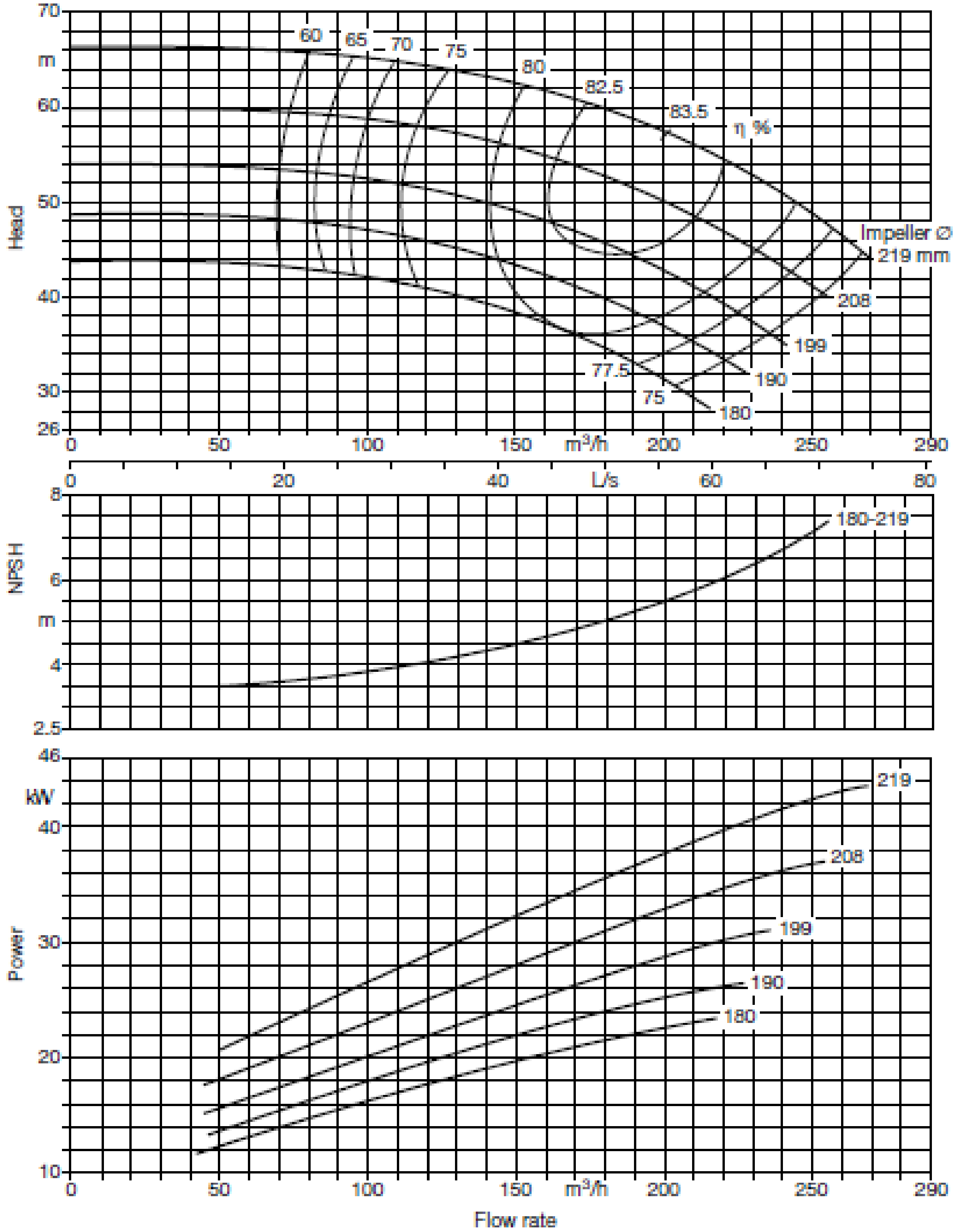
Summary of Overall Results

Project Phase	Technical	Project Management	Sponsor	Business
Concept	50%	20%	15%	15%
Planning	45%	35%	10%	10%
Execution	30%	45%	10%	15%
Delivery	30%	35%	10%	25%

APPENDIX 11: PUMP IMPELLER SELECTION MODEL

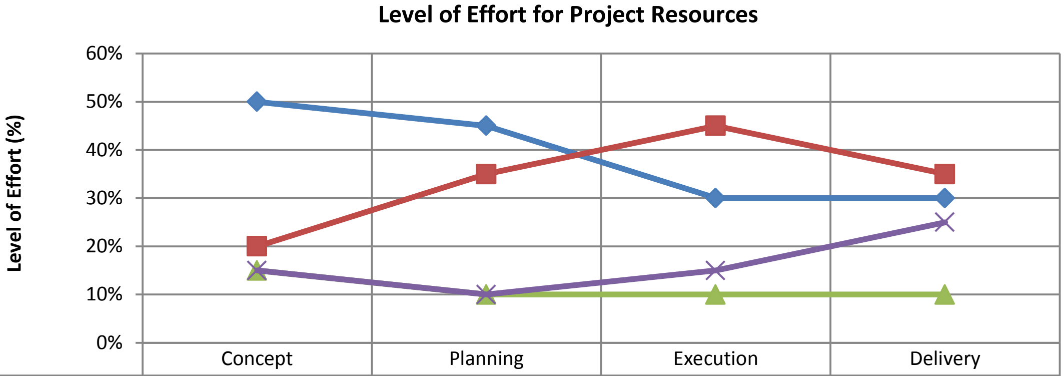
Impeller shape	n_q	Outlet velocity triangle	Performance curves
 $d_2/d_1 = 3.5 - 2.0$	15		
 $d_2/d_1 = 2.0 - 1.5$	30		
 $d_2/d_1 = 1.5 - 1.3$	50		
 $d_2/d_1 = 1.2 - 1.1$	90		
 $d_1 = d_2$	110		

Adapted from: Grundfos Research Technology, c.2014, p. 75



Adapted from: KSB, 2005, p. 28

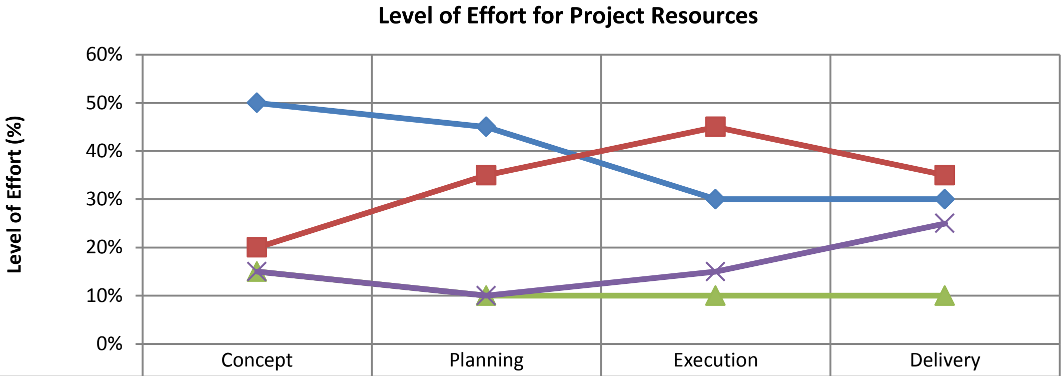
APPENDIX 12: LEVEL OF EFFORT MODEL: SMALL PROJECTS



	Concept	Planning	Execution	Delivery
Technical	50%	45%	30%	30%
Project Management	20%	35%	45%	35%
Sponsor	15%	10%	10%	10%
Business	15%	10%	15%	25%

Technical Resource Deliverables	- Feasibility Study - Concept Design - Technical Justification Report - Scope of work - Tender evaluation - Review of previous failures and maintenance strategies. - Registration of the required modification. - Preliminary schedule for technical scope. - Obtain existing system technical information. - Technology selection for the project.	-Update schedule for technical scope. - Basic Design - Managing the completion of technical activities. - Ensure procurement and fabrication of long lead items. - Completing engineering studies.	- Detailed Design - Developing scope of work for tendering purposes. - Tender evaluations. - Support in ensuring quality control measures. - Inspections and sign-off on work completed - Interface management of different engineering disciplines. - Pre-commissioning report.	- Review of end-of-job documentation. - Updating of internal documents. - Close out of change management process. - Ensuring operation of the equipment or system is as per original requirements.

Sponsor Resources Deliverables	- Evaluate the need for the project. - Develop and maintain organisational project budgets. - Ensure project governance. - Provide funding for concept phase of the project. - Appoint a project manager.	- Providing alignment and support between the project team and the business. - Support and address project risks. - Provide funding for the project. - Ensure project governance. - Review the project schedule and scope of work.	- Ensure project governance. - Provide funding for execution phase of the project. - Hold the project manager accountable for project triangle measures.	- Review final project reports. - Ensure governance. - Ensure all business documentation has been updated. - Approval to commission the system/project.



	Concept	Planning	Execution	Delivery
Technical	50%	45%	30%	30%
Project Management	20%	35%	45%	35%
Sponsor	15%	10%	10%	10%
Business	15%	10%	15%	25%

Business Resources Deliverables	- Develop the business case. - Evaluate the concept design and the technology selection. - Inform the rest of the business on the project progress.	- Provide input to the design based on operational requirements. - Participate in engineering studies such as HAZOP and RAM studies.	- Develop operating procedures. - Participate in design reviews based on operational experience.	- Commission and operate the new product or system. - Assessing the impact of the project on business.
Project Management Deliverables	- Develop level 1 project schedule. - Develop a Potential Deviation Analysis. - Develop a resource plan. - Ensure all the governance documentation is completed as per schedule. - Manage interfaces between different disciplines.	- Develop level 3 project schedule. - Define project team - Develop project critical factors. - Ensure the project is accommodated in the outage/shut-down plan. - Arrange the project communication and meeting guidelines. - Apply for project execution phase funds. - Approval of contracts for the project.	- Update project schedule (Level 4 Schedule) - Appoint service providers and contractors for the execution scope. - Management and reporting on project triangle. - Ensuring all required resources and equipment is available for the project. - Approval of milestone payments - Site inspections and sign-off on work completed.	- Final reports for the project. - Project close out - Gather information from project resources to provide feedback. - Manage the project triangle.

APPENDIX 13: TURN-IT IN SIMILARITY REPORT

Turnitin Originality Report

Critical Resource Effort Level for Small Projects within the Petro-Chemical Industry by Mfundo Verby

From Initial Draft (Research Dissertation 2015)

- Processed on 27-May-2015 8:54 AM CAT
- ID: 545643315
- Word Count: 23390

Similarity Index

1%

Similarity by Source

Internet Sources:

1%

Publications:

0%

Student Papers:

0%

sources:

1

1% match ()

http://www.jessehwest.homesandland.com/Magazine/ListingCriteria.cfm?MagId=0419

source text:

Homes & Land of St. Augustine - Listing Search H&L National Page | Search Other Areas | Magazine Home Homes & Land of St. Augustine Here: Homes & Land National Site > Homes & Land of St. Augustine > Home On the Cover of Homes & Land of St. Augustine Volume 26, Issue 11 Pick up your copy today! Oh... how Beautiful is the St. Johns River basin! Check out are new supplement, Homes & Land of the St. Johns River Basin. It covers all of Northeat Florida's "Best Kept Secret", Putnam County, including Palatka, Welaka, Crescent City, Pomona Park, Interlachen & more, each month in Homes & Land of St. Augustine. To see our Putnam county advertisers and their listings, click the link at the right! Start browsing... Leaf through the latest issue page by page, by clicking here. Jump to a specific page... You can jump to any page in the current issue by selecting the page from the menu below.

 Search All Homes for Sale Find your next dream home by searching listings from the best real estate professionals in your community. City and State: Any within area Beverly Beach, FLBunnell, FLCrescent Beach, FLEast Palatka, FLElkton, FLFlagler Beach, FLGeorgetown, FLGreen Cove Springs, FLHastings, FLInterlachen, FLJacksonville, FLOrmond Beach, FLPalatka, FLPalm Coast, FLPicolota, FLPomona Park, FLPonte Vedra, FLSaint Augustine Area, FLSan Mateo, FLSatsuma, FLSt Augustine Area, FLSt Augustine Beach, FLVilano Beach, FLWelaka, FL Price range: No Minimum $10,000$20,000$30,000$40,000$50,000$60,000$70,000$80,000$90,000$100,000$110,000$120,000$130,000$140,000$150,000$160,000$170,000$180,000$190,000$200,000$210,000$220,000$230,000$240,000$250,000$260,000$270,000$280,000$290,000$300,000$350,000$400,000$450,000$500,000$550,000$600,000$650,000$700,000$750,000$800,000$850,000$900,000$950,000$1,000,000$1,250,000$1,500,000$1,750,000$2,000,000$2,250,000$2,500,000$2,750,000$3,000,000$3,250,000$3,500,000$3,750,000$4,000,000$4,250,000$4,500,000$4,750,000$5,000,000 to No Maximum $10,000$20,000$30,000$40,000$50,000$60,000$70,000$80,000$90,000$100,000$110,000$120,000$130,000$140,000$150,000$160,000$170,000$180,000$190,000$200,000$210,000$220,000$230,000$240,000$250,000$260,000$270,000$280,000$290,000$300,000$350,000$400,000$450,000$500,000$550,000$600,000$650,000$700,000$750,000$800,000$850,000$900,000$950,000$1,000,000$1,250,000$1,500,000$1,750,000$2,000,000$2,250,000$2,500,000$2,750,000$3,000,000$3,250,000$3,500,000$3,750,000$4,000,000$4,250,000$4,500,000$4,750,000$5,000,000 Bedrooms: Any 1 or more 2 or more 3 or more 4 or more 5 or more Bathrooms: Any 1 or more 1.5 or more 2 or more 2.5 or more 3 or more 3.5 or more Property Type: Residential Properties New Homes Rentals Resort Rentals Commercial Properties Resort Homes Townhomes and Condos Ranch Properties Lots & Acreage Farm Properties Waterfront Properties Golf Course Properties Welcome to Homes & Land of St. Augustine Serving St. Johns County Top 5 Cities: St Augustine Area, FL Palm Coast, FL Palatka, FL Flagler Beach, FL Satsuma, FL Advertise with Us! Homes & Land delivers results! To learn more about advertising in this magazine, click here. St. John's River Basin Palatka,Welaka & more!! Our Community Advertiser Index Find an Agent School Info Commercial Real Estate City of St. Augustine Brave Kids Articles & Tips Whatever your Real Estate needs or interest, we have information that can help! View Articles For Advertisers Current advertisers login here. To learn more about advertising in this magazine, click here. About This Magazine About the Assoc. Pub. Contact the Assoc. Pub. Get a Free Magazine | Franchise Opportunities | About Homes & Land | Contact Homes & Land Copyright C2005 Homes & Land Affiliates, LLC. All Rights Reserved. Terms and Conditions | Privacy Policy Equal Housing Opportunity

paper text:

CHAPTER 1: INTRODUCTION 1.1 Introduction This research thesis was written as part of the requirements for the degree of master in commerce. The research focused on project management specifically for small projects, the different project life cycle phases, the deliverables per phase, the resources allocated to the project and the level of effort required for successful project completion. Many organizations execute numerous projects at any point in time; these can range from human resource changes, administrative changes, development of new products, extension of organizations and so forth. Projects can have tangible results or intangible results, however what is critical as will be seen in the research later is a project needs to have a definite start and finish. The measures that define projects which are utilized by many organizations that execute projects are namely, cost, schedule and quality. These measures are generally utilized to also define the success or failure of a particular project. The span of the research was primarily on small projects within the petro-chemical industry. The focus being on a qualitative analysis to understand the adopted project life cycle model, the type of resources utilized in projects, the required deliverables during the project life cycle and the level of effort required from the resources. In obtaining this insight from numerous project engineers and project managers within Sasol Technology, Sasol Synfuels, Sasol South Africa Energy and consulting engineering companies that execute projects within the petro-chemical industry, the research project aimed to define a qualitative model that would define a project life cycle model, the deliverables per phase, the resources and lastly the level of effort required per resource at the different project phases. 1.2 Background A large number of organisations undertaking large to small scale projects on an annual basis utilise the best skill resources in the organisation for evaluation, execution and approval of projects. Different project management models or guidelines are being utilised by numerous organisations as tools towards justifying the necessary funds for planned and unplanned projects. Sasol as an organisation utilizes three models for justifying, evaluating, approving and managing projects namely, Business Development and Implementation Model (BD&I); the Joint Venture Model (JV) and lastly the Research and Development model (R&D) with the primary focus being on governance, managing risk and ensuring that there is alignment within the organisation. These models ensure alignment and focus by indicating what work should typically be completed at various stages of the project by having “gates” to check that development is proceeding in a co-ordinated fashion within all resources and stakeholder groups in the organisation. A recent benchmarking evaluation of small projects executed within Sasol highlighted several areas as being key to successful project implementation. These key areas were defined as follows: ? Good front end loading. ? Better project controls, such as estimating, cost control, scheduling and change management. ? More extensive team integration to help with alignment and to optimise the project design earlier in the development phase. ? More use of value improving practices. 1.2.1 Business Development and Implementation Model The BD&I model given in Figure 1, is primarily utilised for most projects in Sasol and defines the project life cycle into eight (8) phases instead of the four phases commonly adopted by project managers. This model has been utilised by Sasol for numerous project due to the strict governance requirements the model requires from the different project tracks, commonly referred to as resources in order to move from one phase to another. Figure 1: Business Development & Implementation Model Source: Sasol Limited, 2012 1.2.2 Joint Venture Model The Joint Venture Model seen in Figure 2 is utilised in projects that Sasol is executing together with other stakeholders and only has seven (7) phases instead of the eight (8) seen in the BD&I model. The evaluation and operation phases are combined to allow for a faster hand over processes. Figure 2: Joint Venture Model Source: Sasol Limited, 2012 1.2.3 Research and Development Model The Research and Development Model is used for projects that are specifically implemented for new research or technology at a smaller scale. This model is more simplistic with only four phases as seen in Figure 3. The Sasol project management models will not form part of the focus for the dissertation however they have been illustrated for background purposes as they are heavily utilised within the Sasol environment on numerous projects. Figure 3: Research and Development Model Source: Sasol Limited, 2012 1.3 Motivation for the Study The main motivation for the project was to develop a tool or model that young or developing engineers, project engineers and project managers can utilize for executing small projects. The aim was to develop a model that is very simplistic in its nature and qualitative in that it can be used for guidance rather than as a procedure. The model would then aid the project manager in developing multiple resource plans for a number of small projects for a number of resources based on the effort required per resource at a particular phase of the project. In defining the resources and effort level required per resource for projects that are not very strongly governed, the young project manager will be able to see potential concerns in terms of resource effort level and therefore the potential impact on the successful completion of the projects on schedule, cost and as per the specified quality. Furthermore the research was also motivated by the need to understand the perception by the participants regarding the perceived required level of effort at the different phases of the project from the different project resources. Clearly a serious misalignment in this regard can potentially impact the successful completion of a project. 1.4 Focus of the Study The focus of the study was to understand the different project life cycle models used for small projects in the petro-chemical industry, the resources required, the deliverables required and link accordingly to the level of effort required for the different resources. The research undertook the analysis by means of literature review, participant observation and research questionnaires that were circulated to project engineers and project managers. The research was required as resources allocated to small projects are generally shared amongst a group of small projects and unrelated day to day activities executed by the associated resources. 1.5 Research Methodology The two key concepts that were fundamental in this thesis were firstly developing a clear hypothesis that would later be developed into a theory and secondly present the qualitative feedback from the research questionnaires. The theory would encompass numerous hypotheses regarding resource loading and level of effort for small projects at different phases of the project life cycle. In order to narrow the research topic to add more value to a specific environment or industry the research topic was amended to only be specific to small projects within the petro- chemical industry. The analysis would be qualitative in its nature and the theoretical graphs that would be developed to define the hypothesis would be tested during the data collection, data analysis and literature review phases of the research project. The research process utilised in the qualitative research was deductive, empirical cycle in the scientific expansion of knowledge indicated in Figure 4. Designing a research strategy Formulate research hypothesis Collecting data Analysis and interpretation Figure 4: Cycle for Expansion of Knowledge Adapted from: Welman and Kruger, 1999, pp.11 The approach to focus on a qualitative research study was based on the need to develop a qualitative model which would give an indication of the adopted methods and principles in industry. A qualitative model was also more practical as a quantitative model would need to be specific to numerous factors for a particular project. The value in a quantitative model was not seem as there are numerous computer models that project planners can utilize to develop resource plans for projects, which are typically utilized on larger projects that have development funds allocated from an early stage. 1.6 Problem Statement The key problem with small projects is mainly the volume of these projects within any particular organization. Due to the administrative requirements associated with projects. Organizations have adopted an approach of defining projects according to size, complexity and budget (cost and potential benefits associated). Once projects are categorized according to the scale utilized by the organization, which varies from one organization to another as will be seen later in the research, small projects are merely left to the appointed project manager to plan, execute and close out with very little governance requirements. This of course has the potential to allow for a very dynamic, flexible system where projects flourish and organizations continue to grow from the numerous products, innovations etc. that are the result of these projects. However this does also have the potential of creating an environment that is filled with re-occurring project failures, revenue losses and missed opportunities. Sasol Synfuels in Secunda budgets annually an estimated five hundred million rands (R500 million) for small projects which are generally grouped according to the following criteria: ? Renewal Projects, replacement in kind due to technical reasons such as equipment reaching end of life. ? Project end of job estimate is below twenty million rands (R20 million). ? Project is repetitive in its nature. ? The technical resources required for the replacement are mainly single discipline, i.e. Mechanical or Electrical Engineering. ? Project is to be installed and commissioned within twenty four (24) to thirty six (36) months from time of initiation. ? Project will not necessarily generate significant additional revenue stream; merely restore integrity to continue operations. These types of projects are seen in the organization as simple repetitive type projects which are generally executed by project engineers, plant technicians and young project managers, commonly referred to as tier 5 projects. The tiering system starts with tier 1 projects which are Greenfields projects, tier 2 being Brownfields, tier 3 being highly complex and multi- discipline, tier 4 being slightly complex multi-discipline projects and lastly tier 5. The success rate of these small projects in Sasol has been extremely low and has cost the organization over the years due to the following reasons: ? Equipment delivered late for the installation window. The installation window is based on the refinery shut-down plan, which generally means an opportunity to replace a piece of equipment comes once every four years. Equipment not installed generally means more extensive expensive maintenance on an old unit which has reached end of life. ? Equipment that requires expediting the fabrication schedule to allow for installation during the installation window which comes at escalated costs. ? Roll-over of approved funds due to projects not being on schedule which affects the entire renewal budget planning which is generally planned ten (10) years in advance. ? Competence in managing projects, contracts, fabrication queries, risk etc. which leads to delays, compensation events and equipment that is scrapped due to process, technical or legal concerns. The potential future impact due to the above mentioned on the organization's profit margin is a major threat as the Sasol refinery is over 30 years old and a large volume of the equipment on site is due for replacement as it has reached its end of life. The organization's strategy is to continue operations up to the year 2050, this clearly means successful completion of simple like for like tier 5 projects within the Secunda refinery is critical for sustainable production and profitability into the future. The Sasol Synfuels refinery is also seen within the organization as the cash-cow of the organization and a large number of future tier 1, 2 and 3 projects depend on the profitability of Synfuels. The successful execution of small projects to restore the asset base of the refinery to ensure sustainable operation up to the year 2050 can potentially affect the Sasol group strategy towards the funding of major projects. 1.7 Research Questions The research focused on answering three main questions namely: ? What percentage of effort is required for the critical resources identified in projects for the activities required at the different phases of the project life cycle? ? Is there an alignment or congruency between the current literature and research data regarding the resources and percentage of effort required at different phases of a project? ? What graphical representation can be utilised to illustrate the resources and level of effort required for the activities required at different phases of the project? Note: This research does not consider physical resources required for the construction of any equipment, product or structure required for the project. 1.8 Research Objectives The objectives for the dissertation were summarised as follows: ? Develop a hypothesis for the critical resources for a small project from starting to closure phase specifically on the level of effort required per phase. Develop these hypotheses into a theory. ? Review the hypothesis and theory developed by utilising theoretical data or literature to prove the relevance or accuracy of the hypothesis and theory. ? Develop qualitative mathematical graphs in terms of percentage of effort (Level of Effort) recommended for the key resources at different phases of the project life cycle based on the deliverables per resource and as per the project team. 1.9 Limitations of the Study The population group that was analyzed for the research is people that are either Sasol employees or consultants that have executed projects for Sasol; the research therefore has the potential of giving feedback that is only specific to the Sasol environment. Irrespective the respondents do not only have Sasol specific experience, most of the respondents have executed projects outside the Sasol environment. The literature review feedback included in the research was also not only specific to the Sasol environment. The following limitations are applicable to this research: ? The research only applies to small projects within the petro-chemical industry. ? Respondents were project engineers and project managers. ? The research is only defined from a qualitative perspective. 1.10 Contribution of the Study This research project has contributed a set of qualitative mathematical graphs or models for small sized projects within the Petro-Chemical Industry in South Africa, which will assist in defining, planning, allocation and utilization of a dynamic project team, which will increase or decrease in size for different phases of the project life cycle. Such a tool for project managers will allow organisations, engineering and project management firms the opportunity to effectively utilise the resource pool available to the company on various projects, and it will serve as an optimisation tool for skills required at different phases of the project life cycle. 1.11 Summary The definition of the project life cycle, the project phases, the deliverables required per phase, the resources and level of effort required from project start to completion is critical in projects. These concepts are well understand by experienced project managers and are governed and managed well for large and medium size projects in many organizations. The concept of completing a project on budget, schedule and as per the specified quality is not a new one and is well understood in industry, however for small projects in many organizations including Sasol it remains a serious concern, as it eludes many project managers in industry. Thus the motivation for this thesis was to develop a tool for project engineers, engineers, young project managers and plant technicians that are tasked to execute small projects year after year. The focus of the research was to define a qualitative model that can be utilized for small projects within the petro-chemical industry in South Africa after a qualitative research process that also entailed a very extensive literature review. The limitation of the study being that it was mainly on Sasol projects. The final contribution to the knowledge base and industry being a set of qualitative graphs that will define the level of effort required for the resources required throughout the project life cycle for small projects. CHAPTER 2: LITERATURE REVIEW 2.1 Introduction The academic literature reviewed or utilised for this dissertation included electronic books, journals, websites and books which gave detail on the following: ? Definition of the different types of project life cycles and the associated phases of the project life cycle. ? Project management knowledge used to define, align, and specify deliverables for the different phases of the project management cycle. ? Resource allocation for small projects within the petro-chemical industry. ? Level of effort in project management. ? Management of projects within organisations. ? Defining qualitative mathematical graphs or models for qualitative resource loading. The literature reviewed was specific to ensure the following: ? It was organized and related around the research questions. ? Summarised the outputs around what is known and what is not known. ? Discussed controversial areas or areas of misalignment on the research topic. In ensuring a structured and wide literature review process the following gives an indication of the extent of literature review that was conducted for the purpose of this research project: ? Books (including electronic books): 30 ? Journals: 65 ? Websites: 22 2.2 Project Definition It was critical to define what constitutes a project versus normal maintenance or production activities. This section of the dissertation gives guidelines and definitions both from literature and industry on projects. The basic definition of the word project comes from Latin language where "pro" means forward and "jacere" means throw. In simple terms it refers to an event that requires forward planning. A paper from the University of Aalborg (Munk-Madsen, c.2005, pp.6-7) gives two definitions of a project namely: Definition 1: A project is an organizational unit that solves a unique and complex task. Definition 2: A project is an organisational unit where the prime coordinating mechanism is mutual adjustment. The project management guide (Project Management Institute, 2000, pp.4) gives an interesting definition, 'a project is a temporary endeavour undertaken to create a unique product or service'. The literature definition of a project that was utilised in the research is given below as defined by the British Standards Institute (2002, pp.2): A unique set of co-ordinated activities, with definite starting and finishing points, undertaken by an individual or organisation to meet specific objectives within defined schedule, cost and performance parameters. The literature that was utilised for research clearly indicates a project to be an activity or list of activities driven by change, proactive change rather than ongoing operation or number of activities that have as little disruptions as possible. It was also clearly noted from the literature that projects are initiated to generate additional revenue for the organisation or improve operational efficiencies while maintenance or production activities sustain current or marginally improve the current revenue stream. It was thus critical to understand and elaborate further on how a project differs from regular maintenance or production activities, for example replacement of pumps or vessels as per a maintenance strategy which is defined in most refineries as a shut-down or annual outage. A shut-down will have a definite schedule, budget and performance parameters and multiple activities; however this is seen in industry as regular maintenance rather than a project and follows less stringent governance in terms of approvals and execution than any typical project. This dissertation defines a small project on the following key parameters that were used to test data received from industry or literature before it was utilised with the hypothesis that will be introduced later in the research methodology chapter: ? A clearly defined project diamond (Schedule, Cost and Quality Performance or Scope). ? Total end of job cost (budget) of not more than one hundred million rands (R100 Million). ? A business case motivated by financial, legal, safety or environmental improvements. ? A project schedule from concept to hand-over phase equal to or less than thirty six (36) months. ? Compliance or clearly defined organisational governance and approvals from one phase to another. It is however imperative to accept that certain organization will define projects in a manner that could contradict the definitions discussed in this section. Irrespective the research definition does cover the majority of key stakeholder definitions of what is termed as a project. 2.3 Project Typology Organizations and scholars have adopted and utilized the word project very loosely when referring to work executed within a structured manner. However as discussed earlier a project can be clearly defined and key parameters should be ticked off when referring to a certain set of activities as a project. However this section of the thesis will give insight on the different types of projects executed within organizations. Furthermore the size of the project will also be discussed as this does have an impact on the governance, interest and management associated with the particular project. Previously the classification of projects was based on the size of the change associated with the project, minor changes being referred to as alpha projects and major changes being called beta projects (Blake, 1978). A more recent study however classified projects according to the degree to which the project would change the organization's product portfolio (Wheelwright and Clark, 1992). Further studies have gone into more detail and have given insight towards defining the project typology according to four levels of technological uncertainty at initial stages and three levels of system scope (Shenhar et al., 1995). This approach is shown in Figure 5, where technology is defined from classic to super high and project management scope, which entails organizing, controlling resource, managing communication between resources etc., is categorized from single unit to a set of projects within a project or program. Figure 5: Project Typology (Technology and Scope Variables) Adapted from: Slusarczyk and Kuchta, 2011, pp.144 Page 16 This train of though was further developed by classifying the nature of technology from high to low, the innovation from incremental to radical, and the market from new to existing (Balachandra and Friar, 1997). More recent literature however introduced a new project classification tool, termed project diamond-shape NTCP based on four dimensions, given below and illustrated on Figure 6 (Slusarczyk and Kuchta, 2011, pp 145-147): ? Novelty ? Technology ? Complexity ? Pace Figure 6: NTCP Diamond Model Adapted from: Slusarczyk and Kuchta, 2011, pp.147 2.4 Definition of Complexity in Projects The definition of complexity within the project management knowledge environment and according to other literature will be evaluated in this section. Numerous organizations utilize operational parameters such as budget and size to give an indication of the project complexity. Other organizations that see complexity as key in that it can influence project governance and success utilize a set of key factors updated into a complexity measurement tool to define complexity of different projects. While management teams in many organizations strive to define complexity in organizations and projects, research relating to Complex Adaptive Systems (CAS) shows complexity to be very dynamic and difficult to control or measure. Complexity is always prevalent because all systems are complex as there are numerous stakeholders, agents, systems that interface, connect, communicate and influence each other within an extremely dynamic environment or environments in order to survive, grow, innovate and sustain themselves (Chan, 2001). In defining complexity, it is critical to understand not only do we need to define the parameters that influence complexity but also need to understand the level of severity on the complexity which makes it difficult to predict certain factors such as outcomes and controls required. The accepted definition of project complexity for the research is given as consisting of many varied interrelated parts, namely differentiation and interdependency. Differentiation looks at the number of varied elements while interdependency considers the degree of interrelatedness between elements. Within projects, complexity is defined by two dimensions namely structural uncertainty and uncertainty (International Journal of Project Management, 1999, pp.269). These concepts are simply defined as follows and shown in Figure 7: ? Structural complexity: refers to the project or product complexity, thus the complexity associated with the project or product design, sub-systems, components, connections, interactions, construction, manufacture, installation and commissioning. ? Uncertainty: refers to how well or not the goals and methods are defined for a particular project. Figure 7: Project Complexity Factors Source: International Journal of Project Management, 1999, pp.271 Research obtained from the International Research Network of Project Management Conference (2009) indicates that project managers identify the following aspects as directly contributing to the complexity of a project: ? Goals ? Stakeholders ? Interfaces ? Dependencies ? Technology ? Management process ? Work practices ? Time The impact of complexity on the research questions and objectives was evident from literature reviewed and had to be defined explicitly in order to ensure the qualitative feedback and analysis could be restricted to projects that have a similar or equal complexity measure or perceived complexity. Figure 8: Degree of Complexity for Simple, Complicated and Complex Projects Source: International Project Management Association, 2013, pp.17 The relationship between complexity and level of effort is shown very well in Figure 8, the effort required from management, engineering and other disciplines will increase as the complexity of a project increases. The figure shows a qualitative relationship as it does not indicate the magnitude in complexity or management effort level. However understanding the relationship is critical and has been considered in the hypothesis of this research thesis. Small projects can also be as important as large projects to an organisation in that they can have a significant impact to the plant or organisation’s profitability should they not be executed successfully. Specifically because many small projects take place in operating plants. What compounds the importance of small projects further is organisations can execute numerous small projects compared to the limited number of large projects executed or approved in a particular period. 2.5 Project Management In defining the different aspects that are critical in projects, it is also imperative to understand what the term project management means and what are the associated responsibilities or roles associated with project management. This section of the thesis will give insight on how this concept has been summarized in literature. Project management is not a simple concept where an individual’s or groups of individuals’ activities constitute management of a project and later the success of a particular project. Project management needs to be seen in a very holistic manner. Project management success factors are directly influenced by the following (Crooke-Davis, 2002, pp.186): ? Adequacy of organizational knowledge on risk management in projects. ? Maturity of the organization in assigning ownership to risks. ? The organization’s ability to maintaining up to date and visible risk registers. ? Accuracy and commitment to maintaining documentation with organizational responsibilities on projects. ? Ensuring project phase durations is no longer than 3 years. ? Ensuring scope changes are governed through a controlled process. ? Maintaining the integrity of performance measurement baseline. ? Existence of mutual co-operation between project management and line management. ? Portfolio and program management practices that allow the organization to resource fully projects that thoughtfully and dynamically matched to the organizational strategy and objectives. ? A suite of project and portfolio metrics that provide line of sight feedback on current and future project key performance indicators, a balanced score card for projects and corporate success. Figure 9: Importance of project and operations management alignment Source: Crooke-Davies, 2002, pp.187 Figure 9 above give a pictorial indication of the relationship between project management, operations management and the corporate strategy, thus the success of the project will directly impact operations and the long term strategy and organizational sustainability. The qualities of the project management team or project manager are not discussed but are intended as the quality of human interactions in projects are critical and in essence it is the people that count, the people that develop the systems discussed and the people that make things happen. 2.6 Project Phases In order to manage projects more effectively and to ensure better control, organisations in industry tend to divide projects into different phases. These phases are defined as a project life cycle when considered collectively. The phases are however defined or marked based on the deliverables. These deliverables are tangible, verifiable work such as feasibility package, detailed package or a final product. The end of a phase is marked by hand-over and review of the required deliverables for that particular phase. PMBOK (Project Management Institute, 2000, pp.11) refers to these phase-end reviews as phase exits, stage gates or kill points. Therefore the project life cycle will define the scope that needs to be completed per project phase and give an indication on the resources involved in each phase. The project life cycle does however need to be more extensively defined in order to provide structure and consistency, most project life cycle descriptions have common ground. Projects globally as seen in research are generally managed according to the four phase project life cycle. This is a very simplistic approach towards projects, as given in Figure 10. Figure 10: Four Phase Project Life Cycle Adapted from: Archibald, Di Filippo and Di Filippo, c.2011, pp.5 The four phase project life cycle has been further developed as seen in Figure 11 and 12 to a six phase project life cycle. The six phase project life cycle includes two additional phases namely, Feasibility and Post-Project Evaluation. This Project life cycle allows for a more structured approach for review and investigation of projects post closure and pre-starting of the project.

There are numerous benefits that have been documented regarding this approach. Figure 11: Six Phase SCADA Project Life Cycle Adapted from: Mohamed and Mohamed, 2012, pp. 159 Figure 12: Six Phase project life cycle Adapted from: Archibald, Di Filippo and Di Filippo, c.2011, pp.8 More recent literature regarding project management life cycle however gives some indication of intermediate steps as seen in Figure 13, between phases which allow for project definition, detailed planning, monitoring and implementation review. This approach can also be considered in defining a four phase project life cycle. Sasol Limited has adopted this approach, however Sasol has developed this project life cycle to the seven (7) gates of the BD&I model discussed earlier in the thesis. Figure 13: The four phase project life cycle Source: Westland, 2006, pp.4 The simplistic four phase project management life cycle will be utilised for the purpose of this thesis because for small project it has been adopted and utilised by numerous researchers and project managers in industry. 2.7 Project Phase Deliverables Once the project phases have been defined for the particular project, definition of the deliverables and schedule needs to be finalised. This is however at a very high level rather than at activity level which is detail that is finalised during detailed planning. Deliverables are defined as the work or product located at the end of a hierarchy of activities. The deliverables can be actual equipment, plants, products or structures; however they can also be abstract such as audits, systems or change processes, irrespective the final project deliverable is generally defined by the project client. The project management book of knowledge gives a very simplistic generic cycle which serves specifically to indicate that cost and staffing levels will be low when project start, increase gradually and drop rapidly towards completion of the project, also seen in Figure 14. Figure 14: Total Resource Effort Level for Project Phases Adapted from: Slevin and Pinto, 1987, pp. 34 Figure 15 on the next page gives slightly descriptive graphical overview of a project life cycle with the respective activities. This schematic is a conceptual depiction of the hypothesis proposed by this research and was extensively used during the research process, as some of the activities defined in the schematic require a certain effort level from various resources. Figure 15: Effort Level for a Project Life Cycle Adapted from: Abdou, c.2012, pp. 23 In understanding the project life cycle phases and the project deliverables, it is critical to clearly indicate the level of effort while also mapping the project progress in terms of the project scope completed. Figure 16 gives a simplistic illustration of the percentage of work completed for the project at the different project phase gates. This graph is not to be mistaken with the level of effort required from the numerous resources as discussed early, the effort levels start low, increase during stage two (2) and three (3) then later decrease rapidly during the final stage. Figure 16: Project Life Cycle Stages Source: Project Management Institute, 2000, pp.15 The key deliverables required for the four phase project life cycle are also given in the following figures, Figure 17, 18, 19 and 20 from project initiation or start phase to the project closure phase respectively. These deliverables will be categorised according to the resource that is accountable for the deliverable and further research evaluated on the resource effort or magnitude required per deliverable. Figure 17: Project Initiation Activities Adapted from: Westland, 2006, pp.5 Figure 18: Project planning activities Adapted from: Westland, 2006, pp.7 Figure 19: Project Management Execution Activities Adapted from: Westland, 2006, pp.11 Figure 20: Project Closure Activities Adapted from: Westland, 2006, pp.14 2.8 Project Phase Resources Westland (2006, pp. 8) highlights that the next action after developing a project plan is to define the resource plan which is not only limited to individuals but will include the following: ? Type and quantity of resources required. ? Roles, responsibilities and skill-sets of all human resources required. ? Specification of all resource equipment required. ? Type and quantity of all material resources required. Project resources are referred to as project stakeholders according to the PMBOK (Project Management Institute, 2000, pp.11), which can be individuals or organisations that are actively involved in the project and can exert influence over the project and its results. These stakeholders need to be identified and their requirements clearly defined for each project. The key stakeholders as defined in PMBOK are namely, with their simplified responsibilities: ? Project Manager: responsible to manage the project. ? Customer: individual or organization that will utilise the project's product. ? Performing Organization: organisation whose employees are mostly doing the work of the project. ? Project Team Members: group of people doing the work of the project. ? Sponsor: individual or group providing financial resources for the project. Literature by Abdou (c.2012, pp.17) is in agreement and also refers to the sponsor, project manager, customer, performing organisation and project team members as the stakeholders required for every project. Sasol (Sasol Limited, 2012) defines the project stakeholder into four main resources, namely: ? Technical ? Business ? Project Management ? Sponsor These are very similar to those adopted by PMBOK; however this naming of resources is primarily for individuals and organisations to be aware of their responsibilities; however stakeholder roles and responsibilities may also overlap depending on the project, environment and other factors. Page 30 The project resources to be considered in the scope of this research projects were limited to the following group of skills: ? Technical Resource: o All engineering disciplines resources. ? Business Resource: o Business Analysts. o Financial officers. o Management in the organisation to assist with review and approval of documents according to the necessary governance. o Steering committees. o Employees to compile supporting documents, fund application and business cases. o Operate the system or product. ? Project management Resource: o Project managers o Site supervisors o Safety Officers o Cost controllers o Document controllers o Commercial officers o Planners/Schedulers ? Sponsor Resource: o Management personnel to support and give guidance to the project with regards to resources, governance and schedule compliance. o Employee to draft documents as required from the sponsor according to the governance. In defining the resources for the project life cycle, key issues to be considered are as follows: ? The type of work and the size of the team. ? The match between the job and the resource. ? The experience of the resources. ? The leaders in the project team. Page 31 The scope will not include defining the resources required for the physical construction activities required; only engineering, project management, business and sponsor resources will be considered. The following two figures seen in Figure 21 and 22 qualitatively indicate the relationship between time, scope and resources within projects. In the hypothesis this relationship will also be considered in defining the level of effort required from resources over the project duration or schedule. Figure 21: Variation in Scope, Time and Resource Impact Source: Lynch, 2003, pp.7 Figure 22: Trade-off between Resources, Scope and Time in Projects Source: Lynch, 2003, pp.8 Page 32 Organisations are forced to prioritise on a large number of small projects due to limited project, engineering, business representatives and other resources within organisations. It is very crucial for an organisation to know when these resources need to be moved between projects as projects progress through their life cycle in ensuring the efficiency of resources. Resource allocation is more of a challenge is smaller projects mainly due to the changing priorities, difficulty in obtaining commitment from other parts of the organisation to provide resources and sharing of a fixed pool of resources. In small projects as discussed in literature (Westney, 1992, pp. 77) it is generally assumed that the number of resources in each category or resource track is constant over the duration of the activity. Research has been done previously in this area where resource allocation is done utilising sophisticated computer systems. What has been revealed is when project resources are considered, there are sharp peaks in the resource requirement that can exceed the availability. When reviewing resource histogram over the project life cycle, specifically on resource consumption, Frame (1995, pp.191) states that resources will gear up at the early stages of the project, when few resources are employed, when the project reaches the middle the resources will start moving full steam ahead and at the end of the cycle the resources will wind down. 2.9 Level of Effort The term level of effort (LOE) in project management is referred to as a support-type project activity that needs to be done to support other work activities or the entire project effort. LOE activity is therefore an activity that supports completion of work. The word level of effort is thus utilized to define the amount of work performance within a time and is measured in staff days or staff hours per day, week or month (Wikipedia, 2014). The estimation of the level of effort is one of the key responsibilities of the project manager. The Project Management Body of Knowledge defines Level of Effort as a support type activity and gives a more detailed definition as follows (Project Management Institute, 2000, pp. 202): Support-type activity (e.g., vendor or customer liaison) that does not readily lend itself to measure of discrete accomplishment. It is generally characterised by a uniform rate of activity over a period of time determined by the activities it supports. Simplistically defined it refers to the specific and quantifiable count and measure of definable labor units that is defined to be required in the attempts to arrive at the completion of a phase of a particular project schedule (Project Management Knowledge, 2014). Research regarding the level of effort gives additional insight when estimating the level of effort for a project, which needs to be completed before cost and schedule estimation is performed. The following ten steps can be utilized to determine effort hours (The International Community of Project Managers, 2014): 1. Understand the accuracy required from the estimate. 2. Utilize one estimating technique (Analogy, prior history etc.) to define the initial estimate. 3. Factor the effort hours based on the resources available. (Optional step) 4. Include for specialist and part time resources. 5. Add the time required for rework. (Optional step) 6. Include time required for project management, rule of thumb 15% of total hours should be allocated to project management. 7. Add hours for contingency or risk associated with the estimate. 8. Calculate the total effort. 9. Review the information, assumption, calculations and results and adjust where necessary. 10. Document all the assumptions at that point in time. 2.10 Project Success Factors The analysis and definition of different models to execute projects all comes back to the benefits of implementing a project successfully. This section will focus on the concept of project success rather than project management success which is mainly associated with traditional measurements of performance against cost, time and quality (Cooke-Davies, 2002, pp. 185) Project success refers to the measures to which the project success or failure will be measured. This concept is referred to in literature as the critical success factors for a project; it is the inputs that directly or indirectly lead to project success. Literature by Pinto and Slevin identified a list of ten project success factors (Turner and Muller, 2005, pp.56) as seen in Table 2 below. Table 1: Project Success Factors Source: Turner and Muller, 2005, pp.56 2.11 Opposing Literature 2.11.1 Project Phases The project life cycle for projects within the petro-chemical industry is sometimes seen as two phased rather than the traditional four phase project life cycle. A paper dated January 2011 (Selaru, 2012, pp.276-277) states that projects are typically seen in two phases namely: ? Development Phase which has a deliverable of a Basic Engineering Package. ? Implementation Phase which includes detailed engineering, procurement, and construction. The definition of the phases in this manner allows for easier allocation of contracts such as EPC (Engineering Procurement and Construction) and EPCM (Engineering Procurement Construction Management) which are very popular contracting strategies within the petro-chemical industry. Westney (1992, pp.9) highlighted the need for treating small projects differently to the conventional approach discussed earlier in the research. He highlighted that any project management technique could be adopted provided it could allow the following: ? Allow one to handle many projects at once. ? Be used effectively without training or previous experience. ? Cope with short schedules. ? Simplify organisational interfaces. ? Handle complexities of work in an operating plant. ? Provide a basis to accumulate data (cost and schedule information) for future projects. ? Improve the multiple project managers' capabilities regarding key responsibilities for projects. In evaluating what other project life cycle models could be utilised for small projects (Archibald, Di Filippo and Di Filippo c.2011, pp. 5-6) also argues that the project life cycle needs to be more specific, thus could include up to ten (10) or more phases. Literature indicates there are predictive and adaptive project life models that have been developed and can be utilised as they are more specific to the type of project. Predictive models being more focused on optimization rather than adaptability, whereas the adaptive models, as seen in Figure 23, accept and embrace change during the planning or development process of the project life cycle. Figure 23: Adaptive Project Life Cycle for New Product Launch Source: Archibald, Di Filippo and Di Filippo, c.2011, pp. 6 A project management project life cycle defined by Westney (1992, pp. 50) in managing projects is give in Figure 24 below which does not necessarily define phases but rather key milestones for planning or executing a small project. This is commonly referred to in industry as the three phase project cycle. Start Preliminary Design Complete Construction Start Up Finish Preliminary Design Complete Plan and Cost Estimate Start Construction Project Approval Figure 24: Small Project Life Cycle Source: Westney, 1992, pp.50 Other scholars (Frame, 1995, pp.7) have defined the project life cycle or projects as having beginnings, middle periods and endings, this may seem simplistic but it is not trivial when considering management of projects. Milton (2005, pp.34) defines a five(5) phased project life which is defined specifically for the oil industry, figure 25 below gives some detail of the proposed project life cycle. Appraise Select Define Execute Figure 25: Oil Industry Stage Gate Framework Source: Milton, 2005, pp.34 2.11.2 Project Resources Operate Most literature gives an indication on the resources required to execute projects at the different phases, however Frame (1995, pp.84-85) states that resources should be defined in such a way that it will facilitate the effective management of projects, in other words structure to enhance team efficiency rather than to suit a particular project management model. A structure that leads to exceptional performance for one project can fail dismally for another project. The role of the project manager is what is seen as critical as the project manager needs to have competencies in the following areas: ? Scope, time and cost management. ? Human resource management. ? Risk and quality management. ? Contract and communication management. 2.12 Summary Extensive research and theoretic literature has been documented on many project management concepts. The information obtained from the literature review was extremely valuable and is directly linked to research questions and objectives. A large volume of the information is in agreement or aligned however there are scholars and researchers that have expressed alternative concepts which were also reviewed in this section. In summary to this chapter the key concepts that influenced the research project will be discussed in brief in this section of the report. The definition of what entails a project was critical and was clearly discussed and the final definition adopted for this research was based on the British Standards Institute definition, summarized as follows, a project defined as a set of coordinated activities with a definite start and finish with objectives centered around completing the activities on cost, schedule and as per the specified quality. Once the definition of a project was finalized, research to understand how the types of projects are defined or rather project typology was also critical for the research as it does influence other factors within the project structure. The literature indicates that two main models have been adopted regarding project typology. The first which defines typology on two concepts; namely nature of technology and project management scope. The second model defines typology based on four concepts, namely nature of technology, project management scope, novelty and lastly pace. The complexity of organizations which execute projects and the complexity of projects were evaluated; this area of research was found to have extremely conflicting concepts as there are currently two schools of thought. The first being that all systems, projects included, are complex adaptive systems that are always changing, and their complexity cannot be managed or measured easily, thus managing complex adaptive systems in a certain manner does not guarantee an outcome. The second school of thought states complexity can be measured and managed accordingly to ensure project success. The measure of complexity is then based on structural uncertainty and certainty. Understanding the complexity of a particular project is critical as research has also show that complexity does directly influence the effort level required from the resources allocated and associated with the project. Literature around project management, project life cycles, project phases and project deliverables has been adopted very well in industry and there are numerous books and research completed on the topic. The literature evaluated for this thesis clearly highlighted an agreement on the four phase project life cycle which entails the following phases: ? Project Start/Initiation ? Project Definition/Planning ? Project Execution ? Project Closure However more recent literature gives insight on project life cycles that included additional phases which have been confirmed to be beneficial specifically during the early stages of the project and towards the end of the project. The six phase project life cycle discussed in the literature review included for two additional phases, namely incubation or feasibility phase which is pre the project start phase. The other additional phase is post project closure which is termed post project evaluation phase. The six phase model was also further developed to an eight phase model which is utilized by organizations that execute large projects, typically brown or green field projects. This model allows two additional phases, one phase pre execution and another post execution. Once the literature regarding project life cycle model was addressed, the next critical concept was the deliverables and resources defined or required as per the different models. The literature reviewed provides some insight on the key deliverables and the resources but this concept has not been well evaluated by scholars and remains subject to numerous factors that are specific to a particular project. However there is common ground on the generic resources and deliverables required for a project to move from one phase to another and finally in defining the project as complete or closed out. The concept of level of effort as seen in literature is quite a recent concept with evidence of the first definition by the Project Management Body of Knowledge in the year 2000, where the term was defined as a support activity that is measureable and is categorized by a uniform rate of activity over a period of time. More recent literature defines this term in line with the research objectives as a quantifiable count and measure of definable labor units that is defined to be required in the attempts to arrive at the completion of a phase of a particular project schedule. Calculating or defining the level of effort for the project is critical for this research project and literature by The International Community of Project Managers (2014) gives a ten step guide which will also be used later in the research process. In conclusion, literature was also reviewed to define the term project success and what constitutes as failure or success in projects, thus the concept of project success factors was investigated. Recent literature defines clearly the difference between project management success and project success, Turner and Muller (2005) defined critical project success factors in a very comprehensive table indicated in the literature reviewed. CHAPTER 3: RESEARCH METHODOLOGY 3.1 Introduction This chapter of the thesis provides detail on the research design and research methodology utilized for the research process. The qualitative research method was adopted for this research as it proved to be more beneficial especially as the aim of the research is to define a generic tool that can be utilized for different scenarios. Detailed insight will be given in this section on the key factors that were defined and investigated before the research process could be undertaken. These factors included but were not limited to defining the following: ? detailed hypothesis ? null hypothesis ? research framework ? relevant qualitative research methods ? the size of the research target group ? the methods used to collect data ? method used to analyze information ? research questionnaire utilized for the research process 3.2 Research Design The research design was developed to allow the research process to ensure the research questions and objectives defined in Chapter 1 are successfully answered or achieved respectively. The choice of the approach as previously discussed was determined by the nature of the research problem statement. In order to allow for information that tends to vary significantly per organisation, project and project manager to be analysed and defined into a model that can be used for a large number of projects as a qualitative model, while maintaining confidentiality and anonymity the qualitative approach was considered. The research design entailed the following: ? Literature evaluation, which entailed evaluating the concepts and theories that have been researched and accepted globally regarding the project life cycle phases, resources, deliverables and the level of effort required from the resources throughout the project life cycle. ? Information gathering, focused on obtaining data from project engineers, engineers and project managers from Sasol Synfuels, Sasol Technology, Sasol South Africa Energy and engineering firms/consultants that have completed small projects successfully. ? Defining a detailed hypothesis based on experience, participant observations, literature and case studies. ? Data Analysis, which entailed a detailed analysis of the literature reviewed, feedback from questionnaires, input from participant observation notes and qualitative analysis of the data sourced from various participants. 3.3 Research Questions The research questions as defined in Chapter 1 of this research thesis were defined prior to the research methodology being finalised. These questions were utilised in order to ensure alignment towards the research objectives during development of the research questionnaire, as discussed later in section 3.5.4. The research questions are summarised as follows: ? What percentage of effort is required for the critical resources identified in projects for the activities required at the different phases of the project life cycle? ? Is there an alignment or congruency between the current literature and research data regarding the resources and percentage of effort required at different phases of a project? ? What graphical representation can be utilised to illustrate the resources and percentage of effort required for the activities required at different phases of the project? Note: This research does not consider physical resources required for the construction of any equipment, product or structure required for the project. 3.4 Hypothesis In defining the research hypothesis, the research questions had to be clear and then translated into a hypothesis that states a relationship between two or more variables in one (or more) population(s). Hypothesis Statement It is hypothesised that the level of effort (percentage of effort) of critical project resources will vary significantly depending on the phases of the project life cycle for small sized projects, the four key resource tracks being namely, Technical, Business, Project Management and Sponsor resources. Null Hypotheses There are no critical resource tracks in the management of small projects and the level of effort (percentage of effort) for the project resources are not dependent on the deliverables or the phases of the project life cycle but rather other internal and external factors. Detailed Hypothesis There are four critical resource tracks in projects, namely technical, business, project management and sponsor resources. The level of effort for each of these resources is dynamic and changes as the project moves from one phase to another of the four phase project life cycle. The resource track level of effort increases and decrease mainly due to the deliverables (scope, governance requirements, accountability, responsibility, cost, schedule, safety, and quality) required during the particular phases of the project life cycle. Figures 26, 27, 28, 29 and 30 give a graphical hypothesis prior to the qualitative research that will be conducted for the research project. The graphs indicate the level of effort per resource from project initiation to project completion. The project life cycle is defined from zero percent (0%) to one hundred percent (100%). The four phase project life cycle is utilised therefore the project life cycle is divided into four phases as follows: ? Project Start/Initiation: 0% to 25% of project completion. ? Project Definition/Planning: 25% to 50% of project completion. ? Project Execution: 50% to 75% of project completion. ? Project Closure: 75% to 100% of project completion. It is critical that the graphs are interpreted with the understanding of the different phases and percentage of the project completed, as defined above. The detailed hypothesis graphs for the level of effort required per phase for the four different resource types are given in Appendix One. 45 40 35 Level of Effort (%) 30 25 20 15 10 5 0 Project Management Resources: Level of Effort 0 10 20 30 40 50 60 70 80 90 100 Project Completion (%) Figure 26: Level of Effort Hypothesis for Project Management

Resources Technical Resources: Level of Effort 60 50 40 Level of Effort 30 20 10 0 0 10 20 30 40 50 60 70 80 90 100 Project Completion (%) Figure 27: Level of Effort Hypothesis for Technical Resources 50 45 40 35 Level of Effort 30 25 20 15 10 5 0 Sponsor Resources: Level of Effort 0 10 20 30 40 50 60 70 80 90 100 Project Completion (%) Figure 28: Level of Effort Hypothesis for Sponsor Resources Page 46 Business Resources: Level of Effort 30 25 Level of Effort 20 15 10 5 0 0 10 20 30 40 50 60 70 80 90 100 Project Completion (%) Figure 29: Level of Effort Hypothesis for Business Resources 60 50 Level of Effort 40 30 20 10 0 All Project Resources: Level of Effort 0 10 20 30 40 50 60 70 80 90 100 Project Completion (%) Project Management Resources Sponsor Resources Figure 30: Level of Effort Hypothesis for All Project Resources Technical Resources Business Resources The approach of testing counter hypothesis currently available in literature or industry will not be considered for this dissertation but can be considered by future scholars. 3.5 Research Methodology 3.5.1 Qualitative Method Qualitative research is simply defined by Nigatu (2009, pp.5) as developing concepts that assist in understanding phenomena in natural settings which give emphasis to the participants views and experiences. There are numerous methods commonly utilised in qualitative research, which are namely: ? Phenomenology ? Ethnography ? Inductive Thematic Analysis ? Historical research ? Grounded Theory ? Case study ? Participant observation ? Unstructured and in-depth interviews ? Narrative Analysis ? Focus groups ? Mixed Methods ? Combining qualitative and quantitative This dissertation however only focused on four key methods, namely, historical research, case study, structured interviews (questionnaires) and lastly participant observation in obtaining information that will be used in evaluating the hypothesis and developing the proposed qualitative model. One of the critical issues relating to qualitative research is to maintain good ethics in that confidentiality and consent must be addressed and ensured before and during the research process. 3.5.2 Historical Research Historical research was used to add value in evaluating the hypothesis defined in the thesis, the primary sources of historical data were sourced and utilised in defining and refining the hypothesis as discussed in detail in Chapter 2. In qualitative analysis, it was critical to utilise primary rather than secondary sources and this was fundamental in evaluating the relevance of the information from secondary sources as it can be inadvertently or deliberately distorted and influence the research findings. 3.5.3 Case Study A detailed analysis of Sasol as an organisation that manages numerous small projects within the petro-chemical industry formed the basis for the case study section of the dissertation. Focus being on the resources utilised at different phases of the project life cycle which was used to gather data that was used in reviewing the qualitative graphs developed as the hypothesis. The pool of projects considered was limited to the following criteria: ? Small technical projects within the Secunda Refinery Complex. ? Small scale projects being managed by Sasol technology and engineering consultants only within South Africa. 3.5.4 Research Questionnaires The questionnaire given in Appendix Six was circulated within the Sasol group of companies to project managers, project engineers and to various engineering and project management firms for feedback. The information received was used to develop qualitative graphs that were used to test the hypothesis developed earlier in the research. The questionnaire was structured to ensure that information regarding key areas of the research would be tested while also ensuring that it was linked to the research questions and objectives. Questionnaire: Part 1 Questions 1 to 9 were structure to get insight on the project size (magnitude), typology, complexity and strategic importance. These questions were utilised in the research to ensure that projects that are similar in nature, size, complexity and strategic importance are grouped and reviewed as a group in order to draw a mean that is accurate based on the project typology as defined in the research. Questionnaire: Part 2 Questions 10 to 13 were utilised to get information on the types of resources involved in the project and the magnitude of the resources involved in the project. Questionnaire: Part 3 Questions 14 to 17 focused on gathering information on the activities and/or deliverables that were completed during the four phases of the project life cycle by the four different resource types for the particular project. Questionnaire: Part 4 Questions 18, 19 and 20 were structured to obtain qualitative and quantitative feedback from the respondents on the amount of hours or level of effort required per resource for the four different resource types for the four phases of the project life cycle. Questionnaire: Part 5 The last set of questions, namely question 21 and 22 we included to understand if external factors or risks influenced the project during the project life cycle and how this was managed and lastly if the project was considered a success. The minimum number of questionnaires considered for both internal and external distribution, external to Sasol, was fifty (50). 3.5.5 Participant Observation Participant observation as a qualitative method was also utilised and provided very valuable information towards refining the research hypothesis. As the researcher was also a participant in the Sasol Synfuels Projects Department. The extensive period, at the time of this research was declared to be ten (10) years of experience, the researcher has worked as a project engineer within the power utility and petro-chemical industry in South Africa made it possible for the inclusion of this tool in the research methodology. Information from archived projects and from previous project managers that the participant had worked with regarding the level of effort, man-hours and the distribution of the man-hours was also represented in a graphical model which was used to define the research hypothesis on the level of effort and the different project life cycle models. This information and the interpretation there of will be discussed extensively in Chapter 4 of the thesis. In undertaking qualitative research it is clear that the researcher cannot be totally detached from the research process even when desired, it is impossible. Instead of seeing this as a concern it has been identified in this research project as a benefit and will be utilised as unstructured information under the participant observation qualitative method. This idea is also referred to in literature as reflexivity. Reflexivity is defined by Horsburgh (2003, pp.308) as the active knowledge or understanding by the researcher that their actions and decisions will inevitably impact upon the meaning and context of the experience under investigation. Therefore the researcher realizes and accepts that they are an integral part of the world being investigated, thus neutrality or objectivity regarding the data collection, analysis and interpretation is not possible. 3.6 Research Site The research site for the thesis was limited to the researcher's ability to access what many organisations consider to be confidential information, namely the resource loading at different phases of the project. Project management and engineering consulting firms also consider this information to be of strategic importance as organisations that execute projects successfully with the optimal number of resources can be more profitable than one that does not use its resources efficiently. However due to the volume of small projects executed within the different business units or companies within Sasol, the availability of information internally was not a concern. The following Sasol business units formed part of the research site: ? Sasol Synfuels, located in Secunda Mpumalanga. The site consists of two power stations and refineries on the same site. The site employees more than 15 000 people. In terms of production, the site produces eight hundred (800) megawatts of electricity and imports six hundred (600) megawatts of electricity continuously in order to produce 7.4 million tons of numerous types of products ranging from petrol to fertilizers per annum. The average annual budget for small projects within Synfuels is five hundred million rands (R500 million). ? Sasol Technology, located both in Secunda Mpumalanga and Rosebank Gauteng. This Sasol business unit is focused on developing new technologies for Sasol and executing projects for the Sasol group internationally in countries such as Mozambique, Nigeria, Canada and the United States of America to name a few. ? Sasol South Africa based in Randburg, Alberton and Germiston in Gauteng focuses on retail and wholesale business in South Africa. The projects related to the construction of retail sites and commercial sites are managed within this business unit. Two consulting organisations that provide project management and engineering services also formed part of the research site for the thesis. The names of the organisations will not be disclosed as anonymity was guaranteed when gate keeper approval was requested. The two consulting firms however render a service to the Sasol group. The research site was also limited to projects executed within the boundaries of South Africa. 3.7 Description of Participant Group Defining the participant group and the sample size for a research project is a very important step as it is neither practical nor effective to strive to study an entire population group. Many researchers therefore have previously opted for random samples. In terms of sample size many researchers believed that the larger the sample size the better the research feedback as the sampling error was assumed to decrease with size. However more recent literature shows that there benefit of a large sample size does not surpass the benefits associated with defining an optimum sample and key parameters that are important to the sample group. An optimum sample is defined by Marshall (1996) as one that adequately answers the research question(s). Literature (Marshall, 1996, pp 523) shows that there are mainly three sample strategies namely, convenience, judgement and theoretical samples. Convenience sample is many focused on the ease of access to the participants; this technique can be the least rigorous and can lead to poor results. This method is generally seen as not credible or representative. The judgement sample is commonly utilised by researchers as the researcher selects the most productive sample to respond to the research questionnaire. This sampling method can be very informative but the research needs to be well informed on the research topic to ensure this sampling method is well utilised to allow valuable feedback from the research process. The theoretical sampling method requires an iterative process in that it entails the building of interpretative theories from the data received and later elaborating on theories built. Therefore participants will be selected or defined based on their ability to provide relevant data on the area or subject under research. Analysis of the feedback from the research questionnaires or interviews will also give guidance in the future sample group, this approach is part of theoretical sampling (Horsburgh, 2003, pp.311). The qualitative sampling method utilised for this research was a combination of judgment sampling and theoretical sampling. The participant group was not restricted by gender, race or age as many qualitative research studies which generally focus on a specific group. The specific group for this research was restricted to the parameters defined below. ? The participants needed to have an engineering or project management background or qualification. ? The participants' experience within the industry or projects had to exceed a period of three years. ? The feedback from the questionnaires would not be restricted to a particular field; however the projects needed to be executed within the petro-chemical industry. ? The participants had to be working for Sasol or either one of the project and engineering consulting forms. ? The age, gender, race or nationality of the participant was not a restricting parameter for participation. ? The participation was also restricted to only English speaking individuals. The size of the participant group was not limited as the research objective was based on obtaining a large volume of information that would be utilised to evaluate the hypothesis and define the graphical models. However the time available for the research was the limiting factor as data collection, analysis and interpretation was very time consuming. 3.8 Methods of Data Collection The data that was utilised for the research process was categorised into two, namely structured and unstructured i.e. historical data, surveys, participant observation and questionnaires. The raw data obtain from the different qualitative research methods was collected, organised and processed into Microsoft Excel. 3.8.1 Structured Data Structured information on resource loading at different phases of the project life cycle was sourced from the following organisations: ? Consulting Engineering and Project Management firms. ? Sasol project and engineering groups: • • • Sasol technology project managers for small projects. Sasol Synfuels project managers and project engineers for small projects. Sasol South Africa Energy project managers and project engineers for small projects. Data on technical, business, sponsor and project management resources required from start to closure phase in terms of man-hours or effort level was requested and treated as confidential for only the purpose of this research project. 3.8.2 Unstructured Data Unstructured data refers to information that was obtained during the research process from participant observations and feedback from the research questionnaires from the participants. The information was categorised and recorded utilising a hardcopy filing system and later transferred to Microsoft excel. 3.9 Data Analysis In order to complete the analysis of the information, the raw data that was available had to be structured in a manner that would allow efficient analysis of the information. A systematic approach was developed which entailed the following steps: ? Quantitative information on the resource loading hours was reviewed to ensure the information was relevant to projects only considered for the purpose of this research. ? The qualitative information on the resources hours was turned into an average to ensure anonymity and confidentiality. ? The qualitative and quantitative information was later developed into graphs to indicate the average level of effort per resource for the project life cycle. ? The qualitative information was obtained from two main sources, namely the participant observations and the research questionnaires. ? The qualitative feedback from the questionnaires was also checked for validity to the research topic. All valid feedback was then filed according to the project life cycle phase. ? The information was also converted into an average measure and converted into graphical representation. ? The participant observation feedback was also structured into graphical models based on previous projects. The key focus of the data analysis process while maintaining confidentiality and anonymity was to search for differences, similarities, themes, areas of development, areas of future research and new ideas or themes during the continuous research process. Testing the hypothesis while also adjusting where necessary in order to define a qualitative graphical model from the research process was also very key. Ultimately the final outcome of the research process was to define a qualitative graphical model that would give an indication of the project life cycle, project life cycle phases, key project deliverables per phase and the level of effort required per phase of the project life cycle. 3.10 Assumption and Risks The graphical representations that would be developed for the purpose of the research would consider certain assumptions and risk which would clearly be defined with the graphs. Some of the assumptions and risks can be summarised as follows: ? Exclusion for factors to allow for efficiency, effectiveness and other undefined risks. ? A function to allow for expediting the project through certain phases of the project life cycle. ? Scope creep or additional scope being included into the approved project scope. ? Competency and work experience of the resources will also be assumed. Page 56 3.11 Ethical Considerations Due to the sensitivity and confidentiality of the information that was required for the research process, a formal request to conduct the study, as seen in Appendix Five, was sent to a group of desired participants for the research project. Consent to continue with the research and send out the research questionnaire was given by the following organizations: ? Sasol Technology. ? Sasol South Africa Energy. ? Sasol Synfuels. ? Two

Project Management and Engineering Consulting Firms. The gate keeper approvals were obtained and filed as seen in Appendix Seven as proof that the management representatives were aware of the research and did consent at the time of the research. The participants were assured anonymity and confidentiality, as this was clearly stated in the introduction of the research questionnaire. Furthermore participation into the research process was also clearly indicated as voluntary in the questionnaire. However due to the number of questionnaires sent out for the research, participant consent was not documented but assumed for questionnaires that were returned for the purpose of the research. Lastly ethical clearance, as seen in Appendix Eight, was also obtained from the University of KwaZulu-Natal to conduct the qualitative research for the purpose of completing the thesis required for the partial completion of a master of commerce in leadership studies. 3.12 Summary This chapter of the research thesis introduced the research design that was utilized to address the research questions and achieve the research objectives. A qualitative research methodology was defined and adopted for the purpose of the research. The qualitative research methods utilized for this particular research were limited to historical research, case studies, research questionnaires and participant observation. The hypothesis statement, null hypothesis and detailed hypothesis statement were clearly defined and introduced in this chapter. The hypothesis in summary states that the level of effort for critical resources varies significantly depending on the phase of the project for small sized projects. The hypothesis was further defined graphically into models indicating the level of effort required per resource for the project life cycle. This hypothesis was developed prior to commencement of the research process. The data obtained from structured and unstructured sources discussed in this chapter was used to further refine the hypothesis, test the hypothesis and further develop the hypothesis. The data analysis process was clearly defined, and with the aid of Microsoft excel the research information will be stored, refined, evaluated, analyzed and illustrated into graphical models as will be discussed in the next chapter. The research site consisted of three main sites, namely Sasol Synfuels Secunda, Sasol Technology South Africa and Sasol South Africa Energy Projects environment. The focus was mainly on South African projects for the research questionnaires sent out for feedback. The research participants were not limited or restricted by race, gender or age but rather by their competency, experience and working experience within the petro-chemical industry. The research questionnaire was structured into five parts which ensured that feedback from the participants would include feedback specifically on the following: ? Insight on the project size, complexity and strategic importance. ? The types of resources involved in the project. ? The activities and deliverables completed per phase. Page 58 ? Qualitative and quantitative feedback on resource level of effort. ? External factors that influenced the project. Lastly the approval from gate keepers and the University of KwaZulu-Natal was critical for the research process. Consent from gate keepers, participants and the University was requested via a formal letter to execute the research, detailed consent in the introduction of the research questionnaire and a detailed ethical clearance application. The formal approvals from the University ethics committee and the gate keepers to undertake the research process were filled and are attached to this thesis report. CHAPTER 4: RESULTS AND DISCUSSION 4.1 Introduction This chapter of the research thesis will focus on presentation of the results after the analysis of the data obtained from the numerous qualitative sources as per the research methodology discussed in the previous chapter. The results from the respondents will be presented by means of graphs and tables in order to give a collective or cumulative presentation as to maintain confidentiality while also providing in depth feedback from the research process. The results will also be discussed in detail in this section of the report while re-visiting the research questions and objectives discussed in Chapter One. The literature reviewed in Chapter Two will also form part of the discussion of the results. The discussion will clearly indicate the information that supported the research hypothesis while also highlighting the key areas of misalignment. The hypothesis will also be reviewed and areas of agreement and misalignment will be shown. The discussion will be centered around the objectives as closure regarding the objectives is critical and will form the basis for Chapter Five, in order to clearly define the outcomes, lessons and contributions of this particular research project. The discussions associated with the objective that ties to the feedback from the questionnaires will be discussed later in the chapter after the analysis and representation of the feedback from the respondents. 4.2 Research Results in terms of the Objectives This section of the thesis will present qualitative data collected and discuss the associated relevance and alignment to the literature reviewed in Chapter Two. Concepts that were identified and any incongruence with the feedback and the literature will be explored. The structured approach that was followed was based on the objectives for the thesis and later the presentation of the results and then concludes with a summary of key findings and an updated hypothesis to conclude the Chapter. 4.2.1 Objective One and Two The first two objectives for the research were focused around developing a hypothesis for critical resources for a small project from start to finish specifically on the level of effort required per phase. The research process defined in Chapter Three of the thesis supported in answering the research question linked to these objectives. A detailed analysis of literature highlighted numerous project life cycles for small projects. The following project life cycles have been adopted by many scholars and organizations: ? Four Phase project life cycle ? Six phase project life cycle ? Eight phase project life cycle These three models are very similar and in essence can be seen as an evolution from one to the next, in simple terms, the eight phase project life cycle model is an evolution of the six phase cycle. The six phase project life cycle similarly is the evolution of the four phase project life cycle. As shown in Chapter Two these models are similar and merely include for additional phases to allow firstly for better governance pre project initiation, post project initiation, prior to project closure and lastly the additional phases improve the planning or development of key activities especially on large scale projects. In the project management of specific types of projects, for example small size project with a low complexity the four phase project management cycle has proven adequate and does yield success across many organizations. However the research process did highlight new concepts and areas of incongruence regarding project life cycle models. There is a small group of organizations and project managers specifically within the engineering sector that have also adopted a two phase project management life cycle. The first phase as highlighted in Section 2.11.1 being a combination of an initiation and planning phase. The second and last phase being a combination of a detailed planning phase, execution and project closure. The Engineering Council of South Africa recognizes a five phase project life cycle referred to as the stages of services, namely (Republic of South Africa, 2014, pp.40): ? Inception ? Concept and Viability, ? Design Development, Documentation and Procurement, ? Contract Administration and Inspection ? Close-out. Another new concept introduced by Westney (1992, pp.9) is that any project management technique can be adopted; projects can be managed according to the convectional approach. In so doing so projects can be addressed more adaptively and embrace change during planning and development process which could exploit available efficiencies and become more innovative by nature. A more radical approach which is believed to be in line with complexity theories such as those defined in literature associated with complex adaptive systems indicates projects are complex adaptive systems that need dynamic thinking and no particular model, actions or guidelines can guarantee a particular outcome. Irrespective of the conflicting project life cycles that have been documented and researched, there is still common agreement of the four, six and eight phase project life cycle. The most commonly utilized and adopted model for small and less complex projects being the four phase project life cycle as observed from the literature review, case studies and participant observation undertaken during the research process. The four phases of this model being primarily focused on the specific scope and deliverables required per phase. The four phases are namely project initiation or start, project definition or planning, project execution and lastly project closure or start-up, in that particular order of sequencing. In defining or developing the hypothesis for small projects the project life cycle model adopted was critical as this would form the basis for the scope or deliverables required at different milestones of the project which would have a direct correlation on the level of effort required from the resources. In further developing the hypothesis, the research process assisted in obtaining information on the definition and specification of critical resources within the project management environment. The literature clearly highlighted that resources are not limited to individuals or groups of individuals but can be inclusive to include tangible and intangible items such as knowledge, materials, structures, tools and so forth. However there is common agreement from literature, case studies and participant observation in terms of key or critical resources required for projects and these have been defined as follows: ? Project manager who is responsible for the management of the project, resources, schedule, cost, quality and overall success of the project. ? The customer, client or business, which will utilize the project's product. ? The performing organization, which is the organization whose employees are mostly doing the physical work of the project. ? Project team, which is the group of individuals doing work on the project. ? Sponsor, who is the individual or group that provides funding for the project. There are some new concepts that are also very valuable observed from the research process, specifically around critical resources, these go as far as to say resources need to be defined in a way that allows for effective management of the project and that the role of the project manager and his competencies are the critical issues when evaluating the concept around resources for a project. After detailed analysis and review of the different sources of information optimal or critical list of resources, the resources were grouped and limited as follows, project manager, technical resources, business resources and sponsor resources. The performing resources were excluded from the research process as these resources and their effort level tend to vary significantly depending on the scope of the project. The performing resources are also not defined in the front end loading of a project but are rather defined by the contractor or service provider early in the execution phase of the project. The qualitative research associated with the definition of these resources or effort level can be considered for future research. The concept of level of effort is one that is relatively new within the project management environments and it was a very key concept to the research conducted. This concept is simply defined in Chapter Two as a quantifiable count and measure of definable labor units that is required to arrive at the completion of a phase of a particular project schedule. Literature on the definition or calculation of level of effort for project resources is very limited currently as there are currently numerous computer programs utilized by organizations and project managers to define quantitative resource plans thus the need for a qualitative tool does not seem to be a point of current focus. In terms of the level of effort required from the technical resources throughout the project life cycle, the Engineering Council of South Africa gives an indication of the level of effort per phase based on the recommended percentage of payment for the technical resources per phase, this detail is given in Table 2 on the next page. Table 2: Summary of Project Deliverables according to ECSA Source: Republic of South Africa, 2014, pp.40 Project Phase Typical Percentage (Stage of Service) points for each stage Inception 5 Concept and Viability 15 Design Development & Documentation and Procurement 40 Contract Administration and Inspection 35 Close-out 5 However there is very recent literature from the international community of project managers that was very useful towards defining the level of effort required from a resource which was discussed in detail in Section 2.9 of this thesis. These guidelines together with the qualitative representation given in Section 2.7 and knowledge of the researcher based on previous projects aided in defining the level of effort at different phases for different resources for small projects. The assumptions and information from literature related to level of effort will later be compared to the feedback from the questionnaire. In evaluating all the aspects related to projects and project management as defined earlier in this section it was important to also acknowledge that the project deliverables are also dependent or influenced by numerous factors including those discussed earlier. The project deliverables as discussed in Section 2.7 can be defined as the work or product located at the end of a hierarchy of activities, which can be a product, equipment or documentation. These deliverables are generally determined by the client, the organizational governance and the project life cycle model adopted. The definition of deliverables and milestones is key in that it directly influences whether the project is termed a success or not. Prior to concluding the discussion regarding project deliverables the concept of project success will be explored as this can influence the project deliverables. This concept of project success or project success factors was discussed in section 2.10 of the report. This concept is not similar to project management success which is centered around the successful management of the project diamond, i.e. cost, quality, schedule and scope, but rather is centered around the measures that have been specified in the definition of a project being a success or not. These measures were highlighted in detail in Table 1 of this report and vary from adherence to the project mission, client acceptance of the final product and provision of timely and accurate data to key stakeholders. In understanding project success, project success factors or the definition of victory for small projects it then becomes clear what the list of key deliverables for the critical resources in small projects within the petro-chemical industry should include. Literature by Westland (2006) gives insight into the deliverables for the four phase project life cycle acceptable by the project management fraternity. These deliverables are summarized per phase in Table 3 below, however these are not indicated per resources. Table 3: Summary: Project Deliverables according to Literature Source: Westland, 2006, pp.221 Project Phases Initiation Phase Develop Business Case Planning Phase Develop Project Plan Execution Build/Contract/Fabricate Deliverables Closure Perform Project Closure Complete Feasibility Study Create Resource Plan Monitor and Control Review project completion Deliverables Establish Terms of Reference Create Financial Plan Cost Management Appoint Project Team Create Quality Plan Quality Management Set up Project Office Create Risk Plan Risk Management Gate review and Sign-off Create Acceptance Plan Acceptance Management Create Communication Plan Communication Management Create Procurement Plan Procurement Management Contract Suppliers Issue Management Gate review and Sign-off Change Management Time Management Gate review and Sign-off The list of deliverables for small projects can be extremely detailed as seen in Table 4 beyond what has been defined above in Table 3. The information highlighted in Table 4 was based on the feedback and analysis of the different sources of information utilized for the qualitative research process as defined earlier under research methodology. Appendix Two gives a detailed list of deliverables as observed during the participant observation research process. The deliverables are indicated per phase for the three types of projects currently executed in Sasol Synfuels, namely complex renewals or capital projects, in- house/EPC Renewals and lastly in-house renewals. The magnitude and type of projects as defined earlier specific to this research can be categorized as in-house renewals according to the Sasol Synfuels Project Management Procedure. However the questionnaire feedback regarding deliverables required per project life cycle phase will be discussed later in more detail in Section 4.3. This feedback will also be reviewed, analyzed and included in the final discussion of results and development of the model as per the objectives of the research project. Table 4: Summary: Project Deliverables according to Qualitative Research Process Project Phases Initiation Phase Develop Business Case Planning Phase Develop Project Plan Execution Build/Contract/Fabricate Deliverables Closure Perform Project Closure Develop Business Plan Create Resource Plan Monitor and Control Review project completion Deliverables Complete Feasibility Study Create Financial Plan Cost Management Post Audit Report Appoint Interim Project Team Create Quality Plan Quality Management Performance Certified Develop Preliminary and Conceptual Engineering Proposals Create Risk Plan Risk Management Close out of all governance documents Develop Project Execution Philosophy Create Acceptance Plan Acceptance Management Optimize business and product Develop Project Execution Strategy Create Communication Plan Communication Management Post Audit Report Initiation Phase Planning Phase Execution Closure Establish Terms of Reference Create Procurement Plan Procurement Management Performance Certified Develop Basic Development Charter Contract Suppliers Issue Management Project Close-out Report Develop Level 1 Schedule Update Project Estimate Change Management Ensure Governance Develop Very Rough Order of Magnitude Estimate Develop Final Business Case Time Management Optimize business and product Gate review and Sign-off Finalize Basic Engineering Package Start-up Assistance Optimize facility, safety, reliability and integrity Execution Funds Approval Ensure Technical Integrity Project Governance Develop Level 2 Schedule Develop Level 3 Schedule Corporate Governance Gate review and Sign-off Ensure Governance Gate review and Sign- off Final product or running entity Project Close-out review plan Gate review and Sign-off The literature, case studies and participant observation discussed were all used in further developing the hypothesis model in order to address the requirements of the objectives of this research project. The research hypothesis for this research therefore states, as defined earlier in Chapter Three that there are four phases for small projects which are namely project initiation or start, project definition or planning, project execution and lastly project closure or start-up. The level of effort required per resource per phase is very dynamic and varies significantly throughout the project life cycle. The four key resources being namely the project management resources, technical resources, business resources and sponsor resources. The information obtained from the participant observation research process also indicated clearly the changes in the effort level from the different resources involved within the project as the project moves from one phase to another. The resources were identified as follows: ? Project Management ? Technical or Engineering ?

Operations ? Strategy and Business Figure 31 clearly indicates the changes in the level of involvement or level of effort as termed in this research, for the four resource types as the project moves from one phase to another as defined by the Sasol Synfuels Project Management Procedure. The alphabets indicated in the sketch give an indication of which resource is Responsible (R), Accountable (A), Consulted (C), Supports (S) and Informed (I). Appendix Three gives a graph indicating the level of involvement per resources for complex projects as an indication of the changes or variations in terms of responsibilities for the different resources depending on the typology and complexity of a project. Figure 31: In-house Renewal Project Level of Effort Source: Synfuels Projects, 2013, pp.32 The research hypothesis is defined taking into consideration the different research methods utilized for this research project and is further defined in Table 5 and graphically in Figure 32 in terms of the effort level required per resource at the different phases of the project life cycle. Table 5: Hypothesis Maximum Effort Level per Resource Resources Project Life Cycle Phases (Maximum Effort Level Per Resource %) Initiation Planning Execution Closure Project Management 20 16 40 20 Technical Resources 40 50 15 5 Business Resources 10 10 5 25 Sponsor Resource 10 30 10 45 60 All Project Resources: L evel of Effort 50 40 Level of Effort 30 20 10 0 Initiation Phase Planning Phase Exececuation Phase Closure Phase Project Management Resources Technical Resources Figure 32: Research Hypothesis Graphical Presentation Later in the thesis the feedback from the research questionnaires will be analyzed and evaluated against the current literature specifically on four concepts, the definition of key resources, the level of effort required, the deliverables and the project phases. The representation of the hypothesis will be evaluated graphically later against the respondent feedback to clearly indicate the gap or alignment between the hypothesis and the qualitative feedback. The research objectives also include for a discussion regarding the areas of alignment or congruency from current literature to the hypothesis. Table 6: Summary of Research Findings Area of Review Literature Review Hypothesis Case Study Summary Project Life Cycle Aligned to four, six and eight phase model Defined around the four phase model Support for four and six phase models Significant alignment observed through the research process with very minor conflicting ideas. Project Phases Initiation, Planning, Execution and closure phases Initiation, Planning, Execution and closure phases Start, Detailed, Execution and Termination The naming convention is different however in essence there is also alignment in terms of the objectives for the different project phases. Critical Resources Project Manager, Customer, Performing Organization, Project Team and Sponsor Project Manager, Technical, Business and Sponsor Resources Project Manager, Customer, Engineering and Sponsor resources Significant alignment observed in terms of critical resources for projects. New ideas that conflict the idea of critical resources however are developing and are gaining support within research. Deliverables Extensive list of deliverables documented well in research literature. Hypothesis provided a summary of deliverables which in principle are similar to research literature. The deliverables are well understood and tend to vary depending on project complexity and organizational governance. Alignment on key deliverables for the different phases. This is a subject that is well documented and understood in industry. Organizational governance gives stringent requirements with gate keepers specific to deliverables for different types of projects. Level of Effort Methodology defined by International Community of Project Manager Aligned to participant observation Not documented. The concept of level of effort is one that has not be well research or documented by scholars. The focus in the industry is mainly on quantitative resource definition rather than qualitative. 4.2.2 Objective Three The third objective of the research project centers on the development of a graphical model to give an indication or guidance in terms of the resources required and level of effort for the different phases of the project life cycle for small projects within the petro-chemical industry. In essence this allows for a graphical representation of the key aspects observed from the literature reviewed and the qualitative data analysis completed for the purpose of this research project. The graphical representation can be utilized for front end loading on projects or be further refined by other scholars in the future. Project managers will have the opportunity to utilize the graphical model when planning to execute small projects within the petro-chemical industry in South Africa. The graphical model will be defined later in the thesis after analysis of the data obtained from the qualitative questionnaires and the participant observations. 4.3 Data Analysis Data analysis for a qualitative research project required the researcher to evaluate the information from three distinct perspectives, namely literally, reflexively and interpretively. Allowing analysis in these three different methods added value towards reviewing the information and the results specifically because the researcher's sample for qualitative research was generally small. The data was analysed primarily from the deductive approach utilising the questionnaires to group the information and then looked for areas of alignment and areas of differences. The information was then reviewed together with case studies, historical research, latest literature and participant observations to further adjust the hypothesis and develop the graphical model as per the research objective deliverables. 4.3.1 Participant Observation The number of projects that were utilised in terms of participant observation for the purpose of the research were limited to five (5) over a period of thirty six (36) months. The information was then categorised based on the qualitative research method utilised as discussed earlier in Section 3.5.1. Microsoft Excel and Word were utilised to structure the information and develop graphical trends or representation. The information will later in this Chapter be shown primarily in graphical form with only key information highlighted on the graphs. The calculations and the raw data used in developing and defining the graphs are included in Appendix Nine for detailed review and analysis. Table 7: Average measure from the participant observation on five projects Average Measures from all Projects Project Phase Resources Project Management Technical Business Sponsor Initiation 18% 36% 26% 19% Planning 26% 40% 17% 17% Execution 52% 22% 16% 10% Closure 40% 20% 31% 9%

Average Level of Effort from Participant Observation Leve of Effort 60% 50% 40% 30% 20% 10% 0% Initiation Planning Execution Closure Resources Project Management 18% 26% 52% 40% Resources Technical 36% 40% 22% 20% Resources Business 26% 17% 16% 31% Resources Sponsor 19% 17% 10% 9% Project Phases Figure 33: Average level of effort from five projects observed by participant. 4.3.2 Research Questionnaires The research questionnaire attached in Appendix Six was utilised to obtain qualitative feedback from engineers and project managers within Sasol and externally from consultants that undertake projects for Sasol and other organisations within the petro-chemical industry. The detail of the departments and consultant that provided consent in terms of the feedback required for the research project is given in Appendix Seven; however this information should remain strictly confidential. The research questionnaire was circulated to over 120 participants, however only 53 responses (44%) were received back from the group, both internal to Sasol and engineering consultants, were considered for the purpose of the research project. The percentage of response from the questionnaires was not very positive however as the questionnaires were very extensive in the detail required and the sensitivity of the information required. The quality and quantity of the feedback obtained was acknowledged to be a good presentation of the research group. This section of the thesis provides a summary of the qualitative feedback received from the research group, the detail of the feedback can be found in Appendix Ten. The information was evaluated from a qualitative and quantitative point of view; Table 8 gives an indication of the spilt of the information. Table 8: Grouping of Questionnaire feedback data Research Questionnaire Feedback Qualitative Review (Summation of the details) Quantitative Review (Graphical Representation) Project Typology, Complexity and Schedule. x Project Deliverables per Phase x Project Resource Loading: Total Hours Details were not provided by all respondents. Project Resource Loading: Percentage x Project Success x 4.3.3 Interpretations of Questionnaire Results The data obtained from the qualitative questionnaires as discussed in the previous section was analyzed and summarized into key areas as per the research objectives to highlight the feedback from the research process. The results will be summarized as follows in this section of the thesis: ? Project typology, complexity and schedule. ? Project deliverables. ? Level of effort per resource. The summary of results from the questionnaires, participant observations and literature reviews will then be critically compared later in this section to clearly indicate areas of alignment and misalignment. In order to prevent dilution and misrepresentation of the research data and results, the misalignments identified from the three different research processes specifically pertaining to the level of effort measures will not be addressed by means of averaging the information or utilizing the mean of the various data points. The researcher’s experience and knowledge of the project management environment was utilized in adjusting the difference from the different research sources to provide input towards the final graphical model that would be presented as a deliverable in line with the research objectives. It was however imperative to focus on providing a model that can be utilized further in research or in industry specifically regarding the level of effort required per resource for the different phases and the deliverables required per phase. The following graphs, Figure 34 and provide detail on the project complexity, type, budget and schedule as observed from the review of the research questionnaires obtained. Research Questionnaire Feedback: Project Type Non- technical 11% Research Questionnaire: Project Complexity High 9% Low 23% Technical Medium 89% 68% Figure 34: Research Questionnaire Feedback: Project Type and Complexity. Research Questionnaire: Project Questionnaire: Project Budget Project Schedule Below R50 Million R50.1 to R99 Million R100 to R199 Million Above R200 Million Less than 12 Months 12 to 24 Months 25 to 36 Months More than 37 Months Figure 35: Research Questionnaires Feedback: Project Budget and Schedule. Table 9: Summary of Research Questionnaires Project Deliverables Feedback Project Phase Resources Research Questionnaires Feedback CONCEPT PHASE Technical Resources ? ? ? ? ? ? ? ? ? ? Feasibility Study Report Technical Justification Report Scope of work for concept design. Tender evaluation Concept Design Review of previous failures and maintenance strategies. Registration of the required modification Preliminary schedule for technical scope Obtain existing system technical information. Technology selection for the project Project Management Resources ? ? ? ? ? Develop level 1 project schedule Develop a Potential Deviation Analysis Develop a resource plan Ensure all the governance documentation is completed as per schedule. Manage interfaces between different disciplines. Sponsor Resources ? ? ? ? ? Evaluate the need for the project Develop and maintain organizational project budgets. Ensure project governance. Provide funding for concept phase of the project Appoint a project manager Business Resources ? ? ? Develop the business case Evaluate the concept design and the technology selection. Inform the rest of the business on the project progress Project Phase Resources Research Questionnaires Feedback PLANNING PHASE Technical Resources ? ? ? ? ? Update schedule for technical scope Basic Design Managing the completion of technical activities Ensure procurement and fabrication of long lead items. Completing engineering studies such as HAZOP (Hazard and Operability) and RAM (Reliability Availability and Maintainability) studies. Project Management Resources ? ? ? ? ? ? ? Develop level 3 project schedule Define project team Develop project critical factors Ensure the project is accommodated in the outage/shut-down plan. Arrange the project communication and meeting guidelines. Apply for project execution phase funds. Approval of contracts for the project Sponsor Resources ? ? ? ? ? Providing alignment and support between the project team and the business. Support address project risks Provide funding for the project. Ensure project governance Review the project schedule and scope of work Business Resources ? ? Provide input to the design based on operational requirements. Participate in engineering studies such as HAZOP and RAM studies. Project Phase Resources Research Questionnaires Feedback EXECUATION PHASE Technical Resources ? ? ? ? ? ? ? ? Detailed Design Developing scope of work for tendering purposes. Tender evaluations Placing contracts for resources and materials required for the project. Support in ensuring quality control measures. Inspections and sign-off on work completed Interface management between different engineering disciplines. Pre-commissioning report. Project Management Resources ? ? ? ? ? ? Update project schedule (Level 4 Schedule) Appoint service providers and contractors for the execution scope. Management and reporting on project triangle. Ensuring all required resources and equipment is available for the project. Approval of milestone payments Site inspections and sign-off on work completed. Sponsor Resources ? ? ? Ensure project governance Provide funding for execution phase of the project Hold the project manager accountable for project triangle measures. Business Resources ? ? Develop operating procedures Participate in design reviews based on operational experience. Project Phase Resources Research Questionnaires Feedback DELIVERY PHASE Technical Resources ? ? ? ? Review of end of job documentation Updating of internal documents Close out of change management process Ensuring operation of the equipment or system is as per original requirements Project Management Resources ? ? ? ? Final reports for the project. Project close out Gather information from project resources to provide feedback. Manage the project triangle. Sponsor Resources ? ? ? ? Review final project reports Ensure governance Ensure all business documentation has been updated Approval to commission the system/project. Business Resources ? ? Commission and operate the new product or system. Assessing the impact of the project on business The graphs given in Figure 36 and 37 give the representation of the level of effort feedback from the research questionnaires. The graphs are separated as some of the respondents provide the quantitative data; the hours booked per resource and also provided a percentage value for the level of effort. This can be clearly observed from question 18 and 19 of the research questionnaire in Appendix Six. The sensitivity and volume of the quantitative data was a concern for respondents as only sixteen percent (16%) of the respondents provided quantitative data. Irrespective of the low response rate on this question, this information did not form the basis for the project as the objective was to develop a qualitative model based on a qualitative research process. Questionnaire Feedback: Quatitative Feedback 80.00 70.00 Level of Effort (%) 60.00 50.00 40.00 30.00 20.00 10.00 0.00 Concept Planning Execuation Delivery Technical 66.85 47.46 42.65 37.49 Project Management 24.77 38.35 41.07 31.59 Sponsor 4.69 8.86 6.22 14.08 Business 3.68 5.33 10.06 16.83 Project Phases Figure 36: Research Questionnaires Feedback: Quantitative Responses. 80.00 Questionnaire Feedback: Qualitative Feedback 70.00 60.00 Level of Effort (%) 50.00 40.00 30.00 20.00 10.00 0.00 Concept Planning Execuation Delivery Technical 69.89 49.78 28.78 37.44 Project Management 17.67 37.89 41.26 33.00 Sponsor 7.33 6.67 15.00 9.89 Business 5.11 5.67 Project Phases 14.97 19.67 Figure 37: Research Questionnaires Feedback: Qualitative Responses. The combined qualitative and quantitative information obtained from the research questionnaires was also compared against the participant observation information as shown previously in section 4.3.1; Table 10 below provides a comparison of this information. As can be seen there we significant discrepancies on the level of effort measure from the questionnaires and that recorded from the participant observation feedback. This discrepancy was noted but not investigated further for this research project. Table 10: Summary of research feedback on level of effort. Project Project Management Technical Business Sponsor Phase Resources Resources Resources Resources Participant Research Participant Research Participant Research Participant Research Observation Questionnaire Observation Questionnaire Observation Questionnaire Observation Questionnaire Concept 18% 18% 36% 70% 26% 5% 19% 7% Planning 26% 38% 40% 50% 17% 6% 17% 7% Execution 52% 42% 22% 29% 16% 15% 10% 15% Delivery 40% 33% 20% 37% 31% 20% 9% 10% The information was then analysed and presented in a manner that shows its consensus or conflict with the original hypothesis for the research. The information was then utilised to modify the hypothesis or to develop future investigations that may be required to prove or disprove the research hypothesis. The graphical patterns drawn were then explained individually and cumulatively in order to provide results that have meaning, experience and views. Table 11: Summary of Research Findings including Research Questionnaires Area of Review Other Qualitative Research Methods Participant Observations Research Questionnaires Project Life Cycle Significant alignment observed through the research process with very minor conflicting ideas. The main project life cycle models being: ? Four phase ? Six Phase ? Eight Phase Exposed to four phase and eight phase project life cycle models The research questionnaire was developed in line with the four phase project life cycle model which is utilized mainly for small projects within the chosen research environment. Area of Review Other Qualitative Research Methods Participant Observations Research Questionnaires Project Phases The naming convention was observed to be different from one source to another however in essence there is also alignment in terms of the objectives for the different project phases. The four phases observed by the participant for the projects evaluated were namely: ? Feasibility Phase ? Basic Development Phase ? Execution Phase ? Start-up Phase The questionnaire was developed in line with the phases utilized within the selected research environment, namely: ? Concept Phase ? Planning Phase ? Execution phase ? Delivery phase Critical Resources Significant alignment observed in terms of critical resources for projects. New ideas that conflict the idea of critical resources however are developing and are gaining support within research. The following resources were identified as critical from the participant observation: ? Project Management Resources ? Technical Resources ? Business Resources ? Sponsor Resources The research questionnaire was developed with four main resource groups, in order to align to the research environment, these resources were namely: ? Project Management Resources ? Technical Resources ? Business Resources ? Sponsor Resources Deliverables Alignment on key deliverables for the different phases. This is a subject that is well documented and understood in industry. Organizational governance gives stringent requirements with gate keepers specific to deliverables for different types of projects. The phase deliverables were clearly defined for the projects as they were directly influenced by the organizational governance and requirements. An extensive list of deliverables was obtained from the 53 research questionnaires received from the respondents. There was alignment in terms of the feedback obtained. The feedback as extremely detailed as it was specific to particular projects. Level of Effort Level of effort is shown in literature as an indication but without detail required for front end loading. The organizational guideline, experience and observation on previous projects were utilized in define the level of effort for the projects considered. The research questionnaire provided extremely valuable information on the detail required to develop the level of effort models. The information from the different respondents was aligned. Proposed Model for Level of Effort for Project Resources 60% Level of Effort (%) 40% 50% 30% 20% 10% 0% Concept Planning Execution Delivery Technical 50% 45% 30% 30% Project Management 20% 35% 45% 35% Sponsor 15% 10% 10% 10% Business 15% 10% 15% 25% Project Phases Figure 38: Proposed Level of Effort Qualitative Graph Table 12: Summary of Research Findings including Research Questionnaires Project Project Management Technical Business Sponsor Phase Resources (LOE) Resources (LOE) Resources (LOE) Resources (LOE) Hypothesis Proposed Model Hypothesis Proposed Model Hypothesis Proposed Model Hypothesis Proposed Model Concept 20% 20% 40% 50% 10% 15% 10% 15% Planning 16% 35% 50% 45% 10% 10% 30% 10% Execution 40% 45% 15% 30% 5% 15% 10% 10% Delivery 20% 35% 5% 30% 25% 25% 45% 10% The comparison of the original hypothesis to the proposed model based on the research process undertaken for this research project indicates a very small margin in terms of the values indicated for the level of effort for the four critical resources from concept to delivery phase. This clearly indicates there was more alignment rather than conflict between the hypothesis detailed in section 3.4 of this report, with the exception of a few values as indicated in Table 12 above. Page 84 4.4 Another Engineering Model The use of a model as a tool within the technical environment is not a new phenomenon and has been adopted and utilized extensively within the petro-chemical industry. A common tool utilized within the mechanical engineering fraternity is the pump and performance curves or model. Figure 39 gives a theoretical illustration of what is commonly referred to in industry as pump curves for centrifugal pumps. Figure 39: Theoretical Model of Pump Curves Source: Grundfos Research Technology, c.2014, pp.56 These theoretical curves are developed to give more detail in terms of the pump performance for every pump before it is supplied to the market. These curves are then termed pump performance curves and will entail the following information on a particular pump as per in service tests conducted pre-entry into the market: ? Head (H) ? Flowrate (Q) Page 85 ? Power Consumption (P) ? Pump Efficiency (η) ? Net Positive Suction Head(NPSH) Figure 40 below gives an indication on how this information can be read from a particular pump performance pump curve. Table 11 gives a summary of the information read from the graph based on a required flow rate of seventy (70) m3/h. Figure 40: Typical Pump Curves for Centrifugal Pump Source: Grundfos Research Technology, c.2014, pp.30 Table 13: Pump Information Obtained from Performance Curve Description Value Value Head 42 m Power Consumption 10 kW Pump Efficiency 85% Net Positive Suction Head 3 m As seen in Appendix Eleven this information can vary significantly depending on the shape of impeller. An example of how the pump curves are issued in industry with a pump (KSB pump) on delivery to the end-user is also attached in Appendix Eleven. The pump curves clearly indicate the benefits of a model that can be used in industry, as these curves are used in projects during detailed engineering of pumping systems, during analysis or fault finding on pump performance during normal operation and other situations. The final model that will be defined in Section 5 of this thesis as per the research objective will function as highlight in this section in providing a qualitative measure of the deliverables, level of effort and the resources required per phase for small projects. 4.5 Conclusion In this section of the thesis, multiple sources of data were utilized in defining a model that can be utilized to qualitatively define the level of effort required per resource at different phases of the project. The data was categorized mainly into three categories for the purpose of data analysis completed. The three main categories being namely: ? Data from previous projects observed by the participant. ? Data obtained from the qualitative research questionnaires ? Concepts and literature noted from the literature review process. The main areas of evaluation during the research process are summarized below: ? The types of project life cycles. ? The types of project phases. ? The critical deliverables at different phases of the project. ? The key resources types for the project. ? The level of effort required per resource at different stages of the project. In evaluating these areas the information was mainly aligned to the hypothesis, literature reviewed and the research process undertaken for the project. The areas of alignment were mainly on the project life cycles, project phases and deliverables per phase. The definition of key resources was not totally aligned to the hypothesis and literature as the hypothesis provided four main resources and literature highlighted multiple ideas which vary from the project manager being the only critical resources to a list similar but longer to that specified in the hypothesis for critical resources. In terms of the research questionnaires, the participants were not requested to give input on the critical resources as the questionnaire was developed based on four critical resources as defined in the hypothesis. The feedback received from the questionnaire however did not conflict this idea as resource loading feedback was aligned to the resources defined in the hypothesis. The qualitative research questionnaires were circulated to a significant group that entailed both internal and external to Sasol respondents. The feedback was based on project detail provided however was from mainly technical projects, specifically (89%) eighty nine percent of the projects were technical, sixty eight percent (68%) of which were of a medium complexity. Three quarters of the projects that feedback was provided for were completed within a period of twenty four to thirty six months, half of which had a total project budget of less than fifty million rands. This is important to highlight for the research findings as it is in line with the research objective of developing a model for small projects which are generally defined in industry in terms of project complexity, budget and schedule. Similarities and areas of misalignment were highlighted in tabular form in detailing the summary of the investigations for the following key research requirements: ? Project life cycles observed and utilized. ? The definition and associated understanding of project phases. ? Critical resources as defined in industry and literature for projects. ? Key deliverables defined at different project phases. ? The definition and understanding of the concept defined as the level of effort. Both in industry and literature reviewed, the areas of alignment were well documented and understood except the concept of level of effort, which is not well documented or understood. Thus the need for this research project which focused on further defining the concept of level of effort and obtaining research data as discussed in section three of the thesis which was utilized in this section after detailed data analysis to further develop the definition of the concept and the magnitude of effort required from four critical resources based on industry experience from the numerous research participants. After the analysis and evaluation of the numerous streams of information, a schematic representation of the information is provided in Figure 41 on the next page, which clearly provides a qualitative representation of the level of effort required per resource as per the deliverables required for the phase per particular resource. This model was developed based on the limited feedback based on small projects within the petro-chemical industry in South Africa. The response from the qualitative questionnaires, at forty four percent (44%) should not be concerning as multiple methods of research were utilized and the responses were well aligned towards the values given in the final model. In conclusion based on the extensive research process undertaken for the research project the concept of level of effort has been addressed and highlighted well in the detailed model indicated in detail in Appendix Twelve. The benefits, further developments and contributions of this model are discussed in the next chapter. It was however very encouraging to note the alignment or how small the variances were for the proposed level of effort measures obtained from the research questionnaire feedback versus the original hypothesis level of effort measures as indicated earlier in this section. In essences there was clear alignment between the hypothesis and the feedback from the research process. Level of Effort for Project Resources 60% 50% Level of Effort (%) 40% 30% 20% Technical Project Management Sponsor Business 10% 0% Concept Planning Execution Delivery Technical Resource Deliverables Feasibility Study & Concept Design Report Basic Design Report Detailed Design and Pre- Commissioning Report Compile and Review End of Job Documentation Sponsor Resources Deliverables Evaluate the Need for the project and provide funding Ensure Provide Funding Review final Governance and and hold Project documentation review scope and Manager and approve for schedule Accountable commissioning Business Develop business Resources case and inform Deliverables business of projects Provide operational requirements in the design. Develop Operating Procedures Commission and Operate the New system. Project Management Deliverables Develop project resources requirements and Plan Develop the project Diamond (Cost, Schedule and Scope) Reporting on and managing the project diamond Provide final documentation and close the project Figure 41: Level of Effort qualitative graph with key deliverables per resource The use of schematics or graphs to extrapolate or obtain information based on a constant in industry has been used and continues to be used extremely well in the engineering environment. An example of a pump curve discussed earlier in this section clearly proves a graphical model can be utilized with much success in industry. Therefore the use of a qualitative model to define the level of effort and the deliverables required for a project can add value in industry. CHAPTER 5: CONCLUSION AND RECOMMENDATIONS 5.1 Introduction This section of the thesis will provide a summary of the conclusions from the research processes followed for the research project, namely: ? Literature reviewed ? Participant observation feedback ? Research questionnaires feedback The information obtained from the numerous research processes was analyzed and evaluated in chapter four of the report. The conclusions from the data analyzed will also be presented as a summary to the report in this section. The final model to be proposed to scholars and industry for managing critical resources on small projects within the petro-chemical industry and the associated level of effort at the different phases of the project life cycle will also be presented in this chapter. In conclusion, the recommendations will also be included in this section which will be presented in this chapter to ensure that the knowledge base is further developed by others in the future. The recommendations will be provide in two sections, firstly recommendations based on the learning observed from the current research project and lastly recommendations for future studies. 5.2 Conclusions A large number of small projects are executed annually by numerous organisations within the petro-chemical industry, these projects vary from changes in organisational structures, information technology changes, construction, manufacturing and procurement of equipment or creation of new organisations to state a few. The management of these projects is critical as organisations typically define the scope, quality, schedule and cost for these projects based on future earnings, profitability, clients and organisational growth from the success of these projects. The successful execution of these projects is therefore crucial for many organisations and continuous to become even more crucial as organisations that have developed systems to manage projects successfully tend to be in a position to sustain themselves into the future and have a competitive advantage over their competitors. This research investigated the current systems, models, ideologies and tools currently utilised and documented specifically for small projects. Small projects are often seen as non-critical mainly because of the end of job budget allocated to the project and the impact each project has to the organisation. However small projects as a collective for most organisations utilise a substantial budget and have the potential to impact the profitability or sustainability of an organisation in the very long term. The research has defined the different project life cycles model and their associated project phases, specifically those that have been adopted by other researchers and project managers in industry. The project phase deliverables were also extensively researched in order to understand and define the activities required from the various resources in order to complete the project. The resources or stakeholders involved in the project at different project phases were defined based on literature, industry research and case studies. The focus was mainly on defining the resources and understanding the level of effort required from the different resources at the different phases of the project life cycle. The concept of level of effort was not extensively documented in literature as most of the literature evaluated only provided a high level definition of the concept. The graphs and models provided in literature did not provide sufficient detail but rather an indication of how dynamic this measure is during project execution. During the research process this concept of level of effort was defined for various resources and a guideline provide by the the International Community of Project Managers. It was clear the reason why this concept has not been documented or investigated extensively in industry or literature was mainly because many organisations and scholars prefer or focus on defining resources more quantitatively rather than qualitatively. The tools and methods recommended for quantitative resource planning in projects is a matter that well understood and preferred in industry. In order to obtain data from industry regarding the hypothesis, questionnaires were circulated to a pool of one hundred and twenty (120) participants within the Petro-Chemical industry and processed, analysed and presented into mathematical graphs that were compared against the research hypothesis. The focus of this qualitative research was primarily to qualitatively define the hypothesis that states that the level of effort for critical project resources varies significantly depending on the phases of the project life cycle for small projects as defined earlier in the research. The hypothesis was defined or illustrated by means of mathematical qualitative graphs that were tested against the research data and literature. The opposing or conflicting literature that was evaluated was also discussed and areas of future investigation will be highlighted for scholars to test and research at a later stage, in this section. The contribution of the research project is a qualitative model that defines the level of effort for resources at different project life cycle phases based on the deliverables required per phase which can later be utilised in industry for effective and efficient resource management on small projects, as given in Figure 42. The model alone as provided in Figure 42 on the next page is not sufficient as a conclusion but the manner or guideline in the utilisation of the tool in practice as seen with the pump graphs illustrated earlier in Chapter four. The model is intended to be utilised for small projects within the petro-chemical industry as defined earlier in the project and on the next page a summary of the definition: ? Projects with no more than a medium complexity interpretation. ? Projects with a project schedule not longer than thirty six (36) months. ? Projects with a budget less than fifty million rands. Level of Effort for Project Resources 60% 50% Level of Effort (%) 40%

30% 20% Technical Project Management Sponsor Business 10% 0% Concept Planning Execution Delivery Technical Resource Deliverables Feasibility Study & Concept Design Report Basic Design Report Detailed Design and Pre- Commissioning Report Compile and Review End of Job Documentation Sponsor Resources Deliverables Evaluate the Need for the project and provide funding Ensure Provide Funding Review final Governance and and hold Project documentation review scope and Manager and approve for schedule Accountable commissioning Business Develop business Resources case and inform Deliverables business of projects Provide operational requirements in the design. Develop Operating Procedures Commission and Operate the New system. Project Management Deliverables Develop project resources requirements and Plan Develop the project Diamond (Cost, Schedule and Scope) Reporting on and managing the project diamond Provide final documentation and close the project Figure 42: Level of Effort qualitative graph with key deliverables per resource Page 95 Once a project is assumed to be within the margins of a small project the model can be utilised to develop a conceptual effort level resource plan as noted below in Table 14 Table 14: Resource Plan Based on Level of Effort as per Qualitative Model Project Level of Effort Phase Project Management Resources Technical Resources Business Resources Sponsor Resources Concept 20% 50% 15% 15% Planning 35% 45% 10% 10% Execution 45% 30% 15% 10% Delivery 35% 30% 25% 10% The detailed model given in Appendix Twelve will provides detail into the key deliverables per resource per phase for example the following are defined as the key deliverables for the project management resources for the concept phase: ? Develop level 1 project schedule. ? Develop a Potential Deviation Analysis. ? Develop a resource plan. ? Ensure all the governance documentation is completed as per schedule. ? Manage interfaces between different disciplines. Therefore twenty percent of the effort require from the resources at concept phase will be focused on project management deliverables as given in the list above, or defined in another way, twenty percent effort is required from the project management resource to ensure completion of the deliverables given above. In concluding the research project report it is important to confirm that the research questions and objectives were addressed as highlighted at the definition of the research project. The research objectives and questions as seen earlier in chapter one and two are related. The qualitative model given in figure 42 and in detail in Appendix twelve address the first and the third research questions which focused on how to present the changes in the level of effort for different resources at different phases of a project. The model and the values associated with the Page 96 level of effort per resource answers these questions and third objective defined for the research project. The second question of the research project primary questioned validity and alignment in terms of current literature and research data obtained specifically on the level of effort, project phases, project deliverables and project resources. As discussed earlier in chapter four, a detailed summary of the areas of alignment and misalignment were indicated and it was clear that there is much alignment or similarity both in literature and the research site on the areas investigated during the research process. The first two objectives of the research were mainly around the definition and review of a hypothesis which would be evaluated against the literature and research data that was obtained for the research site. Chapter three and four provide extensive detail on the hypothesis defined, the null hypothesis and the evaluation of the hypothesis against research feedback from questionnaire, literature reviewed and the participant observation. The areas of alignment between the hypothesis and the research data we significant with very minimal concern in terms of the detail in the original hypothesis that was presented with the research project. The research project as defined in this thesis report has addressed the areas of investigation as initially planned. The research has yielded good results and a qualitative model that has the potential to contribute positively to literature and industry. The thesis will therefore be submitted to the University of Kwa-Zulu Natal as part of the requirements of the Masters in Leadership Studies by no later than the 30th of June 2015. 5.3 Contribution of this Research The research project can contribute to the literature data base for future scholars and provide a tool to industry for the front end loading on projects. Previous research conducted regarding the concept of level of effort was very limited and this research project will add to the body of knowledge. Research conducted previously provided a qualitative graph for the level of effort as given in Chapter Two but the graph provided no indication in terms of magnitude, the graph merely provided a schematic interpretation of a dynamic curve that changes with the project phases based on the resources required at different phases, referred to by other scholars as level of involvement. This research project has given more detail in quantifying the variance in level of effort for different resources across the project life cycle. This research project therefore has contributed a set of qualitative mathematical graphs for small sized projects within the Petro-chemical industry in South Africa, which will assist in defining a dynamic project team, which will increase or decrease in size for different phases of the project life cycle. Section 2.9 of the thesis also provides a guideline that a project manager or engineer can utilise in testing these graphs or developing a level of effort for different resources required in projects. Such a qualitative tool can assist organisations, engineering and project management firms the opportunity to effectively utilise the resource pool available to the company on various projects, and it can further be utilised as an optimisation tool for skills required at different phases of the project life cycle on multiple projects. 5.4 Recommendations After the extensive qualitative research that was conducted in order to provide the research report required for the partial fulfillment of the requirements for the degree of Master of Commerce in Leadership Studies; this section of the thesis provides the recommendations from the researcher's perspective. The qualitative model that has been developed and detailed in Appendix Twelve can be utilized by engineers or project managers managing small projects within the petro-chemical industry at conceptual phase of a project. The model can be used at conceptual phase for projects to assist with defining or understanding the following better: ? Budget estimate for resources required on projects. ? Resource planning across multiple projects. ? Highlighting concerns on resources overloaded. ? Project scheduling or planning synchronized to resource availability. ? Defining key deliverables. The model should however be utilized with a safety margin or correction factor as the model is qualitative, proposal is to utilize a correction factors as defined in the Table 15 when defining the level of effort per resource. Table 15: Recommended Correction factor per Project Phase Project Phase Correction factor Concept 2.5% Planning 5% Execution 5% Closure 2.5% The research project was very specific in defining the model as a model to be utilized within the petro-chemical industry on small projects. However the model can be utilized in other industries with caution but would recommend the model be developed further to include medium and large scale projects. The next section of the thesis will provide more detail into future studies recommended specifically after completion of this research project that other scholars can consider for a thesis. 5.5 Recommendation for Future Studies The research project was conducted as a qualitative research project specifically focused on small projects within the petro-chemical industry. After developing the qualitative model for the level of effort for key resources at different phases of the project life cycle, the following list of recommendations should be considered for future studies: ? Develop the model produced from this research project further by undertaking a quantitative research method. ? Develop the model further to include projects in other industries and for medium and large scale projects. ? Evaluate the concept of critical resources in project management further to understand further the types of resources that can be defined as critical. ? Explore the conflicting ideology that states project life cycle models should be dynamic and specific to a project rather than defined as per current focus of the four, six and eight phase project life cycles. BIBLIOGRAPHY Abdou, A. (c.2012) Introduction to Project Management: United Arab Emirates University [Online], Available at: http://www.engg.uaeu.ac.ae/departments/units/gra/lec/Project Management techniques% 2011-12_ Dr. Alaa Abdou I.pdf [Accessed: 23 July 2014] Adams, J.R. and Barndt, S. E. (1988) Project management handbook: Behavioral implications of the project life cycle, New York: Von Nostrand Reinhold. Ansoff, H. I. (1984) Implanting strategic management, Englewood Cliffs, NJ: Prentice-Hall International. Archibald, R.D., Di Filippo, I. and Di Filippo, D. (c.2011) The Six-Phase Comprehensive Project Life Cycle Model Including the Project Incubation/Feasibility Phase and the Post-Project Evaluation Phase [Online], Available at: http://www.iil.com/downloads/Archibald_Di_Filippo_ComprehensivePLCModel_FINAL.pdf [Accessed: 19 July 2014]. Blake, S.B. (1978) Managing for responsive research and development, San Francisco, CA: Freeman. BRITISH STANDARDS INSTITUTE (2002) BS 6079-1: Guide to Project Management. London: British Standards Institute. Brooks, F. P. (1975) The mythical man-month: Essays on software engineering, New York: Addison Wesley. Burke, R. (2004) Project management: Planning and control techniques, 4th edition, Cape Town: Blue Weaver Marketing and Distribution. Chan, S. (2001) Complex Adaptive Systems

[Online], Available at: http://web.mit.edu/esd.83/www/notebook/Complex Adaptive Systems.pdf [Accessed: 5 September 2014]. Cooke-Davies, T. (2002) The “Real” Success Factors on Projects, International Journal of Project Management, vol. 20, pp. 185 -190. Chapman, C. and Ward, S. (1997) Project risk management, West Sussex: John Wiley & Sons Ltd. Frame, J.D. (1995) Managing projects in organizations, 2nd edition, San Francisco: Jossey-Bass Publishers. Grundfos Research Technology (c.2014) The Centrifugal Pump [Online], Available at: http://www.grundfos.com/content/dam/Global Site/Industries & solutions/Industry /pdf/The_Centrifugal_Pump.pdf [Accessed: 11 November 2014]. Horsburgh, D. (2003) Evaluation of Qualitative Research, Journal of Clinical Nursing, vol. 12, pp. 307-312. Huang, H., Shiu, J. and Chen, T. (2011) The Project Scheduling and Decision Mechanism Based on the Multi-Resource Leveling, EPPM, Singapore, pp.117-126. International Journal of Project Management (1999) The Need for New Paradigms for Complex Projects [Online], Available at: http://ieg.ifs.tuwien.ac.at/~aigner/projects/planninglines/evaluation/Project_Management/paper s/ williams99complexity.pdf [Accessed: 9 September 2014] International Project Management Association (2013) Project Perspectives: The Annual Publication of International Project Management Association [Online], Available at: http://ipma.ch/assets/re-perspectives_2013.pdf [Accessed: 23 July 2014] International Research Network of Project Management Conference (2009) A Model of Project Complexity: Distinguishing Dimensions of Complexity from Severity [Online], Available at: http://eprints.qut.edu.au/29011/1/c29011.pdf [Accessed: 9 September 2014] Izadpanah, H., Arbabi, H. and Kord, B. (2012) The Reality of Project Management Office for Construction Organization in the Oil, Gas and Petrochemical Industry of Iran, Research Journal of Applied Sciences, Engineering and Technology, vol. 4, no. 15, pp. 2515 -2522. Khalili, H.A. and Maleki, A. (2011) Project Risk Management Techniques in Resource Allocation, Scheduling and Planning, World Academy of Science, Engineering and Technology, vol. 5, pp. 196-200. KSB (2005) Selecting Centrifugal Pumps [Online], Available at http://za.grundfos.com/content/dam/Global Site/Industries & solutions/Industry/pd f/The_Centrifugal_Pump.pdf [Accessed: 11 November 2014]. Lewis, J.P. (1998) Mastering Project Management, New York: McGraw-Hill. Lynch, B. (2003) Critical Chain Project Management: Coming to a Radar Screen Near You!, The Journal of Information Technology Management, vol. 16, no. 3, pp. 1 – 35. Marshall, M.N. (1996) Sampling for Qualitative Research, Family Practice, vol. 13. no. 6, pp. 522-525. Meziane, M.E.L., Meziane, K. E. I. and Liang, Y. (c.2010) A Study of Petrochemical Project Management and Design Practices in Petrochemical Firms in China, Hubei Changjiang Petrochemical Equipment Co., LTD (CJPCE) as Study Case, Asian Journal of Business and Management Sciences, vol. 1, no. 7, pp. 68 – 81. Milton, N. (2005) Knowledge management for teams and projects, England: Chandos Publishing. Mohamed, N.L. and Mohamed, K.J. (2012) Project Management Phases of a SCADA System for Automation of Electrical Distribution Networks, IJCSI International

Journal of Computer Science Issues, vol. 9, issue.2, no.2, pp. 157-162. Munk-Madsen, A. (c.2005) The Concept of 'Project': A Proposal for a Unifying Definition [Online], Available at: http://www.metodica.dk/pers/Define032.pdf [Accessed: 20 July 2014] Nigatu,T. (2009) Qualitative Data Analysis [Online], Available at: http://www.slideshare.net/tilahunigatu/qualitative-data-analysis-11895136 [Accessed: 10 August 2014]. Patton, M.Q., Cochran, M. (2002) A Guide to Using Qualitative Research Methodology [Online], Available at: http://fieldresearch.msf.org/msf/bitstream/10144/84230/1/Qualitative research methodolo gy.pdf [Accessed: 9 August 2014]. Project Management Institute (2000) A guide to the project management body of knowledge (PMBOK Guide), 2000 edition, Pennsylvania USA: Project Management Institute, Inc. Project Management Institute (2008) A guide to the project management body of knowledge (PMBOK Guide), 4th edition, Pennsylvania USA: Project Management Institute, Inc. Project Management Knowledge (2014) Effort [Online], Available at: http://project-management- knowledge.com/definitions/e/effort/ [Accessed 5 September 2014]. Republic of South Africa (2014) Government Gazette Guideline for Services and Processes for Estimating Fees for Persons Registered in Terms of the Engineering Profession Act, 2000, (Act 46 of 2000), Vol. 546,No. 38324, pp. 40 – 43. Page 104 Sage Publications (2012) Qualitative Data Analysis [Online], Available at: http://www.sagepub.com/upm-data/43454_10.pdf [Accessed 9 August 2014]. Sasol Limited (2012) Business Development and Implementation Model [Online], Available at: http://intwww.sasol.com/sastech/BDI/bdifrontpage.htm [Accessed: 19 June 2014]. Selaru, C. (2012) Resource Allocation in Project Management, International Journal of Economic Practices and Theories, vol. 2, no. 4, pp. 274-282. Shenhar, A.J, Dvir, D. and Shulman, Y. (1995) A Two Dimensional Taxonomy of Products and Innovations, Journal of Engineering and Technology Management, vol. 12, pp. 175-200. Slusarczyk, A. and Kuchta, D. (2011) The New Approach for Project Activities Classification and its Application in the Critical Chain Buffer Management Method, Institute of Organization and Management, vol. 1, pp. 142-162. Slevin, D.P. and Pinto, J.K. (1987) Balancing Strategy and Tactics in Project Implementation [Online], Available at: http://www.iei.liu.se/fek/utbildning/kurskatalog/723g18/articles_and_papers/1.107456/PintoSle v in1988.pdf [Accessed: 5 September 204]. Synfuels Projects (2013) Procedure: Project Management (SAX 10029304), Secunda: Sasol (Pty) Ltd. Taylor, D. (2014) The Literature Review: A Few Tips on Conducting It [Online], Available at: http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review [Accessed 12 August 2014]. The International Community of Project Managers (2014) Ten Steps to Estimate Effort on Your Project [Online], Available at: http://www.theicpm.com/blog/item/4706-ten-steps-to-estimate- effort-on-your-project [Accessed 5 September 2014] Turner, J.R, Huemann, M. and Keegan, A. (2008) Human resource management in the project- oriented organization, Atlanta: PMI Book Service Center. Turner, J.R. and Muller, R. (2005) The Project Manager's Leadership Style as a Success Factor on Projects: A literature Review, Project Management Journal, vol. 36, no. 1, pp. 49-61. Welman, J.C. and Kruger, S.J. (1999) Research methodology for business and administrative sciences, New York: Thomson. Westland, J. (2006) Project management life cycle, London: Kogan Page. Westney, E.R. (1992) Computerized management of multiple small projects, New York: Marcel Dekker, Inc. Wheelwright, S.C. and Clark, K.B. (1992) Revolutionizing product development, New York: The Free Press. Wikipedia (2014) Level of Effort [Online], Available at: http://en.wikipedia.org/wiki/Level_of_Effort, [Accessed 5 September 2014].

Page 1 Page 2 Page 3 Page 4 Page 5 Page 6 Page 7 Page 8 Page 9 Page 10 Page 11 Page 12 Page 13 Page 14 Page 15 Page 17 Page 18 Page 19 Page 20 Page 21 Page 22 Page 23 Page 24 Page 25 Page 26 Page 27 Page 28 Page 29 Page 33 Page 34 Page 35 Page 36 Page 37 Page 38 Page 39 Page 40 Page 41 Page 42 Page 43 Page 44 Page 45 Page 47 Page 48 Page 49 Page 50 Page 51 Page 52 Page 53 Page 54 Page 55 Page 57 Page 59 Page 60 Page 61 Page 62 Page 63 Page 64 Page 65 Page 66 Page 67 Page 68 Page 69 Page 70 Page 71 Page 72 Page 73 Page 74 Page 75 Page 76 Page 77 Page 78 Page 79 Page 80 Page 81 Page 82 Page 83 Page 86 Page 87 Page 88 Page 89 Page 90 Page 91 Page 92 Page 93 Page 94 Page 97 Page 98 Page 99 Page 100 Page 101 Page 102 Page 103 Page 105 Page 106