MSc PROJECT MANAGEMENT

MINI DISSERTATION

CRITICAL SUCCESS FACTORS: AN ANALYSIS OF SOME FACTORS AT A NUCLEAR POWER UTILITY IN SOUTH AFRICA

CON5023Z

REPARED FOR:

University of Cape Town

Faculty: Engineering and the Built Environment

Department: Construction Economics and Management

Lecturer: Mr C I Jay

PREPARED BY:

Student: W M Galetta

Student No.: GLTWIL001

Submission: 12 October 2021

University of Cape Town

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

University of Cape Town

TABLE OF CONTENTS

PLAGIARISM DECLARATION v
ACKNOWLEDGEMENTS vi
ABSTRACT vii

1. CHAPTER 1: BACKGROUND TO THE RESEARCH PROJECT 1
1.1. Introduction 1
1.2. Research context 1
1.3. Research problem statement 7
1.4. Research aim 7
1.5. Research objectives 7
1.6. Research questions 8
1.7. Research proposition 8
1.8. Research and design methodology 8
1.9. Research assumptions 8
1.10. Research constraints 9
1.11. Structure of the report 9

2. CHAPTER 2: LITERATURE REVIEW 10
2.1. Introduction 10
2.1.1. Project definition 11
2.1.2. Purpose of a project 11
2.1.3. Project success vs. project failure 11
2.1.4. Project success criteria vs. project success factors 13
2.1.5. Project success vs. project management success 17
2.1.6. Project success in the nuclear field 19
2.2. Critical Success Factors 27
2.3. Background of Critical Success Factors 27
2.3.1. Background of PIP 34
2.3.2. CSF of the PIP 35
2.3.3. Characteristics of the PIP Model 38
2.3.4. Benefits of PIP 41
2.3.5. Limitations and criticism of PIP 41
2.4. Conclusion 43

3. CHAPTER 3: RESEARCH METHODOLOGY 45
3.1. Introduction 45
3.2. Research paradigm 45
3.3. Research philosophy 46
3.4. Research approach 48
3.5. Research strategy 48
3.6. Research methodology 51
3.6.1. Case-study 51
3.7. Research design 54
3.8. Research tactics 55
3.9. Procedural research strategy 55
3.9.1. Data collection process 56
3.9.2. Coverage and survey research sampling method 56
3.9.3. Method of data collection 56
3.9.4. Data collection strategy 57
3.9.5. Research questionnaire / instrument 57
3.9.6. Interviews 59
3.9.7. Questionnaires 60
3.9.8. Semi-structured Interviews 60
3.10. Research sample 61
3.11. Data analysis 61
3.11.1. Data analyses techniques 61
3.11.2. Data evaluation criteria 62
3.12. Limitations 62
3.13. Research ethics 62
3.13.1. Ethical code of conduct 62
3.13.2. The research process 63
3.13.3. Participant consent and anonymity 63
3.13.4. Safety of the participants during information gathering 63
3.13.5. Ethics clearance 64
3.14. Value of research 64
3.15. Methodology summary 64

4. CHAPTER 4: DATA ANALYSIS AND INTEPRETATION OF RESULTS 65
4.1. Introduction 65
4.2. Respondent demographics 66
4.3. Survey Research Results 67
4.3.1. Description of the sample 67
4.3.2. Data collection: survey questionnaires 68
4.3.3. Data collection strategy 68
4.3.4. Sample frame 68
4.4. Survey research results 69
4.4.1. Primary data related to CSFs 69
4.4.2. Stakeholder views on CSFs of the PIP and those for nuclear projects success 70
4.5. Data analysis 70
4.5.1. Data format 70
4.5.2. Methods of data analysis 71
4.5.3. Assistance to the Researcher 71
4.6. Interpretation of results 71
4.6.1. Analysis of questionnaires 71
4.6.2. Descriptive statistics 71
4.7. Presentation of data and interpretation of results 71
4.7.1. Question 6 rating of the relative importance of the CSFs of the PIP 72
4.7.1.1. Factor 1: Project Mission 72
4.7.1.2. Factor 2: Top Management Support 73
4.7.1.3. Factor 3: Project Schedule/Plan 74
4.7.1.4. Factor 4: Client Consultation 74
4.7.1.5. Factor 5: Personnel 75
4.7.1.6. Factor 6: Technical Tasks 76
4.7.1.7. Factor 7: Client Acceptance 76
4.7.1.8. Factor 8: Monitoring and Feedback 77
4.7.1.9. Factor 9: Communication 78
4.7.1.10. Factor 10: Trouble-Shooting 78
4.7.2. Question 6(b) - Ranking of the CSFs of the PIP 79
4.7.3. Question 7 - Looking at the CSFs of the PIP, which ones are applicable to a nuclear project? 80
4.7.4. Question 8 - Factors that influence nuclear project success but not listed in the PIP? 81
4.7.5. Question 9 - Additional factors to be included in the implementation of nuclear projects? 81
4.7.6. Question 10 - What factors did you use to measure / determining the success of your project? 95
4.7.7. Question 11 - What were the challenges in determining CSFs for nuclear projects? 97
4.7.8. Question 12 - How and when were CSFs determined for your project and by whom? 99
4.7.9. Question 14 - What are the benefits of having CSFs known for a nuclear project? 102
4.7.10. Question 15 - Do stakeholders understand their role in ensuring a successful project? 103
4.7.11. Question 16 - Do you measure success at all the phases of the lifecycle? If so, then how? 104
4.7.12. Question 17 - What difference did you identify between normal projects and nuclear projects? 105
4.7.13. Question 18 - Any other comments 105

4.8. Discussion of research results 106
4.8.1. Survey Research Results related to additional factors the need to be added to the CSF list 106
4.8.2. Primary research findings 106
4.8.3. Additional research findings 106
4.8.3.1. Analysis of CSFs in the nuclear industry 107
4.9. Conclusions 110

5. CHAPTER 5: RECOMMENDATIONS AND CONCLUSION 112
5.1. Introduction 112
5.2. The research background and approach 112
5.3. Problem statement revisited 112
5.4. Research question revisited 113
5.4.1. How is project success measured in the nuclear industry? 113
5.4.2. Which of the CSFs in the PIP are perceived as adequately catering for nuclear projects? 114
5.4.3. Are there any factors that need to be added to the CSFs of the PIP which will be considered critical for nuclear project success? 115
5.5. Fulfilment of aims and research objectives 115
5.6. The research findings and Conclusions Drawn 117
5.7. Limitations of the research 117
5.8. Recommendations for further studies 118
5.9. Conclusion 118

6. BIBLIOGRAPHY i
Appendix A: Research Questionnaire ii
Appendix B: Cover Letter and Consent Form vii
Appendix C: Ethics Clearance Form ix
Appendix D: Unedited Data xi
Appendix E: Data Analysis - Tables and Figures xiii

PLAGIARISM DECLARATION

1. I know that plagiarism is wrong. Plagiarism is using another's work and to pretend that it is one's own.

2. I have used the Harvard system as the convention for citation and referencing. Each significant contribution to, and quotation in, this research from the work, or works of other people has been attributed and has cited and reference.

3. I declare that all the work in the document, save for that which is properly acknowledged, is my own.

4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

5. I acknowledge that copying someone else's work, or part of it, is wrong, and declare that this is my own work.

6. This thesis/dissertation has been submitted to the Turnitin module.

7. I confirm that my supervisor has seen my report and any concerns revealed by such have been resolved with my supervisor.

W Galetta Signature _____

Date _____

Confidentiality

Please note that this thesis/dissertation contains sensitive information that is not to be distributed.

ACKNOWLEDGEMENTS

The author of this dissertation wishes to thank the following people for their contribution towards completion of this research:

- Firstly I would like to thank my God, without whom, I would not have been able to complete this thesis. He gave me the required knowledge, strength and grit to face this challenge head on and succeed; great is His faithfulness. I can do all things through Christ who strengthens me Philippians 4:16.
- My mom, Lydia Davids, my pillar of strength, my compass, my true North my main supporter and champion for all her prayers, support and encouraging phone calls and for believing in me.
- My loving husband, David, my soul mate and my anchor, who patiently and consistently supported me throughout this journey.
- My six beautiful children: Nikki, Rikki, Emil, Eden, Davina and Neema Kai, for their understanding and support during this time.
- My aunt, "Tietie", who is ready 24/7 to chip in at any time. She is my true rock.
- My sisters, Marcia and Kimberley Davids, who supported and encouraged me.
- To all my friends and colleagues who rooted for me, and to all those who prayed for me and
- My supervisor, Mr Ian Jay, who supported me even in his retirement; thank you.

ABSTRACT

Background: Over the years literature mainly focussed on time, cost and quality, also known as the triple constraint or 'iron triangle', as the main factors to be considered as important for project success. Since then, many other factors were considered by various authors with the most cited being the work of Pinto and Slevin in 1988 who produced the Project Implementation Profile (PIP) which expanded on the triple constraint and listed ten Critical Success Factors (CSF) to be considered toward project success. The indication was that the success of projects can be improved if these factors were considered across the lifecycle of the project and they can be tailor-made to be specific to a particular industry. With this in mind, this research study has been conducted at a nuclear power plant (NPP) and it explores the applicability of the CSFs of the PIP towards nuclear project success.

Purpose: The purpose of the thesis/dissertation was to gain and understanding from various stakeholders of what constitutes CSFs for projects undertaken at a NPP in South Africa; testing if those listed in the PIP would suffice or if additional factors need to be included specifically for nuclear projects.

Research objectives: The research study considered the following research objectives: Understanding which CSFs of the PIP were important for nuclear projects and evaluate which of them are perceived by various stakeholders to be important to nuclear project success. Thereafter some CSFs of the PIP were analysed towards identifying if there were factors not included in the PIP but that were pertinent to nuclear project success.

Research design and methodology: A mixed methods approach was adopted to this research. An interpretive case-study was conducted post event to understand phenomena through the participants' interpretation of their context. The case-study methodology was chosen and data collected using multiple data sources such as interviews with project managers who had successfully implemented projects and some system engineers who had conducted effectiveness reviews on such projects, gleaning the database of completed projects as well as Operating Experience (OE) / lessons learnt at Koeberg Nuclear Power Station (KNPS). This was done to determine the common factors that led to the analysed projects' individual success.

Multiple cases at KNPS and the factors considered for nuclear project success, outside of the CSFs of the PIP were used to conduct the research. The design methodology used towards getting to the CSF framework for nuclear projects was informed by factors considered by the World Organisation of Nuclear Operators (WANO), Institute for Nuclear Plant Operators (INPO) and the International Atomic Energy Agency (IAEA), all organisations that are key role players in the nuclear field. This paper utilised tools and techniques to demonstrate how a framework for determining nuclear project success can be adopted.

Research findings: The results revealed that while CSFs were generally understood but not known in the PIP format. Furthermore, in order for the CSFs to be applicable to nuclear project success, additional factors that are pertinent to nuclear projects needed to be included and a specific framework developed accordingly.

Research Limitations: The research study focused on projects within the nuclear project management department (NPM), in order to simplify the data collection process. Strategic information that was deemed as sensitive or confidential could not be revealed explicitly during the course of data gathering and therefore inferences had to be made. Another limitation was the timing of the distribution which took place during an outage, yielding a low response rate during the allotted time compelling the Researcher to extend the time period for data collection. Finally, the uneven distribution of responses in the various phases of the nuclear project lifecycle posed a challenge with the Execution Phase being the dominating phase. This uneven distribution of results meant that the overall findings would be governed by the Execution Phase. This had an implication on the generalisability of the results. Furthermore, with the respondents' ratings of the CSF being subjective; this may have had an impact on the accuracy of results.

Originality: The CSF framework for nuclear project success, when applied can provide valuable pointers for Koeberg and the nuclear industry when implementing nuclear projects for success.

Practical implication: This information can be shared across NPM and related departments who form part of the nuclear project lifecycle. The information and lessons learned can also be shared in the nuclear industry by way of OE. The paper will benefit other NPP operators in applying the CSFs that are introduced in the framework to nuclear projects and provide them with the ability to monitor and control nuclear project success at each phase of the nuclear project lifecycle towards ensuring nuclear project success. The framework will allow the project manager and project team to identify, analyse, respond and monitor and control CSFs that project participants should plan for to ensure nuclear project success so as not to negatively impact the plant and the business at large with dire consequences that are introduced by project failure.

Keywords: critical success factors, project implementation profile, nuclear projects, modifications Operating Experience, INPO, WANO, Koeberg, Nuclear Project Management, and National Nuclear Regulator.

1. CHAPTER 1: BACKGROUND TO THE RESEARCH PROJECT

1.1. Introduction

Project management Researchers have, since the 1960s, made numerous attempts to determine the factors that result in successful projects (Pinto and Slevin, 1988b: 3; Cooke-Davies, 2002: 185; Tsiga *et al.*, 2017). Research of project management Critical Success Factors (CSFs) has been expansively described in literature related to this field (Pinto and Slevin, 1987; 1988a; 1989a; Pinto and Mantel, 1990; Cooke-Davies, 2002; Turner, 2004). A useful and widely applied tool developed from this research is the Project Implementation Profile (PIP) which can be utilised to assess several CSFs that the project manager has control over (Slevin and Pinto, 1986). The original research from which the PIP was developed was conducted in the 1980s (Pinto and Slevin, 1987). However, despite well-known widely written about results, projects are consistently disappointing stakeholders leading to the question "…*what are the critical factors that really lead to successful projects*? (Cooke-Davies, 2002: 185).

1.2. Research context

A project has been defined as a "…*temporary endeavour undertaken to create a unique product, service, or result*" (PMI, 2013: 3) with social, economic, and environmental benefits that extend beyond the project itself. "*A project is within a program as an undertaking that has a scheduled beginning and end, and that normally involves some primary purpose"* (Kerzner, 2009: 55); it is inherently special with a purpose to create and manage change in an organised way.

The reason a project is undertaken is to accomplish specific goals (Meredith and Mantel Jr, 2011). Where a desire for change is expressed, a project is initiated and this is usually as a result of a business need or opportunity, technical advancement, customer request, legal requirements, organisation benefits, profits, market share and future growth (PMI, 2013). However, in implementing projects there is a need for the project manager to identify those factors which would ensure the project is a success (Slevin and Pinto, 1986).

Eskom is a power utility company with a mandate "to provide electricity in an efficient and sustainable manner, including generation, transmission, distribution and retail". Eskom makes a critical and strategic contribution to the South African government's objective of ensuring security of electricity supply in the country. Koeberg Nuclear Power Station (KNPS) is the only operational part of the Nuclear Operating Unit (NOU), which forms part of the Eskom organisation. Eskom celebrated 95 years of operation on the 1st of March 2018, and focuses on fulfilling its mandate in supporting the lives of all South Africans. KNPS is responsible for supporting this mandate, by supplying electricity and supporting the South African economy on a regional and national basis. Koeberg is now in its 35th year of safe operation (Eskom, 2019b).

KNPS is the only nuclear power generating plant in South Africa, ensuring a dependable supply of electricity to the Western Cape. It has operated safely for more than 35 years. The plant's reactors supply 1 800MW of South Africa's electricity; this translates into 5% of the total electricity grid. Nuclear Power Plants (NPPs) have a very long operational life and were originally designed for 30-40 years with plans, lately, to extend the life of a plant to 60 years. This comes with many challenges, which will inevitably compel plants to "*modernise due to a combination of more stringent safety requirements, opportunities for power upgrades and difficulties to get spares"*(Wahlström, 2011: 65).

A project, in the nuclear industry, is defined as a modification that is undertaken at a NPP and it aims to improve a nuclear plant's performance and increase reliability and safety of the plant (Morcos and Taylor, 1988; IAEA, 2007). Thus a modification or back fit (retrofit) typically refers to a change in an operating NPP's systems or procedures with the intent to meet new regulatory requirements, change or performance improvement, repair of problematic components, reduction of radiation exposure to personnel, and/or the reduction or simplification of maintenance (Morcos and Taylor, 1988). Most NPPs are ageing and this necessitates the refurbishment or replacement of various major plant components. Some modifications are declared obligatory by new regulatory requirements, an ageing plant or obsolescent equipment. The International Atomic Energy Agency (IAEA) however, cautions that updating the plant design to stay abreast of developments in industry can be detrimental rather than beneficial to the NPP if modifications are not rigorously controlled throughout the lifetime of the plant (De Castro *et al.*, 2001).

When modifying the nuclear plant, the assumptions and intent of the design should not be altered to such an extent that it affects the plant's safe operations (De Castro *et al.*, 2001). In addition, the power industry views modifications as an attractive investment, owing to the numerous and complex rules applicable to them. This includes the magnitude of the modifications and the amount of regulatory scrutiny received, which have escalated rapidly (Morcos and Taylor, 1988).

NPPs are unique, well proven installations. They are capital intense IAEA (1988); WNA (2009), high technology, and complex systems, owing to the continuously evolving and increasing safety requirements. They have extended project schedules and significant fixed operating and maintenance costs and low fuel costs and are extremely regulated with plant operations being closely monitored by the regulator and this has significant impact on operations (WNA, 2009).

This is undoubtedly a trying and yet an exciting time for nuclear projects as access to the nuclear facility now provides a modern engineering environment where projects will now move from being routine, maintenance-based to life extension type modifications with major projects being initiated towards to improve the plant's performance. Some of these modifications to extend life of the plant are considered first-of-a-kind (F-O-A-K) and project managers need to ensure that their project teams are up for the challenge (Wahlström, 2011).

According to the World Nuclear Association (WNA), investors now increasingly understand that existing plants are highly profitable as a result of the operating costs being steady and predictable, ensuring exceptional profitability for their owners in any type of electricity market. This is not the case for oil and gas systems where there have been sharp increases in prices. Against this backdrop it is hoped that project managers will be able to obtain better performance on nuclear power projects in order to assist in maintaining nuclear power as a viable energy option (WNA, 2009). Project management in the nuclear industry is as important, like in other industries and as such, appropriate controls are required during the lifecycle of any project (WANO, 2017).

As previously stated, the nuclear industry is governed by stringent controls, with the expectation that a NPP is safely operated; processes and procedures adherence is paramount; and modifications are successfully implemented. This is crucial for an industry that is perceived as an unforgiving one; one that is under constant scrutiny, with modifications being critically evaluated. This view is justified due to past nuclear events that had devastating effects on the nuclear industry and subsequently leading to more rigorous rules. In the past many utilities were opposed to risk resulting in failed projects that did not meet expectations. This led to investigations around the increase in confidence that NPPs will be built according to schedule and budget; realising good economic performance, as being a definite (WNA, 2009).

South Africa is currently embarking on nuclear new build and, as such, KNPS has to provide assurance that modifications can be successfully implemented and that nuclear remains a feasible option; the country, public and economy depend on it. Recently, however, there has been growing concern with project cost overruns, late completion and quality issues throughout the nuclear project lifecycle which have had a negative impact on the success of the implementation of modifications. These needed to be investigated so that the factors that lead to success were clearly defined for nuclear projects.

According to Pinto and Slevin (1988a) "*There are few topics in the field of project management that are so frequently discussed and yet so rarely agreed upon as that of the notion of project success*." The authors describe project success as a complex and often illusory construct. It is critical to successful implementation (Pinto and Slevin, 1989a); but has different meaning to different people (Freeman and Beale, 1992). It has both intrigued and perplexed researchers and project practitioners alike (Müller and Jugdev, 2012b) and is arguably the most favoured word of project practitioners (Radujković and Sjekavica, 2017).

Project success has always been measured in terms of time, money, and quality with research always being based on their successful achievement (Tsiga *et al.*, 2017). In recent times, however, these factors have been perceived as limiting and arguments put forth to broaden this scope to include several other factors. More recent studies suggest a fresher look into ways of measuring project success (Nicholas and Steyn, 2017). For example initial specifications must be achieved and key stakeholders must be satisfied with the project outcomes if a project is to be considered successful (Nicholas and Steyn, 2017; Tsiga *et al.*, 2017).

For nuclear projects, an outage, for example, is considered successful if the units are returned to service on schedule and the modifications are completed on time (Morcos and Taylor, 1988). A successful nuclear power project is designed, constructed and put online within the established parameters of schedule, budget and technical performance (IAEA, 1988). "*A high-quality project is one that meets performance requirements, satisfies its stakeholders and society at large, and causes no harm to the environment* (Nicholas and Steyn, 2017: 320)". The uncompromising use of the ''iron triangle'' to measure project success is questioned by Atkinson (1999), suggesting that this could be the core cause of persistent failures of projects in industry.

It is largely accepted that project success remains to be "*in the eyes of the beholder*" and will continue to be subjective owing to differing views based on the beholder's position in the organisation, as well as their role and worldview (Müller and Jugdev, 2012b: 768) even though numerous factors influence the extent to which a project is successful (Müller and Jugdev, 2012b). Project success factors are said to be the elements of a project, which, increase the probability of success provided they are influenced in that way (Van Niekerk and Steyn, 2011). The authors note that there is no consensus around the project success definition that is applicable to all projects in all environments, despite the topic being widely written about in literature (Van Niekerk and Steyn, 2011) but argue that, "*the most successful projects are those where leadership, trust, communication, and teamwork flourish, regardless of the formal planning and control systems in place"*(Van Niekerk and Steyn, 2011: XVIII). The project and programme managers' quality of working relationship needs to ensure this (Van Niekerk and Steyn, 2011).

In project management CSFs are those characteristics that can impact the success of the project significantly as long as they are suitably sustained, maintained and managed (Milosevic and Patanakul, 2005). CSFs are "*those key areas of activity in which favourable results are absolutely necessary for a manager to reach his/her goals*" (Tsiga *et al.*, 2017: 226). They are inputs that can directly or indirectly lead to project success having elements that have to be synchronised to ensure timely project delivery (Tsiga *et al.*, 2017).

There have been several lists and models proposed in literature for CSFs (Belassi and Tukel, 1996). The perception of the various stakeholders is also regarded as a key factor since different people view success differently (Pinto and Mantel, 1990; Baker *et al.*, 1997). Researchers found that CSFs are sector specific and various attempts were made to establish these factors for different sectors (Tsiga *et al.*, 2017).

CSFs can be categorised in five main categories; human and project related factors, project procedures, project management actions and the external environment as shown in **Figure 1.1**. Focussing on determining CSFs will give an organisation a competitive advantage, lead to content investors, and ensure the company prospers (Chan *et al.*, 2004).

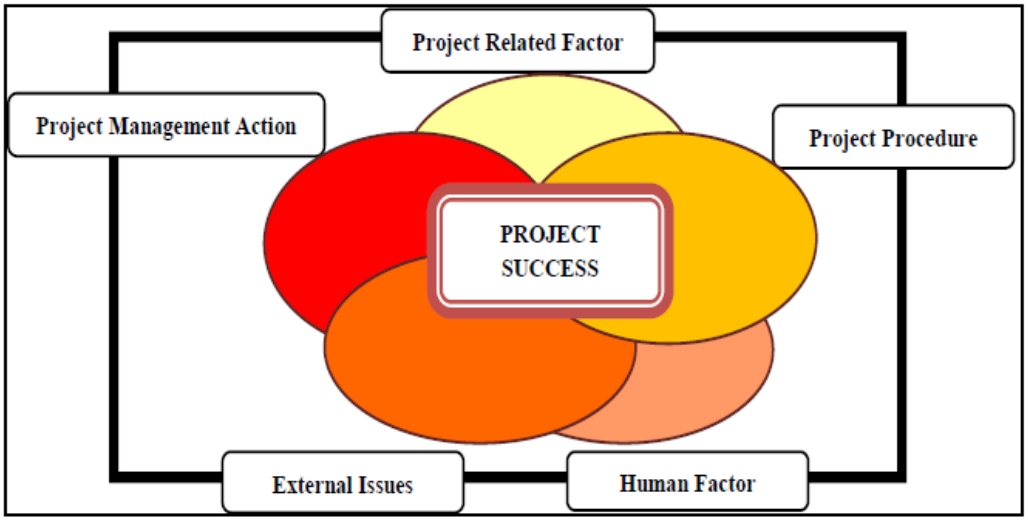

Figure 1.1: Variables of project success. Source: (Chan *et al.*, 2004)

The achievement of CSFs offers project practitioners with better comprehension of how project results can be improved (Tsiga *et al.*, 2017). Different CSFs have been identified by different studies and yet consensus amongst researchers is yet to be reached on how to judge project success and the impact of related factors (Fortune and White, 2006); ‘‘*There are few topics in the field of project management that are so frequently discussed and yet so rarely agreed upon as the notion of project success*’’ (Pinto and Slevin, 1988b: 68). Furthermore it has been observed that not all identified factors lead to project success, therefore not all of them are critical (Chan *et al.*, 2004). Linked to this, researchers found that CSFs are sector specific and various attempts were made to establish them for different sectors (Tsiga *et al.*, 2017). In order to answer the question of which factors are critical to project success; three separate questions first require a response: ‘‘*what factors lead to project management success*?”, ‘‘*what factors lead to a successful project*?’’ and ‘‘*what factors lead to consistently successful projects*?” (Cooke-Davies, 2002: 185). Projects differ in size, uniqueness and complexity, therefore the criteria to measure success varies between projects and from one industry to the next. The question is rather, “*can a unique set of success criteria be identified for all industries*” (Tsiga *et al.*, 2017: 226).

Research points out that the project management process is a complex one which involves focussing on a variety of human, budgetary, and technical variables. Various models (project management tools) have been developed to provide the project manager with technical support (harder aspects) such as critical path, modelling, budgetary spread sheets, activity flow charts, etc., but there is still a need for a model that, in addition to that, addresses the human and managerial aspects of successful project management as these techniques have great advantages but also huge drawbacks (Slevin and Pinto, 1986).

The more complex the project, the more project managers have to contend with a wide variety of technical, human, and budgetary issues also known as project critical factors and it is for this reason that a conceptual model, the (PIP) was developed as a diagnostic instrument for the project manager (Slevin and Pinto, 1986). The model contains ten (10) factors that embody an effective project monitoring framework. These factors are of critical importance to the project manager because they allow the evaluation the 'softer' behavioural side of the project defining the project in relation to its human elements. The PIP also allows the project manager to direct some attention on the strategic issues of project. So while well-established techniques such as the project evaluation and review technique (PERT), Gantt charts and critical path methodologies are tremendously useful in helping project managers decipher the various technical detail 'hard' project activities, the PIP allows them to look at the 'soft' issues, providing them with the ability to look at the bigger picture; this is critical for project success. **Figure 1.2** shows, a framework of project implementation based on the ten (10) factors as revealed by the designers in their analysis (Slevin and Pinto, 1986).

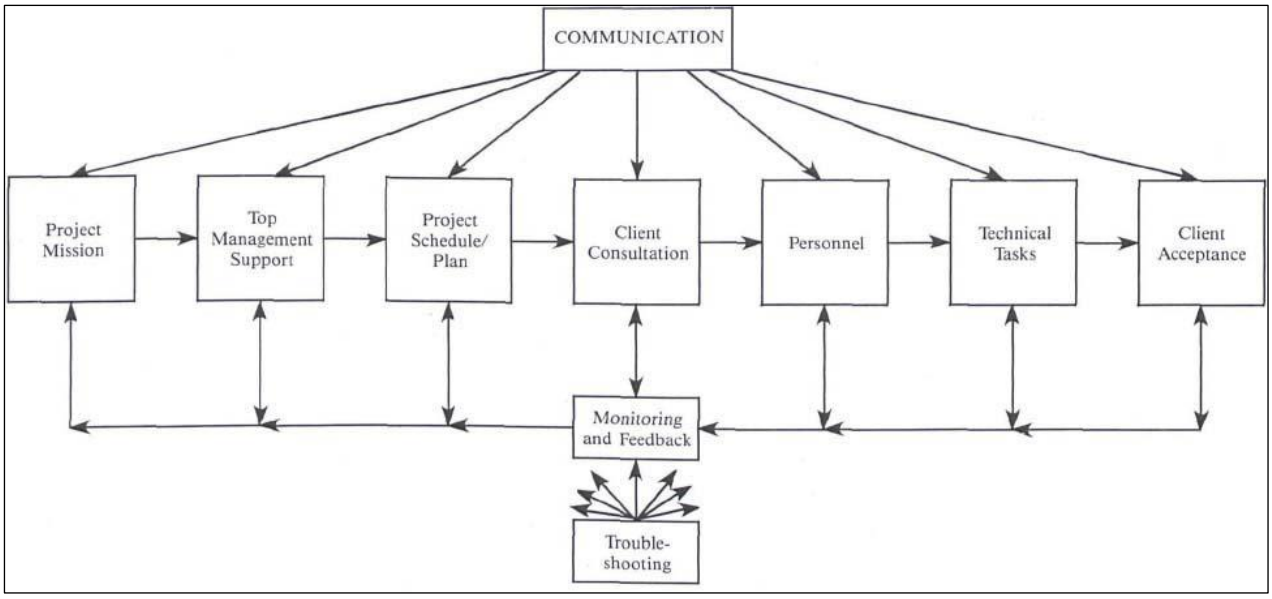

Figure 1.2: Factors of the Project Implementation Profile. Source: (Slevin and Pinto, 1986)

If a company is to ensure future success and its industry, it should identify its CSFs to ensure competitive performance of the organisation (Rockart *et al.*, 1982). This suggests that "*one size does not fit all"* projects when it comes to management approach (Shenhar *et al.*, 2001: 704). In the nuclear context, there are complicating factors such as the limited pool of resources in the nuclear industry globally, regulations considered for nuclear power and the unique South African political landscape; which all require special thought when managing a nuclear project. This then begs the question: "*How should project success be defined for nuclear projects*" (Van Niekerk and Steyn, 2011: 124).

The most crucial and central actor for success and effectiveness is the project manager (Belout and Gauvreau, 2004) and a successful project is one managed by an effective change agent, the project manager (Young, 2007). It is therefore pertinent that, when implementing projects, the project manager identifies those factors which would ensure project success (Slevin and Pinto, 1986).

Pinto and Slevin concluded that "*The project manager requires the necessary tools to help him or her focus attention on important areas and set differential priorities across different project elements. If it can be demonstrated that a set of factors under the project manager's control can have a significant impact on project implementation success, the project manager will be better able to effectively deal with the many demands created by his job, channelling his energy more efficiently in attempting to successfully implement the project under development*." (Pinto and Slevin, 1988b: 480).

Having looked into considerations mentioned above about the nuclear fraternity requirements, standards and expectations coupled with the plan of extending nuclear plant operations from 40 to 60 years (including KNPS) and the strict regulatory requirements which are obligatory; it is vital to introduce a factors specific to this field that will ensure nuclear project success. With literature revealing a lack or absence of a tool that can comprehensively measure CSFs for projects implemented at a nuclear facility, such a tool must be developed, else nuclear projects will continue to be plagued with failure, cost overruns, delays and the like. Furthermore, the CSFs for nuclear projects are assumed therefore the CSFs in the PIP would need to be comprehensively examined and evaluated in relation to nuclear projects to determine the applicability of the tool as an assurance method for nuclear project success.

1.3. Research problem statement

The problem that was examined in this proposed research was stated as:

a) The CSFs available in literature are not comprehensively understood nor applied in the nuclear industry.

1.4. Research aim

The research aim was to analyse the CSFs of the PIP and identify those applicable to the nuclear industry.

1.5. Research objectives

The research objectives that were considered in this research project were the following:

a) To understand which CSFs in the PIP were important for nuclear projects;
b) To evaluate which of the CSFs in the PIP were perceived by various stakeholders to be important to nuclear project success;
c) To analyse some of the CSFs relevant to the nuclear industry while identifying other factors that were not included in the PIP but that are pertinent to nuclear project success;
d) Mapping CSFs of the PIP onto success criteria for nuclear projects.

1.6. Research questions

To address the research problem, the research question and sub-questions for this study were:

a) What factors are considered critical for nuclear project success?

Sub Questions:

- How is project success measured in the nuclear industry?
- Which of the CSFs in the PIP are perceived as adequately catering for nuclear projects?
- Are there any factors that need to be added to the CSFs of the PIP which will be considered critical for nuclear project success?

1.7. Research proposition

The following research proposition was tested in this proposed research:

a) An improved understanding of which CSFs are applicable to the nuclear industry will contribute to improved project performance.

1.8. Research and design methodology

A mixed methods approach to this research was adopted as follows:

a) A literature review was undertaken to understand what the nuclear industry considers to be project success factors; while these may not form part of the PIP;
b) Questionnaires were distributed to project stakeholders to ascertain their understanding of what constitutes project success and the factors they considered important to achieve nuclear project success;
c) Gleaning databases of completed projects and lessons learnt at KNPS to determine the common factors that led to their individual success while being implemented at a NPP;
d) Data analysis and interpretation: These were compiled into a refined CSF list that was suitable for measuring success on nuclear projects. Focus group discussions were conducted with selected stakeholders after the compilation of the preliminary findings to discuss and validate the results.
e) Results, recommendations and conclusions.

1.9. Research assumptions

For the purpose of the proposed research, the assumption was that KNPS was a suitable example to provide insight into CSFs that can be generalised to the operation of similar NPPs across the nuclear fraternity.

1.10. Research constraints

The constraints that the Researcher encountered and that had an impact on this proposed research were:

a) The preliminary research on CSFs and the PIP relating to nuclear projects showed that there was very little information available on the subject. The literature review therefore focussed on general CSFs and inferences made for nuclear projects while looking into nuclear related CSFs according to nuclear bodies. The factors identified out of the literature review were added to the CSFs of the PIP and surveyed against various stakeholders from the nuclear industry to understand their perception on how important the identified factors were to nuclear project success;

b) The study was limited to the KNPS in South Africa within NPM and included seconded and supplemental staff. Project management processes are widely used in the different parts of the organisation, however, the research focussed only on projects managed within NPM. Questionnaires were specific to the relevant stakeholders and departments involved in the nuclear project lifecycle so that the data collection process was simplified;

c) Accessibility to information was a challenge due to the nature of the industry being researched. Information that was considered sensitive or confidential was not explicitly revealed during the course of data gathering and therefore inferences were made;

d) Availability of participants proved challenging as the survey was undertaken during an outage period.

1.11. Structure of the report

Chapter 1:

- Introduction (Background to the study)
- Research context
- Research problem statement
- Research aim
- Research objectives
- Research questions and sub-questions
- Research proposition
- Research and design methodology
- Research assumptions
- Research constraints

Chapter 2: Literature review

Chapter 3: Research methodology

Chapter 4: Data analysis and results

Chapter 5: Interpretation and discussion of research results

Chapter 6: Recommendations, summary and limitations, conclusions and suggested further research

These six chapters will be followed by references for the research study and appendices containing selected document examples and extracts of raw data.

2. CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The purpose of the literature review was to discuss the relevant features of general CSFs, to analyse the factors of the PIP and to identify nuclear project success factors that are not explicitly covered by the CSFs of the PIP. This chapter introduced the review of literature commensurate with the research topic, providing context to the research problem. The first section provides a brief explanation of what a project is and the reasons for them being undertaken. A brief discussion was introduced as to why some projects continue to fail while some are considered successful. Once this was established, the second section provided a distinction between project success, project management success; project success criteria and project success factors. This was done so that the understanding was clear, eliminating confusion about the concepts. The third section delved into what CSFs are and how the lack of agreement amongst researchers led to different models being introduced. For the purpose of this research, however, only the PIP and its CSFs was explored. In the final section, those success factors that are considered pertinent for the nuclear industry were discussed. So while there is a plethora of literature for the topics mentioned, only those relatable to the research questions have been considered. **Figure 2.1** depicts the topics and their concepts in a high level manner.

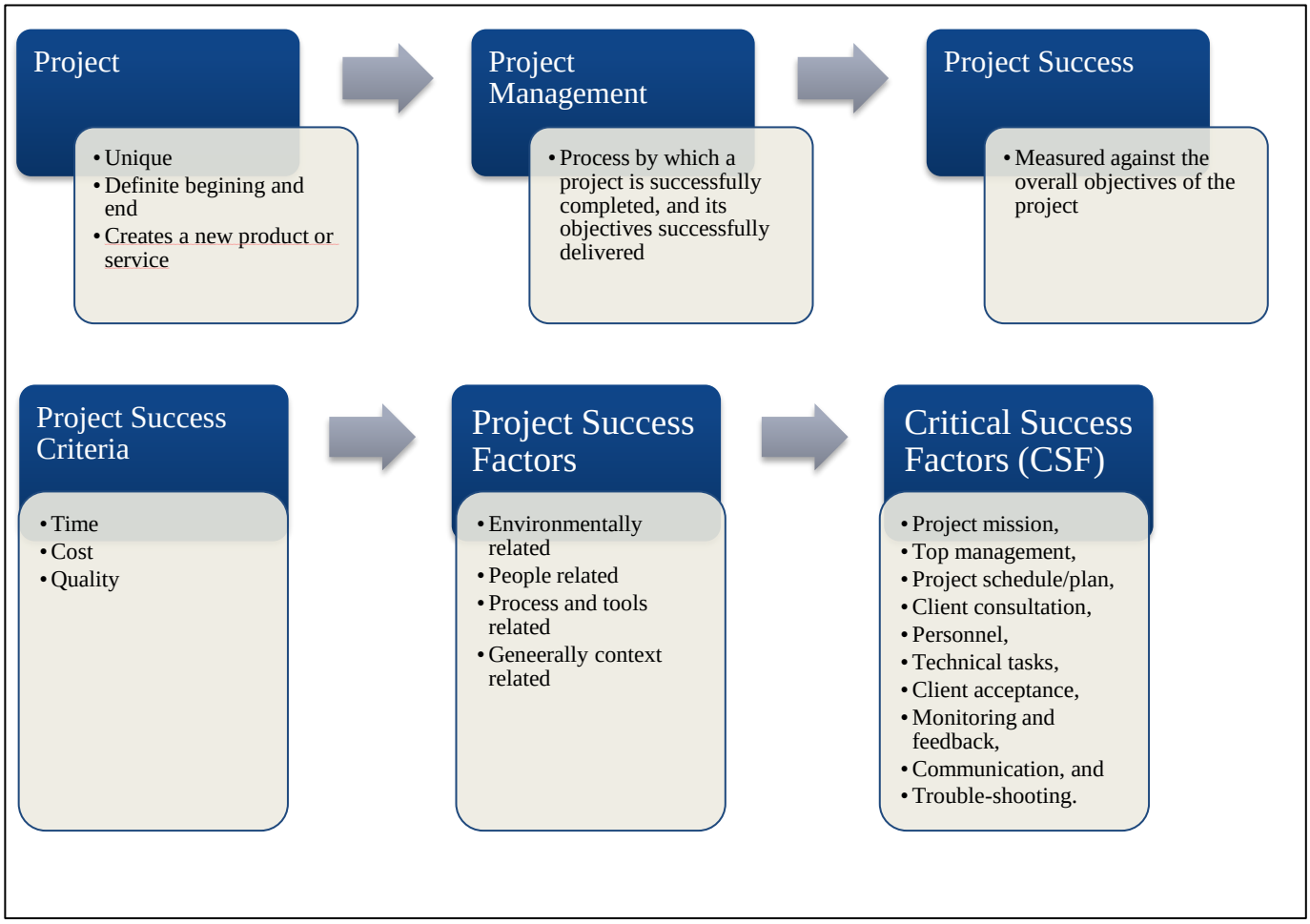

Figure 2.1: Breakdown of elements of project success, their purpose and the difference between them

2.1.1. Project definition

Literature defines a project as a temporary endeavour (Turner and Müller, 2003; Young, 2007; Meredith and Mantel, 2009; Institute, 2013); with a beginning and an end (Turner and Müller, 2003; Gepp *et al.*, 2014) to achieve certain specific objectives (Munns and Bjeirmi, 1996) in a defined time (Young, 2007) and it is undertaken to create a unique product or service (Turner and Müller, 2003); something special (Young, 2007) by its nature. A project is defined as "… *requires the expenditure of one or more resources in each of the separate but interrelated and interdependent activities which must be completed to achieve the objectives for which the task was instituted*" (Gepp *et al.*, 2014: 364).

Closest to nuclear is that a project is a plan, scheme, an organised undertaking with the following elements:

- Project origination and definition;
- Pre-project planning and organisation;
- Design, procurement and pretesting;
- Construction and installation;
- Training;
- Preoperational testing;
- Start-up (commissioning) and initial operations; and
- Closeout and good analysis (Pinkerton and Pinkerton, 2003).

2.1.2. Purpose of a project

The reason for initiating a project is to solve tasks and work assignments of almost any type or size, in almost any type of business (Morris and Hough, 1987; Pinto and Prescott, 1990; Shenhar and Dvir, 1996; Dvir *et al.*, 1998; Maylor, 2001) and have proven to be an integral part of most organisations (Sauser *et al.*, 2009). Projects exist as a result of something important and complex to be solved (Shenhar and Dvir, 1996), to accomplish specific goals (Engwall, 2003) and must be seen as powerful strategic weapons, that can create economic value and competitive advantage (Shenhar *et al.*, 2001; Gomes and Romão, 2016). They mostly create change. Organisation would therefore become out-of-date; lacking relevance and the ability to cope with the current business environment (which mainly focuses on competitiveness) if they did not implement projects to remain abreast of such developments (Shenhar *et al.*, 2001).

2.1.3. Project success vs. project failure

The word "success" is probably the most beloved word of any project practitioner (Radujković and Sjekavica, 2017) and as such, it is imperative to clearly define success among key stakeholders at the beginning of the project as well as at various review points during the project lifecycle; this is viewed as good project management (Thomas and Fernández, 2008). Project success is described as a difficult and elusive concept (Prabhakar, 2008) making success and failure difficult to define and measure; this is because they mean different things to different people (Freeman and Beale, 1992).

The quest for factors that influence project success or failure has intrigued both researchers and practitioners (Sebestyen, 2017). The very concept of project success is questioned as ambiguous (De Wit, 1988; Baccarini, 1999) with some researchers suggesting that it is associated with the presence of numerous critical implementation factors such as clear project mission, detailed project schedules, sufficient resources, etc. Because the approaches differ profoundly, the quest for consensus still continues (Sebestyen, 2017). Researchers and experts have for many years been attempting to answer questions about the success or failure of projects. Projects have been criticised for slipping on previously planned dates but some authors insist that the slippage and the over expenditure on estimated costs do not, by default, represent a serious failure (Van Niekerk and Steyn, 2011).

Historically, project success research mainly focused on the successful realisation of time, cost and quality objectives with projects generally considered as being successful if their initial specifications are achieved and key stakeholders are satisfied with the outcomes (Tsiga *et al.*, 2017). Project management literature tends to relate the measurement of project success directly to the so called ‘‘iron triangle’’. These have dominated for many years (Mir and Pinnington, 2014; Gomes and Romão, 2016) yet, project success means more than just meeting time and budget goals (Pinto and Slevin, 1988b; Shenhar *et al.*, 2001).

Some researchers have conceptualised project success as a uni-dimensional construct related to meeting budget, time and quality (Wateridge, 1995; Brown and Adams, 2000; Müller and Turner, 2007; Bryde, 2008) while others consider it a complex, multi-dimensional concept including many more features (Lipovetsky *et al.*, 1997; Atkinson, 1999; Lim and Mohamed, 1999; Shenhar *et al.*, 2001; Jugdev and Müller, 2005; Joslin and Müller, 2015). Despite various attempts to define project success many studies conclude that numerous projects do not meet their objectives and some fail completely (Cerpa and Verner, 2009; Papke-Shields *et al.*, 2010). These measures have no meaning if client satisfaction is not achieved; owing to the perceived success or failure of projects (Pinto and Slevin, 1988b). Numerous studies have confirmed that most projects do not meet these goals (Sauser *et al.*, 2009). It therefore makes sense to include additional factors (Van Niekerk and Steyn, 2011) since different stakeholders will interpret project success differently(Cleland and King, 1975; Lim and Mohamed, 1999; Cleland and Ireland, 2006).

Project success is one of the most frequently debated issues and yet it is apparent that the lack of consensus as to what constitutes project success still exists (Pinto and Slevin, 1988b; Baccarini, 1999; Shenhar *et al.*, 2001; Prabhakar, 2008; Ika, 2009; Meredith and Mantel, 2012; Gomes and Romão, 2016). It can therefore be concluded that what is considered to be a failure in one project can be perceived as a success in another. For this reason, alternative frameworks have been developed to measure project success or an improved definition of project success and failure is required (Van Niekerk and Steyn, 2011).

2.1.4. Project success criteria vs. project success factors

The difference between project success criteria and project success factors is an ongoing debate in project management. Success criteria are specified as the measures used to judge the success or failure of a project. Project success factors, on the other hand, are those project inputs that require closer managing as they compellingly influence the success of a project (Belassi and Tukel, 1996; Lim and Mohamed, 1999; Cooke-Davies, 2002; Joslin and Müller, 2015). Principally, the factors are the influential characteristics that will either facilitate or impede the achievement of the criteria, and consequently the success of the project as a whole (Lim and Mohamed, 1999).

There are many project success criteria mentioned in literature but the dominating ones are the traditional "'iron triangle'" of time cost and quality as shown in **Figure 2.2** as being the criteria by which success of a project are measured (Pinto and Slevin, 1987; Turner and Cochrane, 1993; Atkinson, 1999; Papke-Shields *et al.*, 2010) and they constitute the basis of the success approaches (Turner and Cochrane, 1993; Agarwal and Rathod, 2006; Fortune and White, 2006). This is because fulfilling these criterions is easy to assess (Jugdev and Müller, 2005). Researchers have relied more on measurable aspects rather than attempting to divide criteria into groups of objectively measureable aspects such as schedule, cost, performance, safety, disputes, accident rate, and a set of subjective evaluation criteria such as quality, client, contractor, project team and other stakeholders' satisfaction (Chan and Chan, 2004; Jha and Iyer, 2006).

Over the years, however, these criteria have been criticised with some authors considering them extreme and others inadequate (Berssaneti and Carvalho, 2015) citing (Angus *et al.*, 2005). Despite this overwhelming view, these are no longer the limiting elements in projects (Atkinson, 1999) and satisfying only these criteria does not lead to the success of a project (Lim and Mohamed, 1999). The observed failures of projects across industries have driven researchers and practitioners to reconsider the traditional operational view of project success in which the only criteria of time, cost and specification are valued (Atkinson, 1999). So if project success factors and criteria well-known, why do they keep failing. It could therefore be argued that the methodologies, tools, knowledge and skills used are based on tried and failed criteria. Thus using the same criteria that leads to project failure will perpetuate the problem. It therefore stands to reason that while the factors have been developed and adopted, changes to the success criteria have been suggested but remain unchanged (Atkinson, 1999).

Project success factors require special and permanent attention to guarantee a strong likelihood of project success; otherwise, if these factors are not taken seriously, they could contribute to the failure of a project (Kandelousi, 2011). Based on empirical surveys, Pinto and Slevin (1987) identified coordination, communication and relationships, structure and control, monitoring and feedback, a project's significance and publicity, and management support as well as the predetermination and acceptance of success criteria as the factors that have a positive impact on a project's outcome.

Other publications (Belassi and Tukel, 1996; Gemuenden and Lechler, 1997; Cooke-Davies, 2002) have attempted to classify these factors and to create a consistent model for success factors. Belassi and Tukel (1996) grouped them into four categories: factors that are related to a project, to a project manager and team, to an organisation and the factors that are related to the external environment. Cooke-Davies (2002) studied so-called real success factors at three different levels: Summarising the results of several studies and outlines, Jugdev and Müller (2005) suggested four necessary conditions for project success, including the agreement on success criteria with the stakeholders before a project starts, a collaborative working relationship between the project owner and project manager, the empowerment of the project manager with a certain amount of flexibility in special situations, and the owner's interest in the performance of the project.

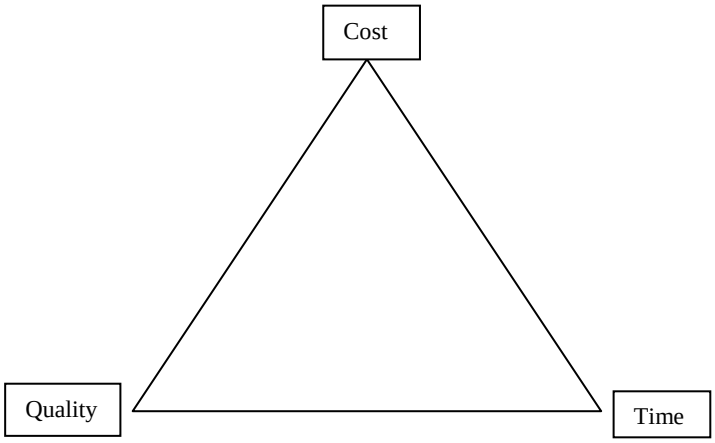

Figure 2.2: The 'iron triangle'. Source: (Atkinson, 1999)

Uncertainty exists as to what really determines project success and it is advisable to not only judge it according to project goals alone (Lim and Mohamed, 1999). **Figure 2.3** shows the criteria and factors for project success and **Figure 2.4** shows the criteria and factors as applied to project success.

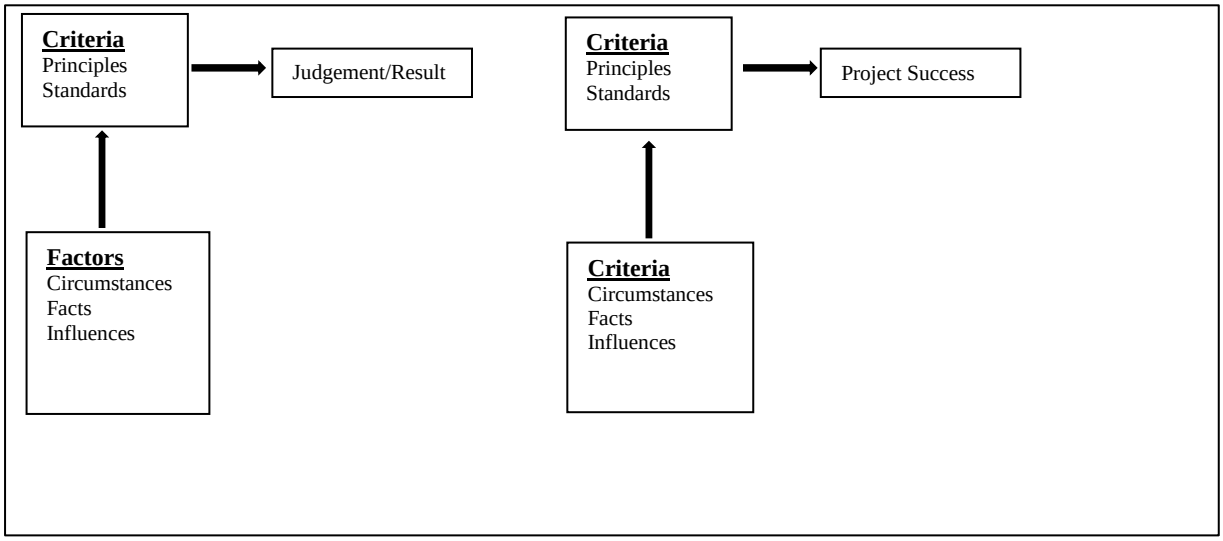

Figure 2.3: Pictorial representation of criteria and factors for project success

Figure 2.4: Pictorial representation of the criteria and factors as applied to project success. Source: (Atkinson, 1999)

Some researchers (Belassi and Tukel, 1996; Cooke-Davies, 2002) have focussed on requirements that ensure project success while others (Tukel and Rom, 2001) paid more attention to the measurement of what success would look like. Notwithstanding this, success criteria have, over the past decade, become diverse and contentious (Atkinson, 1999) and this is the case even with modern projects. This is not only because of the ever changing environment in which projects operate, but also the subjective nature of the construct of project success (Shenhar *et al.*, 2001).

Projects differ in size, uniqueness and complexity, so it would make sense that the criteria for measuring success will differ between projects (Müller and Turner, 2007). This makes it improbable for collective set of project success criteria to be decided (Westerveld, 2003). However, the lack of agreement concerning the criteria by which success is judged is prevalent (Pinto and Slevin, 1988b; Freeman and Beale, 1992; Shenhar *et al.*, 1997; Baccarini, 1999). Over the years the limitations of the traditional approach have been observed indicating the need for the creation of a more sophisticated system (Atkinson, 1999). A review of the literature has revealed, seven (7) main criteria by which project success can be measured (Freeman and Beale, 1992) shown in **Table 2.1.**

Table 2.1: Project Success Criteria. Source: (Freeman and Beale, 1992)

	Success Criterion	Description	
1.	Technical performance	To what extent the technical requirements specified at the commencement of the execution phase were achieved.	93%
2.	Efficiency of project execution	The degree to which targets of time and cost were met.	93%
3.	Managerial and organisational implications	A measure of client, parent and user satisfaction, incorporating the degree to which the project was carried out without disturbing corporate culture or values.	43%
4.	Personal growth	The satisfaction of the project team, particularly in terms of interest, challenge, and professional development.	29%
5.	Project termination	The completeness of the termination, the absence of post-project problems, and the quality of post-audit analysis.	14%
6.	Technical innovativeness	The success in identifying technical problems during the project and solving them.	14%
7.	Manufacturability and business performance	The ease with which the product resulting from the project can be manufactured, and its commercial performance.	43%

* Percentage of 14 papers reviewed.

Belassi and Tukel (1996) reviewed success factors in literature and defined the impact they had on project performance as factors related to the following:

- the project;
- the project managers and the team members;
- the organisation; and
- the external environment.

Research conducted by Engwall (2003) resulted in factors such as project mission, top management support, client consultation, planning and control, staffing, and leadership skills (Engwall, 2003) demonstrating that project success can be viewed as the achievement of a particular combination of objective and subjective measures, manifested in the success criteria and measured at the end of a project (Müller and Jugdev, 2012b). Discouragingly though is that the levels of project success still fail to meet expectations (Jugdev and Müller, 2005). There have been a number of models developed for measuring project success such Pinto and Prescott (1988); Shenhar *et al.* (2002); Hoegl and Gemuenden (2001) or (Turner and Müller, 2006); these are all designed with different underlying assumptions (Engwall, 2003).

The triple constraint of time, cost and quality is evident in every project definition and considered as criteria for success. This view is so prevalent that it can be termed the industrial standard. The extensive use of these criteria is not surprising since together they capture the essence of success in many regards and is applied with ease as shown in **Figure 2.5** below (Sebestyen, 2017).

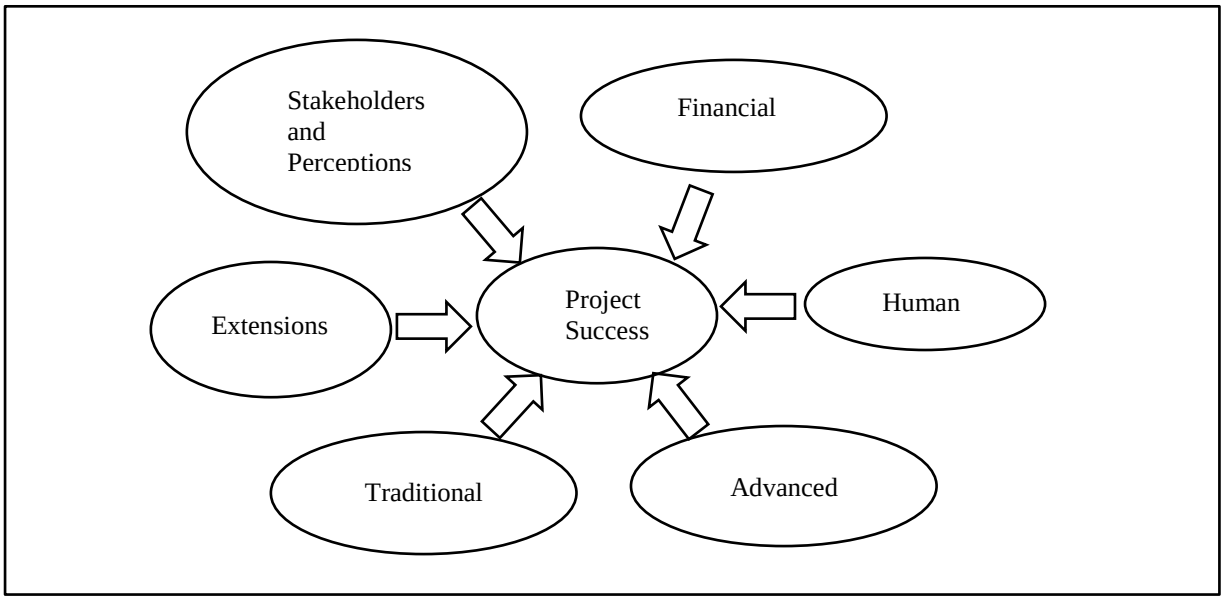

Figure 2.5: Aspects of success. Source: (Sebestyen, 2017)

2.1.5. Project success vs. project management success

Success is a subjective term and therefore dependent on the viewpoint of who is measuring it (Jha and Iyer, 2006). Cooke-Davies (2002) makes a distinction between the two with project success being measured against the overall project objectives and project management success being measured by time, cost and quality. Successful projects mostly highlight project success criteria as opposed to project management success criteria; however, project management success, being less complex, can be easily measured and assessed when closing the project. Project management is aimed at ensuring the success of a project (Jha and Iyer, 2006).

Project success and project management success are similar, yet different (De Wit, 1988; Cooke-Davies, 2002; Shenhar and Dvir, 2007; Serrador and Turner, 2015) with a significantly positive relationship them (Papke-Shields *et al.*, 2010; Mir and Pinnington, 2014; Serrador and Turner, 2015). Literature however commonly makes a distinction between project success and project management success (De Wit, 1988). The main difference is project success is associated with achieving overall project goals; while project management success is concerned with time, cost and quality performance (Cooke-Davies, 2002; Jugdev and Müller, 2005; Ika, 2009; Serrador and Turner, 2015).

So while the ‘‘iron triangle’’ was the very first model of project management success (De Wit, 1988), it was later proven to only be part of overall project success. It is therefore possible to have a successful project with unsuccessful project management; the reverse is also true (Munns and Bjeirmi, 1996). **Figure 2.6** illustrates the aspects related to project management success.

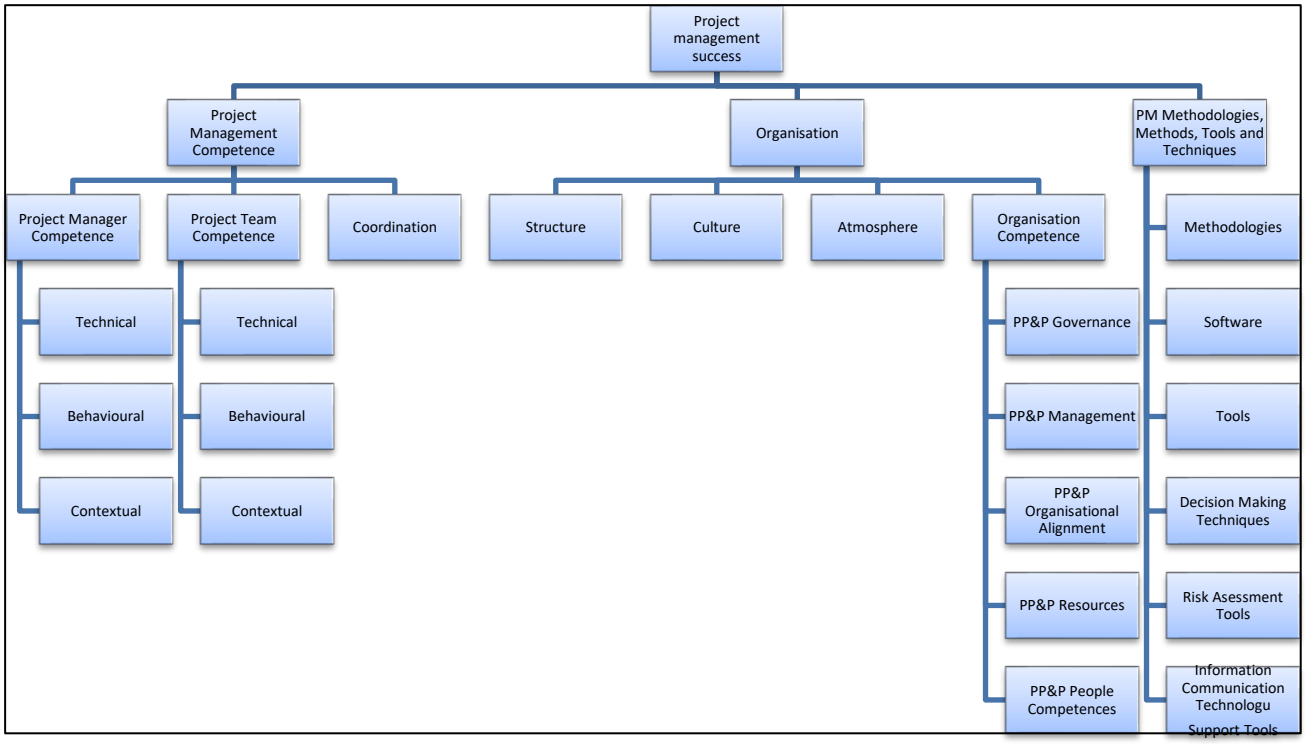

Figure 2.6: Elements of project management success. Source: (Radujković and Sjekavica, 2017)

Conversely, it has been observed, over time, that the two are not directly related (Prabhakar, 2008) if the argument put forth by De Wit (1988) is true that neither practitioners nor academics can agree on what constitutes project success. With there being such wide divergence of opinions on the topic; the only agreement appears to be the disagreement on what constitutes project success (Murphy *et al.*, 1974; Pinto and Slevin, 1988b; Baker *et al.*, 1997; Gemuenden and Lechler, 1997; Shenhar *et al.*, 1997).

There are many ways in which project success can be measured (Serrador and Turner, 2015) but Thomas and Fernández (2008) state that it is not straightforward. Shenhar *et al.* (1997) suggested a model of success based on five dimensions, judged over different timescales. There have been many instances where the original project objectives have not been met but client satisfaction was achieved. An argument can therefore be put forth that while time, budget and scope are an important part of project success; they are necessary but not sufficient conditions (Turner and Zolin, 2012). **Table 2.2** below lists the five dimensions of project success.

Table 2.2: The five dimensions of project success. Source: (Shenhar and Dvir, 2007)

Success dimension	*Measures*	*Time*
1. Project efficiency	Meeting schedule goal Meeting budget goal	End of project
2. Team satisfaction	Team morale Skill development Team member growth Team member retention	End of project
3. Impact on the customer	Meeting functional performance Meeting technical specifications Fulfilling customer needs Solving a customer's problem The customer is using the product Customer satisfaction	Months following project
4. Business success	Commercial success Creating a larger market share	Year following project
5. Preparing for the future	Creating a new market Creating a new product line Developing a new technology	Year following project

It can therefore be concluded that overall project success is a much broader concept than the 'iron triangle' (Shenhar *et al.*, 1997; Atkinson, 1999; Cooke-Davies, 2002; Jugdev and Müller, 2005; Thomas and Fernández, 2008). However, as has highlighted by Turner (2004), although much of the research on this particular topic has agreed on broader definitions of project success, the traditional triple constraint criteria seem to prevail.

2.1.6. Project success in the nuclear field

In the nuclear field, success is mainly linked to a good schedule and nuclear safety. The typical nuclear unit operating cycle of 12 to 24 months is often shorter than a project cycle. Also, the unique challenges and the need for rigorous design and reviews result in a longer design time than in many other industries. Therefore, a comprehensive, long-range plan should be developed to ensure that project planning and scheduling are appropriate for successful project implementation. Scheduled work must be completed as planned, whether outage or online. Modification work is integrated into an overall station plan, along with other non-modification work such as routine maintenance and periodic testing. Any change to this well-orchestrated plan creates a ripple effect at the station. Coordination by the project team is crucial to the success of the project. Early project integration into the outage schedule is critical (WANO, 2017).

Detailed scope definition at the beginning is a key project success factor. Nuclear projects cause highly complex configuration management challenges. The ability to visualise every aspect of a project at the beginning leads to a well-defined scope. This visualisation of the project comes from key stakeholder input, depending on the nature of the project. Operating experience and lessons learned from previous modifications can be invaluable. As part of this phase, it is important to clearly identify the performance requirements of the project and the responsibilities of each functional group and of the potential vendors (WANO, 2017).

The WANO Performance objectives and criteria (PO&Cs) WANO (2013) dictate that the following be considered for planning and implementation:

- A structured project management process is established, communicated and implemented to produce expected results in safety, quality, scope, schedule and resource performance. Project scope is at the level of detail necessary to support the identification of all project work. Project team members are assigned based on project needs;
- Project risks are assessed throughout the project and are prioritised relative to probability and consequence. Actions plans are developed, budgeted and implemented to mitigate risks;
- Expedited projects contain additional controls to reduce the likelihood of error, mitigate risks and address inefficiencies;
- Project performance relative to safety, quality, scope, schedule and resources, is monitored and communicated frequently to ensure the project meets high expectations;
- Project personnel monitor the progress of changes to training, procedures and other documentation that are developed through the implementation of the modification process, to ensure project milestones are supported;
- Project activities are integrated with station on-line and outage schedules. Preparation milestones provide necessary information for on-line and outage scheduling to ensure that necessary work is identified and assigned and that resources are accounted for. This includes installation, testing and return-to-service activities;

- Revisions to project plans are managed, communicated and reviewed for risk. Revisions are assessed for effects on schedules and interface activities;
- Project stakeholders are engaged in and demonstrate ownership of the development and execution of project implementation schedules;
- Testing is developed and performed to demonstrate the expected equipment and system performance;
- Controls are established to ensure that all configuration requirements, contract obligations and project closure actions are completed; and
- Project critiques are performed with the project stakeholders upon project completion. Improvement actions and good practices are identified, documented, tracked to completion and communicated, both internally and externally (WANO, 2013).

Nuclear projects have unique needs, such as operating experience considerations, radiological requirements, testing and turnover protocols, and stringent quality assurance requirements that must be met. Project team members execute all parts of a project. Planning the human resources needed, selecting and acquiring those resources, developing the team and individuals, and managing the project team are critical contributors to the success of a project. A well-developed, technically skilled project team that acts in a manner consistent with the overall project goals and the management sponsor priorities ensures a high probability of successful project completion (WANO, 2017).

The project manager is an important team member and is really the team leader who can make the difference between a project succeeding or failing. They are considered by stakeholders as the single most important factor in achieving project goals. Therefore, it is critical that the right person with the right skill set is selected for this position on a project. While relevant technical knowledge and experience are considered beneficial, it is important to realise that a good project manager can manage a project successfully even without relevant technical knowledge. The owner should consider if the project manager needs to have nuclear experience (WANO, 2017).

Given the characteristics expected of a good project manager, organisations that use project managers should develop detailed responsibilities and expectations for them and for the supporting functional organisations. In addition, a structured training approach needs to be provided to orient people to become effective project managers. Caution is warranted when supplemental personnel (contractors) are brought into an organisation to function as project managers. These individuals need to meet the organisation's guidelines and expectations that are imposed on their own titled project manager employees (WANO, 2017).

The WANO PO&Cs dictate that the following for planning and implementation (WANO, 2013):

- Project managers and supervisors are knowledgeable and well integrated with station programmes, processes and procedures for developing, scheduling, coordinating and executing work to high standards;
- Project managers and supervisors provide intrusive oversight of project personnel to ensure quality craftsmanship and to maintain nuclear safety during work execution;
- Station and supplemental personnel are identified and mobilised in sufficient time to be trained and qualified to support project work activities;
- Material resources are identified, ordered and received with sufficient time to identify and adjust for problems or deficiencies with the materials provided;
- Project sponsors are engaged as senior advocates throughout, addressing issues that may be beyond the project manager's or team's influence (WANO, 2013).

Nuclear safety: Consideration of nuclear, industrial and radiological safety is of primary importance both for the implementation phase and for the final operating configuration of the plant. The assessment of project nuclear safety performance includes any challenges to nuclear safety that result from project activities. This may include configuration errors, work on the wrong component/system, failure to follow station work practices, and other human performance errors that challenge systems important to safety. In the station corrective action programme, project activities that reduce nuclear safety must be documented. Challenges to the margin of safety may not always be documented but should be considered when project performance is evaluated and reported (WANO, 2017).

Industrial safety performance includes measuring lost-time accidents, regulator recordable events, first-aid reports, and near misses. It is important to monitor the first-aid cases as an early warning trend to a more severe regulator recordable event or lost-time accident. For each project, establish quantitative performance expectations for lost-time accidents, regulator recordable events, and first-aid cases. Base these performance expectations on the size and complexity of the project (WANO, 2017).

Radiological safety performance compares project performance with established expectations for dose and contamination control. Higher-than-expected doses or personal contaminations negatively affect project performance. The topic of radiation exposure/ALARA is a nuclear-specific project management factor that can be critical in certain projects. When establishing the approach to project design and implementation, consider the radiation/contamination exposure and radioactive waste generation for project installation and testing, as well as during the plant long-term operation and maintenance of the project's installed equipment. The best project solution in a non-nuclear application may not be the best solution in a nuclear application. Early project identification of the radiation exposure/ALARA risk is essential to managing these factors successfully during all project phases and obtaining the best overall project results. Unplanned radiation exposure is not acceptable in the nuclear industry; therefore, all radiological project activities

must be designed, planned, executed and monitored to the required detail for the radiological safety of personnel (WANO, 2017).

Unique risk considerations arise during a project, in addition to the conventional risks associated with project duration, budget, quality, and personnel safety. System interactions during project implementation, as well as during testing and operation of project deliverables, can result in nuclear safety risks. To minimise risk, the scope, schedule, budget, safety, and quality impact must be fully understood (WANO, 2017).

Operating experience (OE) is used throughout the life cycle of a project. Using OE effectively includes analysing both station and industry experience to identify fundamental weaknesses. The risk management process is then used to evaluate issues that will reduce the likelihood or the consequences of events, schedule perturbations (time), cost overruns (budget), and quality impacts, as well as to reduce risk based on the review of these lessons learned. Project managers should benchmark similar projects to identify what went well, what went wrong, and beneficial practices that could be applied. Particular attention should be paid to quality, scope, schedule, risk, cost, and safety issues. Lessons learned, both good and bad, should be made visible to other project personnel throughout the industry (WANO, 2017).

NPPs are well proven installations, with nearly 400 commercial units operating and about 4000 reactor-years of accumulated experience. NPPs are capital intense, high technology, and complex systems, not least because of the continuously evolving and increasing safety requirements (IAEA, 1988). Investment costs and their amortisation make up the predominant part of the future power generation costs and effectively determine the competitiveness of the nuclear power option with power from fossil fuels or hydroelectric stations. High interest rates have made NPPs particularly vulnerable through the steep cost escalation that results from unforeseen changes or delays. While the operating performance of NPPs has been improving in recent years and has generally been comparable to or better than that of fossil-fired plants in the same size ranges, performance during construction has been variable (IAEA, 1988).

Construction schedules - from the first placement of structural concrete to grid connections have ranged from less than five years to more than twelve years; as-built costs accordingly show increases of up to four hundred per cent in the worst cases. Although additional licensing requirements, public intervention and funding problems have been blamed for most of the delays and cost increases, there is growing recognition that lack of proper project management has been a major factor. Improved steering, control and expediting of NPP projects by competent project management would reduce costs not only through more efficient work sequences and higher productivity but also through the reduction of accumulated interest during construction (IAEA, 1988). The IAEA, in support of maintaining nuclear power as a viable option provides specific advice and guidance and hope that project managers and their assistants will be able to obtain better performance on nuclear power projects (IAEA, 1988).

The mandate of the National Nuclear Regulator (NNR) is to, amongst others, exercise regulatory control over the construction of nuclear facilities to protect the public, property and the environment against nuclear damage. They have prepared a guideline to ensure that the country's nuclear facilities are constructed in compliance with safety requirements, approved plans and procedures with the licensee having the primary responsibility to ensure that the facility is constructed in compliance with applicable safety requirements, approved plans and procedures. The licensee is also obliged to ensure that the facility's suppliers and sub suppliers, delivering services and products important to nuclear safety, comply with safety requirements (NNR, 2017).

The KNPS priorities aligns to Eskom's key focus areas, which is to strengthen its financial position through cost containment and improving efficiencies (reduction in capital and operational spend). Within the prevailing capital expenditure constraints, KNPS will continue to focus on the completion of strategic projects to support plant life extension, and must continue to pursue compliance to nuclear, environmental and safety regulations. The KNPS priorities are based on a solid nuclear safety foundation, focusing on its people, upholding industrial safety, maintaining sustainable plant availability, improving business efficiency and successful implementation of strategic projects (Eskom, 2019b).

Eskom operates the KNPS within a large fleet of fossil power stations, and these high-level objectives have been developed to ensure the performance expectations for KNPS are aligned to the nuclear industry. The main objective is for Eskom to be a top performing nuclear utility with KNPS recognised as a "World Class Power Station". In support of this objective:

- **Nuclear Safety** takes precedence over everything else. Strategic and operational decisions, at all levels consider the unintended consequences on Nuclear Safety. The plant design, the equipment and the practices are continuously improved to keep the plant as safe and reliable as reasonably achievable, thereby exceeding regulatory requirements. Risk mitigation is treated as a priority as the potential consequences of an event is unacceptably catastrophic, regardless of the improbability of occurrence.
- **Plant Performance** is reliable and predictable in accordance with the approved production plan, and future generation from the units is sustainable and economically viable for at least 60 years.
- **Personne**l involved in all nuclear activities are trained and competent to perform their assigned tasks in a safe manner. Leadership and management ensure the availability of adequate resources, foster an open trusting environment that promotes a healthy nuclear culture, the use of error prevention tools and encourage continuous improvement.
- **Regulation**s, Nuclear Installation Licence conditions, all permit limits and radiological release limits are always respected. Processes and practices ensure compliance to the regulations and the practicable minimisation of all radiological and industrial releases. Events that challenge a regulatory requirement, could influence the public perception or have an impact on the environment are treated appropriately.
- **Industry** participation and benchmarking enables Eskom to remain sighted on the continuously improving standards and practices within the international nuclear industry. As part of the participation

in the World Atomic Nuclear Operators (WANO) Performance Indicator Programme, the performance results of each of the Koeberg Units are individually benchmarked on a quarterly basis against the industry performance for each of the individual WANO Performance Indicators (Eskom, 2019c).

The WANO Index provides long-term industry goals for each of the WANO indicators through the point at which score loss commences in the composite WANO Index. The aim being that all plants will strive to operate with as high a rating on the WANO Index as possible, thereby improving the overall performance of the industry (Eskom, 2019c).

This operational plan includes the KNPS business priorities, which is built on the foundation, Nuclear Safety, as the overriding priority. The maintenance and enhancement of an appropriate nuclear safety culture is a priority for KNPS. This overriding priority on nuclear safety must govern the other priority pillars and set the basis for leadership, processes, procedures and behaviours on site (Eskom, 2017). **Figure 2.7** shows the KNPS business priorities and **Table 2.3** explains the objective of each priority.

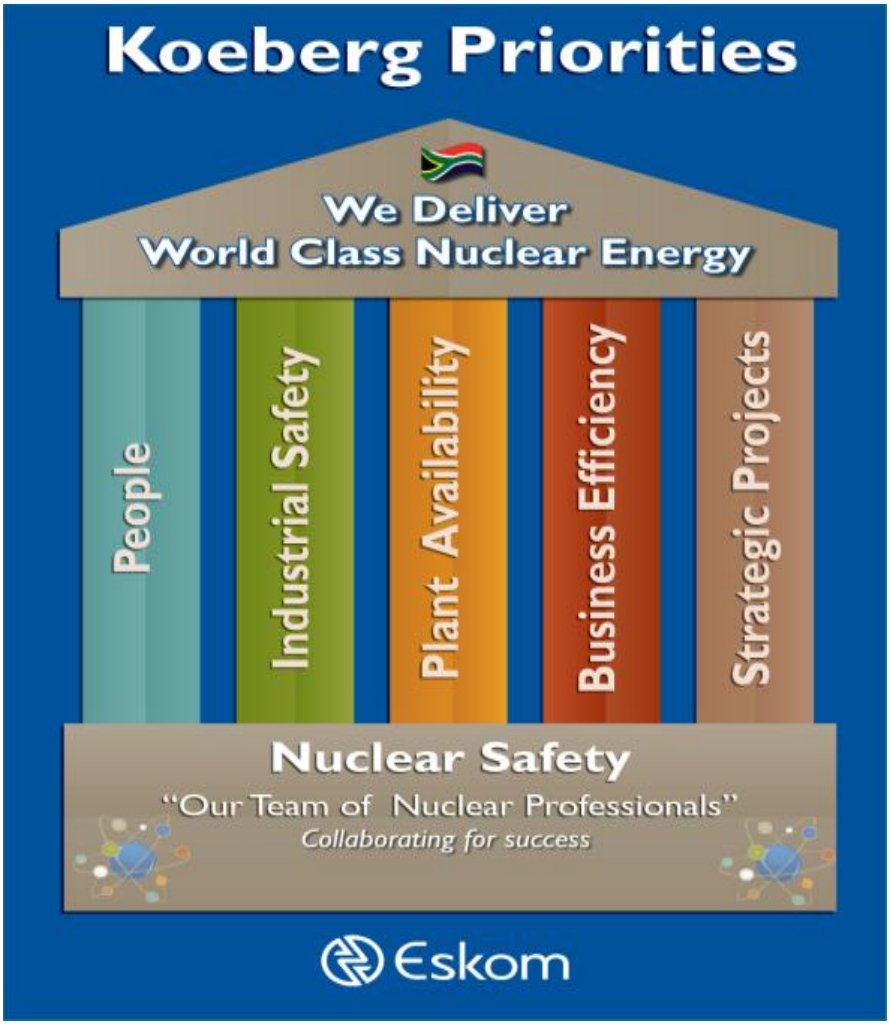

Figure 2.7: Koeberg Nuclear Power Station Business Priorities. Source: (Eskom, 2017)

Table 2.3: The objective of the KNPS Business Priorities. Source: (Eskom, 2017)

Nuclear Safety Takes precedence over everything else. Strategic and operational decisions, at all levels consider the unintended consequences on Nuclear Safety.	
People	To create a sustainable high performance culture through effective application of Talent Management practices, employee development and retention of skilled, committed and engaged employees to achieve operational excellence.
Industrial Safety	To ensure zero harm to our employees, SHE partners, the public and the environment.
Plant Availability	To improve equipment reliability, ensuring safe and reliable operation of the plant, optimising outages, while at the same time striving to maximize KNPS performance.
Business Efficiency	To implement an effective and optimised business resource and processes strategy thereby achieving efficiency and a reduction in overall costs (OPEX and CAPEX).
Strategic Modifications	The purpose of this pillar is to implement a strategy for the timeous planning, monitoring and implementation of all the strategic projects associated with the life extension and long term operation of KNPS from 40 years to 60 years.

These themes will continue to be utilised to improve the alignment of staff on KNPS business priorities and the execution of their responsibilities within the processes. To enable this, all initiatives and activities need to be linked to one (or more) of these business priorities, and be seen as a specific task assigned to a specific area, or a normal business activity that needs strengthening (Eskom, 2017).

The NPM business plan has been developed to be aligned to current vision and KNPS priorities. This plan covers the activities and priorities of NPM to meet KNPS priorities. NPM will provide the function to implement nuclear plant changes in accordance with the KNPS requirements through project management processes and processes (Eskom, 2019b).

NPM aims to execute projects efficiently and effectively in support of nuclear safety and production as follows:

- Nuclear and industrial safety;
- Project quality (Including contractor information);
- Schedule adherence;
- Documentation readiness;
- Project closeout;
- Project handover;
- Collaboration (team work); and
- Cost effective project execution

The key deliverables of NPM business area are:

- To develop and execute strategic projects in support of nuclear safety and to achieve a 60 year operating life;
- To execute operational projects in support of nuclear safety and plant reliability;
- To provide support to Eskom Group Capital as required;
- To provide Project Life Cycle Management (PLCM) of projects approved on the Programme Implementation Plan (PIP); and
- To support the client in their Outage shortening initiatives.

The major priorities of NPM are:

- Improve alignment with KOU in relation to nuclear projects;
- Improve PM maturity through training, exchange programmes and coaching;
- Identify opportunities for improved effectiveness and efficiency; and
- Secure funding

Other priorities of NPM are:

- Project quality (including contractor / vendor management);
- Schedule adherence in executing projects;
- The successful closeout and handover of projects undertaken by NPM;
- Effective systems, processes (e.g. PLCM) and procedures for nuclear portfolio management;
- Proficient and effective project planning and scheduling; and
- Approach planning and effective project planning and scheduling (Eskom, 2017)

Campagna *et al.* (2006:8) illustrates in **Figure 2.8** below that the integration of all the elements that are required to make a project successful can pose a challenge.

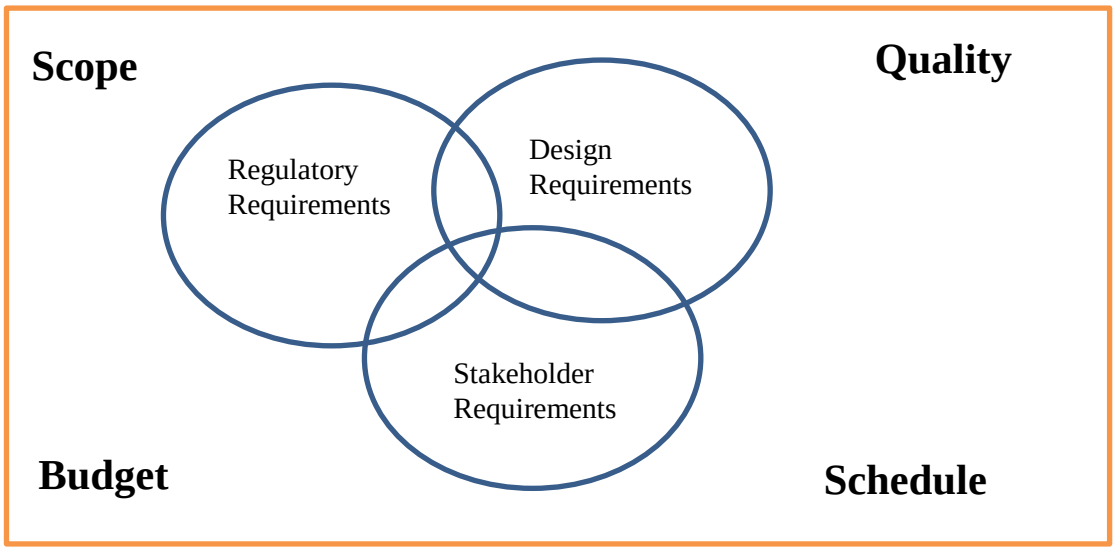

Figure 2.8: Project challenge-integration. Source: Campagna, Lenyk and Hess (2006:8)

2.2. Critical Success Factors

CSFs can be described as those features of projects which have to be achieved so excellent results are realised (Bullen and Rockart, 1981; Rockart and Bullen, 1981; Rockart *et al.*, 1982; Schultz *et al.*, 1987; Pinto and Slevin, 1989b). They are characteristics, conditions, or variables that can significantly influence project success when sustained, maintained and appropriately managed (Milosevic and Patanakul, 2005). They are measurable mechanisms (Müller and Jugdev, 2012a) and can create an environment for projects to be managed consistently with excellence (Kerzner, 1987). CSFs deliver the project success criteria (Gomes and Romão, 2016) towards ensuring client satisfaction which is considered the main project success factor (Kerzner, 1987). The absence of these CSFs can lead to difficulties which can be viewed as obstructions to overall successful outcomes (Rockart, 1979).

CSFs vary by project types, lifecycle phases, industries, nationalities, individuals, and organisations and it is for this reason that the debate in project management literature on the concept of project success persists (Müller and Jugdev, 2012a). Furthermore, there is not much information on how CSFs can reduce problems experienced on projects (Belassi and Tukel, 1996; Clarke, 1999). However, it has been noted by Boynton and Zmud (1984) that despite the drawback of difficulty of application of the CSFs approach, personal bias of those involved and the complexity of modelling the real world accurately; the project could still be a success if the senior managers accept the CSF approach; they could still meet stakeholder expectations (Futrell *et al.*, 2001). So applying this approach would assists implementers with an informed understanding of how project results can be improved (Tsiga *et al.*, 2017).

This review describes the background of CSFs and the PIP. A brief discussion regarding their characteristics and benefits as well as the limitations and criticism of the PIP model was discussed. Other frameworks or lists were also explored to give a comparative view of the various CSFs in literature and an explanation of why the PIP model of (Slevin and Pinto) still, despite all arguments and counter arguments, remain more popular as a project implementation model.

2.3. Background of Critical Success Factors

It was noted by Bullen and Rockart (1981) that managers were facing an increasing complex world. This indicated that they required access to information related to their specific roles and responsibilities. One way of determining the required information was the CSF method. CSFs are small number of important areas that requires a special focus if project success is to be realised. They are industry specific and will change as the environment changes. The five major sources of CSFs are (i) the industry (ii) competitive strategy and industry position (iii) environmental factors (iv) temporal factors and (v) managerial position (Bullen and Rockart, 1981) **Figure 2.9** below shows the CSFs from a corporate viewpoint.

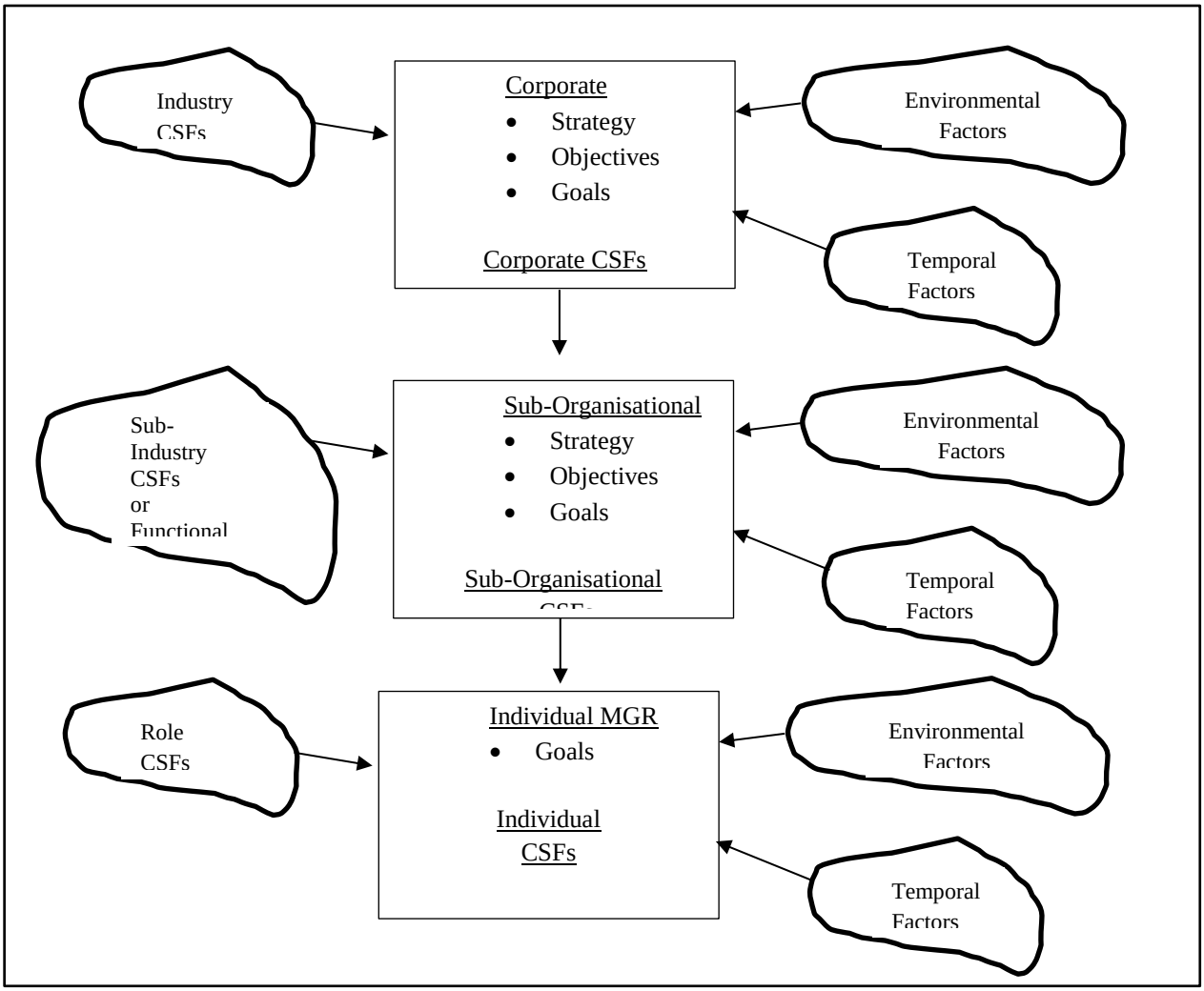

Figure 2.9: CSFs from a corporate viewpoint. Source: (Bullen and Rockart, 1981)

CSFs views have developed and expanded from being simply structural in 1974 to being more task oriented in 1988, and team oriented in 2001. The perception of project success went from being simply hard measurable factors in 1988, to marketing and user orientation in 2002, and a more balanced construct in 2006. This included 50 percent hard dimensions, such as measures, and 50 percent soft dimensions, such as satisfaction of those involved (Müller and Jugdev, 2012a). Since literature generally discusses CSFs across four periods; 1 (1970s); 2 (1980-1990); 3 (1990-2000) and 4 (21st Century), the section below briefly discussed the periods and how they individually influenced CSFs during their time.

Period 1: (1970s)

This period was mainly mechanistic and focussed on the operational side based on the 'iron triangle' (Pinto and Slevin, 1988b; Atkinson, 1999; Cooke-Davies, 2002). It was devoid of the behavioural "soft skills" (Munns and Bjeirmi, 1996), measuring success only at the implementation phase (Lim and Mohamed, 1999). Surveys and feedback were via complaints (Pinto and Slevin, 1988b) making project success either subjective or objective (Freeman and Beale, 1992). The focus was mainly theoretical; lacking empirical evidence (Belassi and Tukel, 1996; Atkinson, 1999; Cooke-Davies, 2002). CSFs produced were not categorised (Turner and Müller, 2005). This period ended with a gradual move towards client satisfaction from the project to the product lifecycle (Atkinson, 1999).

Period 2: (1980s - 1990s)

This period moved away from looking only at the technical aspects to how projects correlated with the client organisation (Pinto and Slevin, 1988a) and the influence of the project manager and the project team. CSF lists were produced by Kerzner (1987) but were not grouped in specific themes as they were thought of instinctively (Davis, 2014). There was also a weakness as these lists did not provide any guidance as to how they were to be applied (Davis, 2014). Pinto and Prescott (1990) used circumstantial studies to collect data from one case instead of grounding it in previous literature. Studies on project success were therefore cross-sectional and only evaluated once in a project (Jugdev and Müller, 2005). This deemed CSFs insufficient if not looked at longitudinally, at various points across the project lifecycle (Turner *et al.*, 2009).

CSFs were related to the environment, senior management and projects. This highlighted the importance of all stakeholders involved to understand project processes with a focus on executive commitment. It also places focus on the significance of selecting a project manager with appropriate experience and leadership skills (Davis, 2014). This is still the case today (The Standish Group, 1995, 2009). The most widely recognised CSFs in this period (Jugdev and Müller, 2005; Turner and Müller, 2005) were those of Pinto and Slevin (1987; 1988a; 1989a) as shown in **Table 2.4**.

Table 2.4: Pinto and Slevin's success factor list. Source: (Pinto and Slevin, 1987)

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 process
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. Trouble-shooting	Ability to handle unexpected problems

This list was however critiqued by Jugdev and Müller (2005) for focussing on the operational level instead of strategic level; not linking project success to overall organisational objectives. The need to measure project success from multiple viewpoints was therefore observed (Davis, 2014).

During this period, with the exception of Pinto, Slevin and Prescott, there was great emphasis on developing CSF lists through anecdotes and single case-studies instead of a categorisation scheme or framework (Müller and Jugdev, 2012a). Project success was described with a single measure and not multiple measures over the lifecycle; so a project was either a success or failure. Early work was primarily focussed on case-studies with Morris and Hough (1987) being among the first to develop a more comprehensive framework

on the preconditions of project success, involving the elements of attitudes, project definition, external factors, finance, organisation and contract strategy, schedule, communications and control, human qualities, and resources management. They considered success as relating to both subjective and objective dimensions; (i) varying across the project and product lifecycle, and (ii) based on different stakeholder perspectives (Müller and Jugdev, 2012b).

Period 3: (1990s - 2000s)

Success continued to have different meanings for different stakeholders with the views on project success changing over the years from definitions that were limited to the implementation phase of the project lifecycle to current definitions that reflect an appreciation of success over the project and product lifecycle (Müller and Jugdev, 2012a). This period is known for the development of CSF frameworks and how both internal and external stakeholders influenced project success (Müller and Jugdev, 2012a; Davis, 2014). A review of CSFs in literature produced a framework, whilst not categorised, showed how they differed across industries (Belassi and Tukel, 1996). The four (4) categories were factors related to the project, the project manager and team, the organisation, and the external environment. The classification allowed clarity around the categories for CSFs and for examination of those (Müller and Jugdev, 2012b; Davis, 2014).

It was however noted that the framework was similar to that of Morris and Hough (1987) and later Turner (1999) raising the question of whether CSFs were stagnant or whether they had changed with time (Davis, 2014). This therefore meant that since these frameworks were so similar, success factors were being reproduced and lacked the creation of new ones. This suggests that an updated list was needed rather than simply testing current ones (Davis, 2014). During this period, (Shenhar) and his colleagues, who built on the work of previous Researchers such as Pinto and colleagues, conducted a number of empirical studies on the multi dimensions of success (Lipovetsky *et al.*, 1997; Shenhar *et al.*, 1997; Shenhar *et al.*, 2002; Maltz *et al.*, 2003).

Period 4: (21st Century)

The 21st century focussed on the stakeholder with project success being dependent on the project lifecycle phase (Turner, 2004; Turner *et al.*, 2009; Turner and Zolin, 2012). This review proves that project success is a multi-dimensional and networked construct that is influenced by the interactions of personal, project, team, and organisational success. Perceptions of success and the related importance of success dimensions also differ by individual personality, nationality, project type, and contract type. Project success, however, still remains 'in the eye of the beholder' and remains a subjective judgement from different perspectives formed by an individual's position in the organisations, their role and their worldview (Müller and Jugdev, 2012a).

Various authors have concluded CSFs over the years as follows (Iyer and Jha, 2005):

1. Project manager's competence, scheduling, control systems and responsibilities, monitoring and feedback and continuing involvement in the project (Avots, 1969; Sayles and Chandler, 1971);
2. Define goals, select project organisational philosophy, general management support, organise and delegate authority, select project team, allocate sufficient resources, provide for control and information mechanics, require planning and review (Martin, 1976);
3. Make project commitments known, project authority from the top, appoint competent project manager, set up control mechanisms (schedules, etc.), progress meetings (Locke, 1976);
4. Instead of time, cost and performance as the project success criteria, perceived performance should be used as the success criteria. Clear goals, goal commitment of project team, on site project manager, adequate funding to completion, adequate project team capability, accurate initial cost estimates, minimum start-up difficulties, planning and control techniques, task (vs. social orientation), absence of bureaucracy (Baker *et al.*, 1983);
5. Project summary, operational concept, top management support, financial support, logistic requirements, facility support, market intelligence (who is the client), project schedule, executive development and training, manpower and organisation, acquisition, information and communication channels and project review (Cleland and King, 1983);
6. Projects fail because of improper basic managerial principles, such as the improper focus of the management system, by rewarding the wrong actions, and the lack of communication of goals (Hughes, 1986);
7. Authors identify the following success factors through a study of eight large and complex projects having great potential economic impact but poorly managed and generally failed project objectives, technical uncertainty innovation, politics, community involvement, schedule duration urgency, financial contract legal problems and implementation problems (Morris and Hough, 1987);
8. The groups that affect project performances at different phases of implementation;
    a. Strategic group consisting of factors like project mission, top management support and project scheduling
    b. Tactical group consisting of factors like client consultation and personnel selection and training (Schultz *et al.*, 1987);
9. Continuing the previous work authors evaluate the relative importance of tactical group and strategic group of factors over the project lifecycle. They conclude that when external success measures are employed, planning factors dominate tactical factors throughout the project lifecycle (Pinto and Slevin, 1989a);
10. Budget performance is given the primary importance in the study. Through an application of neural network approach authors identify the eight important project management attributes associated with achieving successful budget performance: (1) number of organisational levels between the project manager and craft workers; (2) amount of detailed design completed ate the start of construction; (3)

number of control meetings during the construction phase; (4) number of budget updates; (5) implementation of a constructability program; (6) team turnover; (7) amount of money expended on controlling the project; (8) the project manager's technical experience They claim that their model can be used as a predictive tool to forecast budget performance of a construction project (Chua *et al.*, 1999);

11. A set of project success factors for design and build (D&B) projects and examine the relative importance of these factors on project outcome. Using factor analysis from the response of 53 participants on 31 variables they extracted six project success factors. These are project team commitment, contractor's competencies, risk and liability assessment, client's competencies, end-users needs, and constraints imposed by end-users. Further project team commitment, client's competencies, and contractor's competencies were found to be important to bring successful project outcome from multiple regression findings (Chan *et al.*, 2001). Some of the discussed CSFs are shown in **Table 2.5**.

Table 2.5: CSFs in project implementation. Source: (Pinto and Slevin, 1987)

CRITICAL SUCCESS FACTORS IN PROJECT IMPLEMENTATION				
Martin (10)	Locke (8)	Cleland and King (6)	Sayles and Chandler (13)	Baker, Murphy, Fisher (12)
Define goals	Make project commitments known	Project summary	Project manager's competence	Clear goals
Select project organisational philosophy	Project authority from the top	Operational concept	Scheduling	Goal commitment of project team
General management support	Appoint competent project manager	Top management support	Control systems and responsibilities	On-site project manager
Organise and delegate authority	Set up communications and procedures	Financial support	Communication	Adequate funding to completion
Select project team	Set up control mechanisms (schedules, etc.)	Logistic requirements	Monitoring and feedback	Adequate project team capability
Allocate sufficient resources	Progress meetings	Facility support	Continuing involvement in the project	Accurate initial cost estimates
Provide for control and information mechanisms		Market intelligence (who is the client?)		Minimum start-up difficulties
Require planning and review		Project schedule		Planning and control techniques
		Executive development and training of personnel		Task (vs. social) orientation
		Manpower and organisation		Absence of bureaucracy
		Information and communication channels		
		Project review		

Pinto and Slevin (1987) introduced the PIP (Pinto and Slevin, 1987; Slevin and Pinto, 1987) which determined how to use CSFs to establish project status (Andersen *et al.*, 2006). This formed the basis for later lists to which additional factors were added such as:

- Factors related to the project (i.e. size, uniqueness, urgency), the project manager and the team members (i.e. skills, background), the organisation (i.e. management support, structure), and the external environment (i.e. political, technological) (Belassi and Tukel, 1996); and
- A project excellence model with the following CSFs: leadership and team, policy and strategy, stakeholder management, resources, contracting, and project management (Westerveld, 2003).

A framework considering both hard (technical) and soft (behavioural) issues such as:

- Scope: Project mission and goals, terms of reference;
- Planning: Planning global level, planning detail level;
- Organisation: Formal organisation, informal organisation;
- Execution: Activities, decisions; and
- Control: Financial and technical control, internal and external communications (Andersen and Jessen, 2000).

The above demonstrates that there is an ongoing need to identify factors that have a positive effect on project success (Andersen *et al.*, 2006). While CSFs have been identified, it is challenging to classify and decrease them to a controllable number which explains why there is limited agreement in literature on CSFs and how they individually impact project success (Fortune *et.al.*, 2011) resulting in the lack of a convincing model of CSFs (Mir and Pinnington, 2014). A review of the existing literature (Tsiga *et al.*, 2016) categorised CSFs as follows and these were further identified and tested (Tsiga *et al.*, 2017) as shown in **Table 2.6** below.

Table 2.6: Critical success factor identified in literature. Source: (Tsiga *et al.*, 2017)

Category	Critical Success Factors	Sources
External Challenge	Economic environment social environment, political environment physical environment and regulatory/legal environment	27,28,29
Client knowledge and experience	Nature of finance, experience, organisation size, emphasis on costs quality and time, ability to brief, decision making, roles and contribution, expectations and commitment involvement and influence	27,28,30
Top management support	Support given to project head, support to critical activities, understanding of project difficulty and stakeholder influence	22,31,32
Institutional factors	Standards and permits	27
Project characteristics	Project type, size nature, complexity, design, resources allocation time and level of technology	28,33
Project manager competence	Experience, coordination and motivating skills, leading skills, communication and feedback management skills, conflict resolution skills and organisation skills	34,35,36
Project organisation	Planning and control effort team structure and integration, safety and quality program, schedule and work definition, budgeting and control of subcontractors	23,27,32
Contractual aspects	Contract type, tendering (procedures or steps for the selection of that service) and procurement (company selection to provide services) process	28,29,33,37
Project team competence	Team experience, technical skills, planning and organising skills, commitment and involvement teams' adaptability to changing requirements working relationships educational level, training availability and decision making effectiveness	22,27,31,32
Project risk management	The factors under project risk management are sub-divided into two which are firstly hard aspects with initiation, identification assessment, response planning, response implementation and secondly soft aspects of risk which are risk communication and attitude monitoring and review	22,38,39
Requirements management	Elicitation technique, identification, analysis and negotiation, modelling, validation and scope management	39,40

2.3.1. Background of PIP

There have been numerous methods and techniques developed over the years to track and measure the harder technical aspects of project management, such as project schedules, budgets and work breakdown structures. However not many methods and techniques have been advanced to assist in tracking and controlling the softer human elements, such as interpersonal skills like leadership, communication and expectation management (Pinto, 1990).

The PIP is a project tracking and control tool developed by Slevin and Pinto (1986; 1987) see **Figure 2.1** above and allows an organisation to assess their capability to see a project through its entire implementation. The strength or mere presence of these factors is presumed to contribute to a substantial part of the variance in project implementation success (Pinto and Slevin, 1989a). The tool has ten measuring CSFs which were identified through a literature review to be critical to project success (Pinto and Prescott, 1988). The "arrows" in the model represent information flows and sequences, not necessarily causal or correlational relationships (Slevin and Pinto, 1986).

The PIP was developed through responses from project managers who were involved in perceived successful projects (Pinto and Slevin, 1987). They are considered crucial in achieving project stakeholders' expectations (Pinto, 1990). In a study of 408 successful projects, ten CSFs were validated against a wide variety of project types (Pinto, 1990; Finch, 2003). The model affords project managers to periodically monitor the current state of each factor throughout the project's lifecycle using the PIP model Pinto and Slevin (1987); Finch (2003) while they also identify the areas of concern or those problematic areas (Finch, 2003). It also allows them to focus both the 'hard' technical issues of the project, as well as the 'softer' behavioural issues that form part of the CSFs. This provides the project manager with an opportunity to look at the strategic issues of the project's development (Pinto, 1990). Conversely, the PIP monitoring and control is a difficult and often inexact process (Slevin and Pinto, 1991).

So, Pinto, Slevin and Prescott dominated literature in the 1980s for their contribution to CSFs because of their broad and systemic approach. They comprehensively defined project success by identifying factors that supported success and assessing the different weights of each factor over the project lifecycle and in different industries. They also developed a tool to help project managers assess project status. Organisations were able to benchmark their projects status against the average assessment results from applying the PIP to more than 400 projects and identify areas for improvement in their own projects.

In 1987, Slevin and Pinto published a paper on "Critical factors in successful project implementation" (Pinto and Slevin, 1987) acknowledging that success was a multi-dimensional concept and not a single measure. Of the identified CSFs, they found "project mission" to be important in all the stages while some were common to projects, irrespective of project type.

In 1988 Pinto and Slevin addressed CSFs across the project lifecycle (Pinto and Slevin, 1988a) which was an empirical test of their previous CSFs (Slevin and Pinto, 1986). They interviewed 418 members of the Project Management Institute (PMI) looking at the significance and weight of the ten (10) internal CSFs of the PIP and assessed them alongside four (4) external factors (i.e. characteristics of the project team leader, power and politics, environmental events, and urgency (Pinto and Slevin, 1989a). They ran different combination of the fourteen (14) CSFs and noted that only 60 percent explained project success and, like in 1987, project mission was significant across all project phases.

Another article called "Variations in CSFs over the stages in the project lifecycle" concentrated on the ten (10) internal CSFs and used a rigorous statistical technique to assess the influence of CSFs on project success depending on the project lifecycle stage (Pinto and Prescott, 1988). This paper provided a more focused assessment of what the project manager can influence when managing projects. The results concluded that various combinations of seven (7) of the ten (10) factors related to project success in the four (4) stages of the project lifecycle. There were three (3) factors excluded for the following reasons:

- monitoring and feedback and communication were found to be unstable through regressions;
- personnel did not correlate with project success in any stage of the project lifecycle. These exclusions will be expanded on under the limitations and criticism of the PIP section.

In 1990 Pinto and Prescott wrote a paper entitled "Planning and tactical factors in project implementation success" grouping the CSFs into planning and tactical categories (Pinto and Prescott, 1990) with project mission, top management support, project schedule/plan and client consultation falling in the planning category and the rest under tactical. Project success was also deemed multidimensional consisting of budget and schedule, value, and client satisfaction implying that some factors were within the project team's control and others not as they were owing to the environment.

These authors brought about the following clarity:

- Extending understanding of CSFs by project stage,
- CSFs by the planning and tactical categories, and
- CSFs within the project manager's influence (Müller and Jugdev, 2012a).

2.3.2. CSF of the PIP

As previously stated, the project management process is a complex one requiring focus on a huge variety of human, budgetary, and technical variables compelling the project manager to recognise which factors are critical to the success of project implementation (Slevin and Pinto, 1986). The ten (10) CSFs of the PIP were discussed briefly in support of the argument forwarded by (Slevin and Pinto, 1986).

Factor 1: Project Mission

Project mission stipulates the vision, goals and objectives of the project and provides direction to all stakeholders. Before anything can be implemented; it is important that project goals are clear (Cleland and

King, 1983; Morris, 1983; Slevin and Pinto, 1986; 1987). They need to be understood by the project team and the other departments within the organisation (Slevin and Pinto, 1987). It is a statement of where the project will focus its efforts (Pinto and Slevin, 1988b) to ensure that the financial and resource commitments are honoured by top management and that these commitments are used optimally to achieve the project mission (Pinto, 1990; Slevin and Pinto, 1991). The project mission clarifies:

- What the project is trying to achieve or build;
- The project's capabilities;
- Why the project is needed; and
- How the project will benefit the end user (Pinto, 1990).

Factor 2: Top Management Support

Once the goal of the mission is clear and project benefits are known, it is important to gain top management support; without which, the project may not succeed. This support should be both vocal and visible, or the project may not be seen as important by the balance of the organisation. No single factor is as predictive of its success as the support of top management; this is true for the early stages of a project's (Schultz and Slevin, 1975b; Slevin and Pinto, 1986; 1987; Pinto, 1990). It has been observed that this support guarantees allocation of sufficient resources and support in the event of a crisis (Pinto and Slevin, 1987; Rauniar and Rawski, 2012). It has also been implied that if, during the early stages of a project, there is lack of engagement by top management coupled with the lack of attention from the organisation, then this may lead to poor performance (Sosa *et al.*, 2007) with Zwikael (2008) suggesting that this involvement can significantly improve project success. Top management support can be shown by:

- Providing the 'promised' resources during the development and implementation of the project;
- Using the assigned authority under their designation to assist the project; and
- Providing the project team with the necessary guidance and support to the project and the project team during a crisis (Pinto, 1990).

Factor 3: Project Schedule/Plan

If project implementation is to be successful, activities need to be scheduled in detail and all the necessary resources such as people, money and time catered for (Cleland and King, 1983; Morris and Hugh, 1986; Pinto, 1990). This detail is required at every stage of the implementation process (Pinto and Slevin, 1988b). The detail and possible greater likelihood for success of the schedule will be according to the extent to which the project schedules / plans specify:

- Time schedules;
- Milestones;
- Manpower and;
- Equipment requirements (Pinto and Slevin, 1988b).

The project schedule should include a suitable measurement tool that is able to assess actual progress (time and budgetary) against the planned / baseline schedule (Pinto and Slevin, 1988b; Pinto, 1990).

Factor 4: Client Consultation

The project is for the client and therefore they need to be consulted to ensure the project is geared to meet their needs (Slevin and Pinto, 1986; Pinto and Slevin, 1987). It is for this reason that Pinto (1990) states that the project team must be cognisant of the need of the client who must be identified at the beginning of the project. It is important that they are consulted throughout the project to ensure that they accept the final project (Pinto and Slevin, 1988b; Pinto, 1990).

Factor 5: Personnel

Selection, recruitment and training of key and suitable personnel is crucial so the project does not end up with personnel selected based on convenience; whether they harm or help the project (Slevin and Pinto, 1986; 1987; Pinto and Slevin, 1988a). The success of a project is very reliant on the quality of the project team (Pinto, 1990) and yet it was noted that often project team members were selected without a complete understanding of how they would contribute to project implementation success; this factor is overlooked (Slevin and Pinto, 1987).

Factor 6: Technical Tasks

People who manage project implementation need to be well versed with it. They also need to ensure the project is supported by the correct technology. Thus, skilled people and appropriate technology are of equal importance if project implementation is to be successful. This includes the required expertise to accomplish those specific technical action steps (Slevin and Pinto, 1986; 1987; Pinto and Slevin, 1988a; Pinto, 1990).

Factor 7: Client Acceptance

Besides client consultation which is crucial; successful implementation can only be declared once the project has been accepted by the client (Slevin and Pinto, 1986; 1987); this is the final stage in the implementation process (Slevin and Pinto, 1987). Many project managers tend to believe that once the other stages have been successfully achieved, the client will accept the project (Slevin and Pinto, 1987). They do this at their own expense since they still need to sell and market the final product to the end user (Pinto and Slevin, 1988a; Pinto, 1990).

Factor 8: Monitoring and Feedback

Monitoring and feedback mechanisms allow the project manager to remain abreast of any problems, implement any corrective actions, and prevent defects from being overlooked (Slevin and Pinto, 1986; 1987; Pinto and Prescott, 1988; Pinto, 1990). Feedback should be provided on:

- Project schedule;
- Budget; and
- Performance of team members (Pinto and Slevin, 1988a).

Factor 9: Communication

The model indicates that communication is crucial in every factor as it is a catalyst for successful implementation (Pinto, 1990) and should happen at all levels within the organisation, within the project team, between the team and the rest of the organisation, and with the client. As project implementation cannot take place in a vacuum; communication needs to be continuous with and relevant information being available to all project participants (Slevin and Pinto, 1986; 1987; Pinto and Prescott, 1988; Pinto, 1990).

Factor 10: Trouble-Shooting

Project will have challenges despite them being well planned. Therefore constant amendments, adjusting, and trouble-shooting are essential in all the phases of the implementation process (Carrier, 1983). These mechanisms and contingency plans assist the project manager to react to unforeseen problems as well as foresee and limit potential problem areas in the implementation process (Pinto and Prescott, 1988; Pinto, 1990). So it becomes important for each team member to realise that they need to identify issues as they arise. They must be technically competent in the duties that they are assigned to deal with problems as they occur (Slevin and Pinto, 1986; 1987). The CSFs of the PIP are thus a useful tool for the project manager and the project team to use towards ensuring project success making it essential for the project team to believe that the project can succeed (Pinto and Slevin, 1988a).

2.3.3. Characteristics of the PIP Model

Literature describes the PIP has having some distinct characteristics such as being:

- categorised as either strategic or tactical;
- applicable to any phase of the project lifecycle;
- being industry specific; and
- temporal

These characteristics will be expanded on in the section below.

Strategic or tactical

There are two groups of factors in the PIP; strategic and tactical (Schultz *et al.*, 1987; Pinto and Prescott, 1990). The strategic factors involve early planning, policies and general objective setting and include project mission, top management support, project schedule/plan. Tactical factors involve resources allocation and implementation of tasks (Slevin and Pinto, 1986; Schultz *et al.*, 1987; Finch, 2003) and include client consultation, personnel and technical tasks (Slevin and Pinto, 1987). Factors such as feedback capabilities or communication channels can be regarded as either tactical or operational because they relate to the action phase of the implementation process (Schultz *et al.*, 1987). **Figure 2.10** illustrates the strategic and tactical categorisation of the PIP model and **Table 2.7** shows the taxonomy of differences in strategic and tactical issues to project implementation.

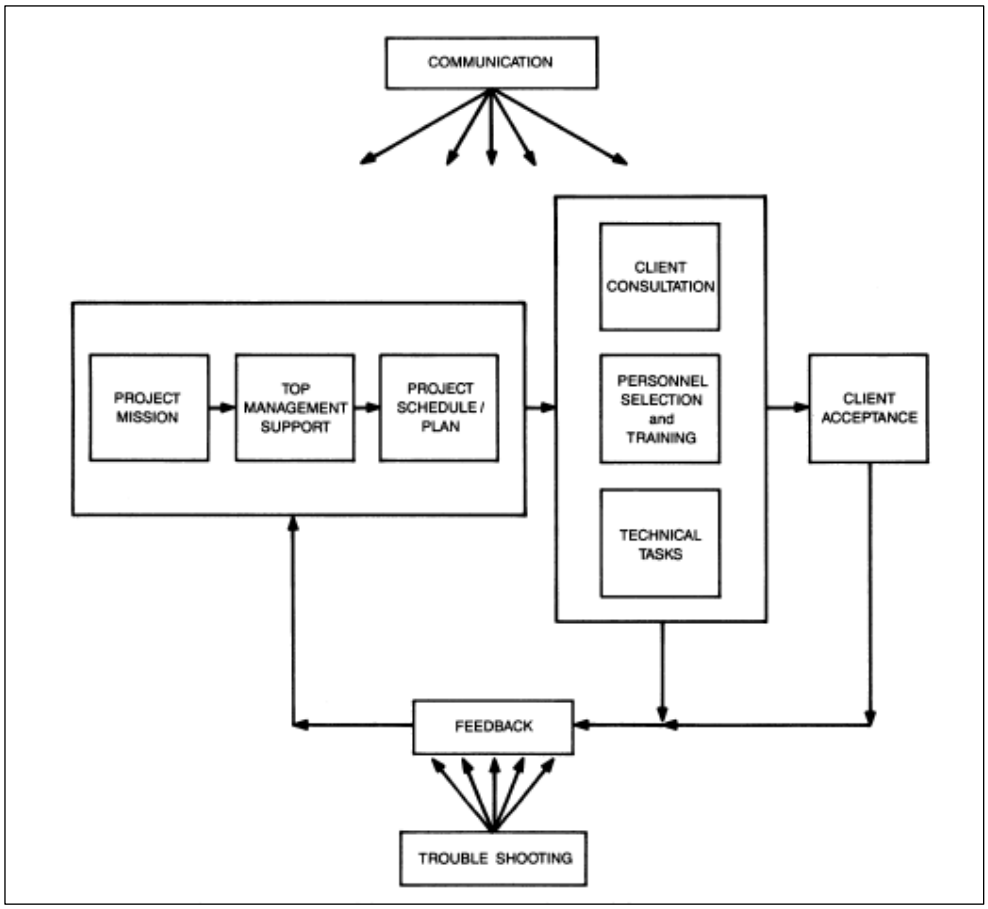

Figure 2.10: Ten factor process model using strategic and tactical factor clustering. Source: (Schultz *et al.*, 1987)

Table 2.7: A taxonomy of differences in strategic and tactical issues to project implementation. Source: (Schultz *et al.*, 1987)

	Strategy	**Tactics**
1. Level of conduct	Top management	Mid-to-lower levels of management
2. Subjective/objective assessment	Greater subjectivity used at strategic use	Less use of subjective values
3. Nature of problem	Unstructured, one at a time	More structured and repetitive
4. Information needs	Large amount of information needed, much that is external	Need for internally generated, specific information
5. Time horizons	Long-term, but it varies with the problem	Short-term and more constant
6. Completeness	Covers the entire scope of the organisation	Concerned only with the sub organisational unit involved
7. Reference	The source of all planning in the organisation is original	Done in pursuit of strategic plans
8. Level of detail	Broad and general	Narrow and problem specific
9. Ease of evaluation	Difficult, because of generality	Easier because of specificity
10. Point of view	Corporate	Functional

Applicabilty to the project lifecycle

Interest has been noted in literature regarding the emphasis that the project lifecycle holds on certain project CSFs (Pinto and Prescott, 1988). The importance of the individual CSF changes over time and it is dependent on where the project is in the lifecycle (Slevin and Pinto, 1987; De Wit, 1988; Pinto and Prescott, 1990; Tishler *et al.*, 1996). They are applicable to any stage of the project (Slevin and Pinto, 1987; Finch, 2003). The ten factors could be superimposed over the four phases (conceptualization, planning, execution and termination) of the lifecycle focussing the project manager's attention to the specific set of critical factors at each of the different phases (Slevin and Pinto, 1987). This is a sequential checklist or set of milestones that enables the tracking towards an improved ability to effectively use and allocate resources. This sequencing allows the project manager to determine project progress as it relates to the project lifecycle (Pinto and Slevin, 1987). **Figure 2.11** is an illustration of the CSFs applicable the project lifecycle phases.

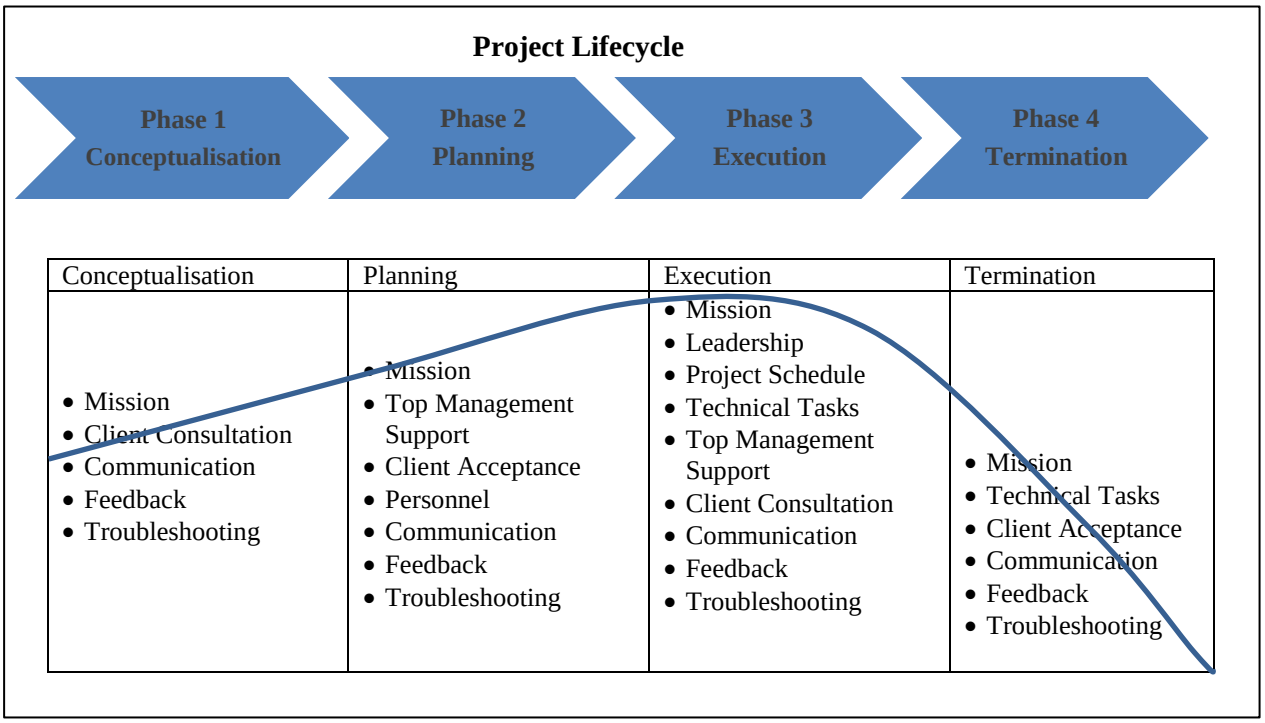

Figure 2.11 - CSFs applicable at each stage in the project lifecycle. Adapted from (Slevin and Pinto, 1987)

The CSFs are arranged in a sequential and time sequenced manner Schultz *et al.* (1987) indicating their interdependent relationship with each other in the project lifecycle. The path begins with *project mission* and concludes with *client acceptance*. The remaining three factors (*monitoring and feedback; communication and trouble-shooting*) are present at all the stages of the implementation process and considered important throughout a project lifecycle (Schultz *et al.*, 1987; Slevin and Pinto, 1987; Pinto and Slevin, 1988a). The other factors are important either at inception or the end of the project Finch (2003) and client acceptance is important only later in the project (Schultz *et al.*, 1987).

Looking at the factors in more detail, the following can be noted (Pinto, 1990; Slevin and Pinto, 1991):

- Because CSFs are interdependent they should not only be examined on their own but also in relation to each other so their effect on project success can be understood; and
- The factors also occur in a logical order and not randomly or concurrently. Even though this sequence exists, it is not absolute and a significant overlap exists in practice (Schultz *et al.*, 1987; Slevin and Pinto, 1987; Pinto and Slevin, 1988b).

Industry specific

Studies have been conducted across industries looking at their specific CSFs. From these studies the refined CSF list was developed. Literature indicates that CSFs are unique to each industry and this is important so that a proper evaluation can be based on these factors (Bullen and Rockart, 1981; Belassi and Tukel, 1996). It therefore appears that although there are some consistently common factors influencing project success irrespective of the project and industry, there are still some project and industry specific factors that affect project success (Pinto and Covin, 1989; Baccarini, 1999; Lim and Mohamed, 1999).

Temporal

The factors appear to be fundamentally temporal because instead of occurring randomly, they occur in a certain order (Schultz *et al.*, 1987). This happens in the areas within an organisation that have become critical for a particular time period owing to something being out of the ordinary leading to the generation of CSFs. Correspondingly in an industry dominated by a single major firm, a CSF for the rest would be to understand the strategies of the leading firm and their apparent impacts. This is also true for the geographic positioning of the company (Rockart and Bullen, 1981).

2.3.4. Benefits of PIP

To the project manager, the PIP is a tracking tool during implementation providing a detailed breakdown of project performance (after the fact) against the CSFs of the PIP. It therefore highlights the areas of concern as well as where future success and failure can be determined. The project manager can thus better monitor and systematically oversee project implementation status (Slevin and Pinto, 1986).

2.3.5. Limitations and criticism of PIP

Despite the PIP model being used extensively and being viewed as adding value to project success, a number of limitations and criticisms of the model have been highlighted in literature (Finch, 2003). These concerns include the PIP methodology validity limitations, reliability and transferability (Finch, 2003). Slevin and Pinto (1991) also criticised the model suggesting that further research on the subject would benefit the model. The following are the main criticism and limitations of the PIP model.

a) Personnel factor

Pinto and Prescott (1988) concluded that the personnel factor (independent variable) was the only factor in their research that was negligible Belout (1998) for project success (dependent variable). This became the most widely written about criticism in literature. The low ranking of this factor (5^{th} in the PIP) has attracted critique as not addressing perceived important critical factors with statements such as: the items "*comprising the Personnel scale are not* useful *from a construct validity standpoint for assessing the factor of personnel"* Belout (1998: 16). This factor is also not correlated, in any phase of the project lifecycle, with project success (Müller and Jugdev, 2012b). This is surprising as many major project failures can be linked to social issues such as qualification of staff, management experience and ability to motivate the project team (Belout, 1998; Belout and Gauvreau, 2004).

There were opposing views to the perception of the importance of this factor suggesting that the conclusions from (Pinto and Slevin) be retested and a number of questions relating to the PIP be addressed. It is believed this is important because most models explaining project success are not based on empirical proof but rather on theory (Belout and Gauvreau, 2004). This is owing to the dependent variable 'project success' lacking rigorous definition and its measurement not being precise. From a methodological viewpoint, many aspects appeared to lack rigour (Belout, 1998). Authors such as Belout and Gauvreau (2004) confirm that a moderating effect between the independent variables and project success, depending on the sector being studied. This study also shows the problem of multicolinearity, which appears to be excessive in the use of PIP (Belout and Gauvreau, 2004).

b) Survey method

The questionnaires were mailed to 586 members of the PMI, which is essentially a national organisation of project managers. The study only surveyed project managers so other stakeholders who could have provided greater insights and perspectives were excluded (Belout, 1998). This means that project managers were the principal evaluators of the personnel factor. In this sense, the PIP instrument did not evaluate the training, motivation, experience and commitment of the project managers as independent variables. This is another weakness in the research because the project managers are considered in project management literature as central actors for success and effectiveness (Belout, 1998). Furthermore, this study did not consider the project manager's competence or expertise (Kuruppuarachchi *et al.*, 2002; Finch, 2003).

c) Internal and external environment

The impact organisational culture and political environment on project success was not considered and the impact of external factors and environment on project success not tested. This brings into question the relevance of some of the questions for certain types of projects, which can have an effect on the scoring for the various factors (Finch, 2003).

d) Advancing theories

The criticisms and limitations of the PIP included failure to advance theories based on the importance of critical factors such as communication. This was evident in overstating the importance of other factors like Human Resource Management (Hyväri, 2006). **Table 2.8** shows the different rankings of the CSFs by various authors. Hyväri (2006) and Finch (2003) ranked communication, client consultation and client acceptance among the top four (4) most important factors as opposed to Pinto and Slevin (1987)'s 9th most important factor for success.

Table 2.8: Ranking of the PIP CSFs from different studies. Source: (Hyväri, 2006)

#	CSF	Hyvari (2006)	Finch (2003)	Delisile & Thomas (2002)	Pinto & Prescott (1988)	Pinto & Slevin (1987)	Totals
1	Client Consultation	3	1	2	2	4	12
2	Project Mission	6	7	1	1	1	16
3	Client Acceptance	3	4	6	4	7	24
4	Communication	1	2	8	6	9	26
5	Project Schedule/Plan	5	5	5	9	3	27
6	Top Management Support	4	6	9	7	2	28
7	Technical Tasks	7	9	4	3	6	29
8	Monitoring and Feedback	10	3	3	5	8	29
9	Troubleshooting	7	8	7	8	10	40
10	Personnel	9	10	10	10	5	44
Note: Numbers in the above table indicate relative ranking of the different factors in individual studies and the total column shows the order of ranking of the factors when these studies rankings are combined							

Reliability and validity

Questions can also be asked of the rating reliability of the PIP and whether the results can be reproduced when repeated. Numerous of internal and external factors influence projects that are not identified by the PIP tool (Kuruppuarachchi *et al.*, 2002; Finch, 2003). The exclusion of these types of factors weakens the validity of the methodology (Belassi and Tukel, 1996; Finch, 2003).

These criticisms discussed above somehow do not weaken the value of the model, but rather strengthens the argument to improve the tool and ensuring that it is adapted to become stronger (Finch, 2003; Hyväri, 2006).

2.4. Conclusion

Literature is clear that a variety of areas need to be considered when deciding on factors that are critical for project success. These factors range from those considered applicable to any project success to those that are specific as in this case study it would be to achieve nuclear project success. The factors can be categorised into those that improve the probability of project management success as well as those that have longer-term impact on the organisation. Although the factors emanate from different areas of practice, they are dependent upon each other and therefore not only applicable to certain types of projects. The literature review was conducted to identify those factors that cover the entire lifecycle and those related to nuclear project success, both from literature and nuclear oversight bodies and identified as follows:

#	CSF (Slevin and Pinto (1986)	Description	Factors from Literature	Factors from Nuclear Oversight Bodies
1	Project Mission	Project mission stipulates the vision, goals and objectives of the project and provides direction to all stakeholders.	✓	✓
2	Top Management Support	Senior management's support to ensure project success and project outputs adopted across the organisation	✓	
3	Project Schedule/Plan	A detailed plan with action steps, resource requirements and timelines	✓	✓
4	Client Consultation	It is important that they are consulted throughout the project to ensure that they accept the final project	✓	
5	Personnel	The success of a project is very reliant on the quality of the project team	✓	
6	Technical Tasks	Availability of the technology and specific technical steps required by the project team to complete project tasks	✓	✓
7	Client Acceptance	A process to ensure that there is constant client acceptance of project deliverables during the implementation and at the end of the project	✓	
8	Monitoring and Feedback	Continuous monitoring and control of the project progression	✓	
9	Communication	communication needs to be continuous with and relevant information being available to all project participants	✓	✓
10	Troubleshooting	A procedure to respond to the dynamic nature of a project, unexpected crises, and deviations from plan	✓	✓
11	Regulatory Requirements	Regulatory authorities interpret and implement the laws in the form of directives and impose detailed requirements on projects depending on their and the affected environment. These regulatory requirements should be anticipated and included in the planning phase and when these requirements are not met, they negatively affect projects		✓
12	Nuclear Safety	The assessment of project nuclear safety performance includes any challenges to nuclear safety that result from project activities		✓
13	Radiological Safety	Radiological safety performance compares project performance with established expectations for dose and contamination control. Higher-than-expected doses or personal contaminations negatively affect project performance		✓
14	Industrial Safety	Industrial safety performance includes measuring lost-time accidents, regulator recordable events, first-aid reports, and near misses. It is important to monitor the first-aid cases as an early warning trend to a more severe regulator recordable event or lost-time accident.		✓
16	Risk Management	Risk must be identified and managed from inception of the project as a strategic driver to the realisation of a product or process in the execution stage		✓

3. CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

Research is the pursuit of knowledge (Rugg and Petre, 2007) involving methodical, meticulous, effective and protracted examination; describing the unknown and including the forming of interconnections and association that enable the accuracy of predicted outcomes related to the conditions that have been specified upfront. It involves the custom of questioning what one does, a methodical investigation of clinical observations that lead to answers to perceptions with a goal of effecting suitable changes (Kumar, 2018).

This chapter described the method used to answer the research question of *'what are the factors considered critical to the success of nuclear projects*?' The structure of the chapter had six sections. The first section defined the research paradigm that was adopted for the study. This was followed by the second section which provided a framework for the research philosophy/paradigm. In the third part, the research philosophy, research approach and research strategy was discussed. The fourth part discussed the research methodology; the case-study in this research. The fifth part discussed the research design and the sub-elements included the research method, the research instrument used, the research sampling method, how data was collected, the research questionnaire design, the survey design and how the data analysis was done. The sixth part described the limitations of the methodology. The chapter concluded with a discussion around the ethical considerations during the study, the value of the research and a summary of the methodology.

3.2. Research paradigm

Research involves making clear assumptions when performing qualitative research; this is to have a good understanding of the dynamics of the worldview, paradigms "*way of thinking that reflects fundamental beliefs and assumptions about the nature of organisations*" (Gioia and Pitre, 1990) in relation to certain problems. The worldview can be understood in various ways (Cresswell, 2007; Maree, 2007).

- **The functionalist paradigm** is considered an objectivist interpretation of the organisational worldview focussing on constancy of the current state of affairs.
- **The interpretive paradigm** is considered a subjectivist view focussed on regulation in an attempt to describe and explain what the CSFs are for a nuclear utility. This paradigm seeks to define and clarify the research problem so that it can be understood. (Gioia and Pitre, 1990). Interviews with programme managers, project managers, project coordinators, and all other relevant stakeholders will be conducted as part of this research. This will be followed by the analysis and interpretation of collected data.
- **The radical humanist paradigm** is considered a subjectivist view, which is ideologically orientated to radically change constructed realities (Gioia and Pitre, 1990).
- **The radical structuralist paradigm** is an objectivist perspective, with an ideological concern for the radical change of structural realities (Gioia and Pitre, 1990).

This research study fell within the interpretive paradigm.

Positivism, social constructivism, advocacy or participatory are considered three (3) principle paradigms.

- **Post positivism:** This paradigm involves quantitative research with a scientific approach to research and a belief system grounded in post positivism. It has a reductionistic approach that is logical, emphasising that empirical data be gathered, cause-and-effect and deterministic based on *priori* theories. Researchers of this paradigm are inclined to view a survey as logical steps that are. They hold the view that participants have numerous viewpoints as opposed to a single reality and adopt arduous methods to collect and analyse data. Computer programmes are often utilised to ensure rigour in data analysis whilst also encouraging using validity approaches and using scientific reports as a form of compiling the qualitative study (Cresswell, 2007).
- **Social constructivism:** The researcher tries to make sense of the world where they work and live developing subjective meanings of their experiences, things or objects. These meanings are diverse and numerous, leading the researcher to look into complexity of views as opposed to reducing the meanings into a manageable groupings. In this case therefore, the goal of research relies heavily on how the participants view the situation (Cresswell, 2007).
- **Advocacy/Participatory:** The ultimate aim of this paradigm is for the conclusion of research to have a plan of action for transformation; changing participants' lives (typically marginalised), the environments in which they live and work; sometimes also those of the researcher (Cresswell, 2007).

The research paradigm adopted for this study was post positivism.

3.3. Research philosophy

A researcher's choice of qualitative research is usually based on five (5) philosophical / theoretical assumptions as described below:

Ontological assumptions: This philosophy involved the nature of an organisation and its characteristics. The ontological assumptions for this research leaned more towards subjectivism where reality was determined through conversation and multiple realities (Saunders, 2016). NPM manages modifications at the NPP and these include the execution of projects to the plant asset creation process, plant related modifications motivated predominantly for operational needs, and in accordance with international standards required to operate plants and the NNR. These are implemented in accordance with the Project Management Process for KNPS Modifications (KAA-501). For this research project, the ontological assumption was that nuclear projects CSFs, if identified and agreed, will have a substantial impact on a project's successful outcome. Furthermore, if there is misalignment on which factors are considered critical between the project organisation and stakeholders involved with the project, the probability of the project being perceived as a success is reduced.

Epistemological assumptions: This philosophy involved understanding the origin, scope and nature of knowledge. The epistemology again leaned toward objectivism where natural science assumptions, facts and observable phenomena are valued (Saunders, 2016). NPM consists of programme managers, project managers, project leaders, construction managers, project coordinators, construction supervisors, construction safety officers, project administrators and advisors in the nuclear project management office (NPMO). The disciplines and professional background of these members are diverse and vast as they are Engineers (Mechanical, Electrical, Civil, System and Project Engineers) and the following Practitioners (Project Management, Health and Safety, Quality Management, Procurement and Finance) as well as Supplemental Staff such as Contractors. This was considered to be subjective. This was in line with the epistemological assumption that for the research data to be valid, the people involved in the data gathering process must have experience in nuclear projects and modifications being executed at the NPP in South Africa. A further assumption made was that by involving a wide range of audiences, the data received from the sample group could be assumed to be representative of the population involved with nuclear projects and modifications in the South African nuclear industry.

Axiology: This philosophy was within the objectivist paradigm involving aesthetics, ethics and justice and considered as an objectivist paradigm. The axiology lied somewhere in between as although based on values the researcher was expected to be detached as an observer and reporter rather than integral involved as an influencer (Saunders, 2016). The axiological assumption was that the view of the Researcher should not bias the results received from the participants so the Researcher interpreted the results based on facts and trends observed. The results were the honest view and perception of the participants and could therefore not be classified as either right or wrong (Saunders, 2016).

Human nature (Rhetorical): To gain an understanding of the relationship between humans and society. The benefits of identifying CSFs for nuclear projects were established in this research.

Methodological assumptions: This philosophy was concerned with the nature of ways of studying phenomena (Kagioglou *et al.*, 2000; Denzin and Lincoln, 2005; Cresswell, 2007) which in this research were the methods employed to determine the CSFs of a nuclear project or modification.

3.4. Research approach

Developing theory is crucial in resolving a research problem where the link between the two is investigated (Eisenhardt, 1989). The difference between deductive and inductive approach is shown in **Table 3.1** below:

Table 3.1: Difference between deductive and inductive approaches. Source: (Class notes)

Inductive	Deductive
Gain richer and in-depth information through the application of a methodology that is less structured	Commences with analysis of the literature
Propose further steps for the collection of data that will attempt to answer the phenomena in question (research question). There is no pre-supposition involved	Identify a single problem and isolate a major research question
Some background information is acceptable and a full literature review is not recommended in the early stages but this may influence the position taken by the researcher	Formulate a hypothesis (can be accompanied by a seriesofsub-hypothesis)
Having observed the empirical world, theories and explanations can be developed.	Having understood the pre-existing knowledge, data is collected and analysed and findings made.

The research study followed a deductive approach. Theory was established through literature. The set CSFs of the PIP were considered as the primary factors. Although a formal hypothesis was not stated, the research study tested the utilisation/applicability of the CSFs of the PIP in the South African nuclear industry. Through the observations from the research, the applicable CSFs were confirmed in the implementation of nuclear projects in South Africa when modifying a NPP and compared to existing knowledge around general and assumed CSFs for nuclear projects.

3.5. Research strategy

Research strategy is the explanation of a high level method to research that defines the comprehensive approach to be undertaken; an expression of the researcher's basic philosophical beliefs and an understanding of the research to be undertaken (Yin, 2009). Literature stipulates two (2) types of data in research; quantitative and qualitative (Miles and Huberman, 1994; Amaratunga *et al.*, 2002). Both are able be used for descriptive, investigative, exploratory, inductive and opening up purposes whilst also being practical to be used for explanatory, confirmatory and the testing of hypotheses (Miles and Huberman, 1994). Quantitative research strategy is for when topics and events are explained through the collection of polls, questionnaires, surveys and analysis using mathematical based methods of relevant data. The main focus is on the representation of opinions or concepts represented by numbers Amaratunga *et al.* (2002) where it is not required for the collected data to be naturally quantitative. This data can be converted into useable quantitative data (surveyed responses can be converted into numerical values) by using measurement instruments (Muijs, 2010).

Qualitative research, on the other hand, places emphasis on words and observations to express reality by describing people in their natural settings (Amaratunga *et al.*, 2002). It leans toward the inductive approach of arriving at knowledge by gathering facts, forming the basis for laws. This is usually conducted through extensive field research that is focussed on ordinary events in natural settings to establish a view on the

reality. This progresses robust and rich holistic data with a possibility of revealing complexity (Amaratunga *et al.*, 2002). This strategy accentuates word mapping and phrases instead of quantifying data collection and analysis (Bryman and Bell, 2003).

Table 3.2 outlines the fundamental differences among these two strategies in terms of three areas: 1) principal orientation in relation to research; 2) epistemological orientation *(questions of what is or should be viewed as acceptable knowledge)*; and 3) ontological orientation *(nature of social entities)* (Bryman and Bell, 2003) while **Table 3.3** explains the strengths and weaknesses of quantitative and qualitative research.

Table 3.2: Fundamental differences between quantitative and qualitative research strategies.
Source: (Bryman and Bell, 2003)

	Area	Quantitative	Qualitative
1	**Principal orientation to the role of theory in relation to research**	Deductive; testing of theory	Inductive; generation of theory
2	**Epistemological orientation**	Natural science model, in particular positivism	Interpretivism
3	**Ontological orientation**	Objectivism	Constructionism

Table 3.3: Comparison between quantitative and qualitative research studies Source: (Amaratunga *et al.*, 2002)

Research Category	Strengths	Weaknesses
Quantitative	Ability to provide a wide coverage of the range of situations	Methods used tends to be rather inflexible and artificial
	Fast and economical	They are not very effective in understanding process or the significance that people attach to actions
	Where statistics are aggregated from large samples they may be of considerable relevance to policy decisions	Not effective in establishing theories
		Because they focus on what is or what has been recently they make t hard for policy makers to infer what changes and actions should take place in the future
Qualitative	Data gathering method seems more as natural tan artificial	Data collection can be tedious and require more resources
	Ability to look at change processes over time	Analyses and interpretation of data may be more difficult
	Ability to understand peoples meaning	Harder to control the pace, progress and end points of research process
	Ability to adjust to new issues and ideas as they emerge	Policy makers give low credibility to results from qualitative approach

In order to get the accurate and validated perspectives of the various project participants and stakeholders about the CSFs for nuclear projects, a combination of both quantitative and qualitative research strategies was utilised to collect different types of information throughout the research study; this is called mixed methods research (Johnson and Onwuegbuzie, 2004; Johnson *et al.*, 2007; Teddlie and Tashakkori, 2011). This method employs both the quantitative and a qualitative phase to interpret and validate the results (Johnson and Onwuegbuzie, 2004).

Clear statements about the generic strategy must be included in the design and methods of the research report. This includes identifying an appropriate research method such as case-study, ethnography or survey as well as a procedural strategy which is described as the explicit steps to be taken to implement the general research strategy; irrespective of strategy being either quantitative or qualitative (Punch, 2013).

Figure 3.1 shows the mixed methodology framework with both quantitative and qualitative strands showing the general strategy followed per strand. It further shows that the general strategy that was followed for the different strands is exploratory (quantitative) and multiple case-studies (qualitative). The procedural strategy was e-mailed questionnaires (quantitative) and semi-structured interviews (qualitative).

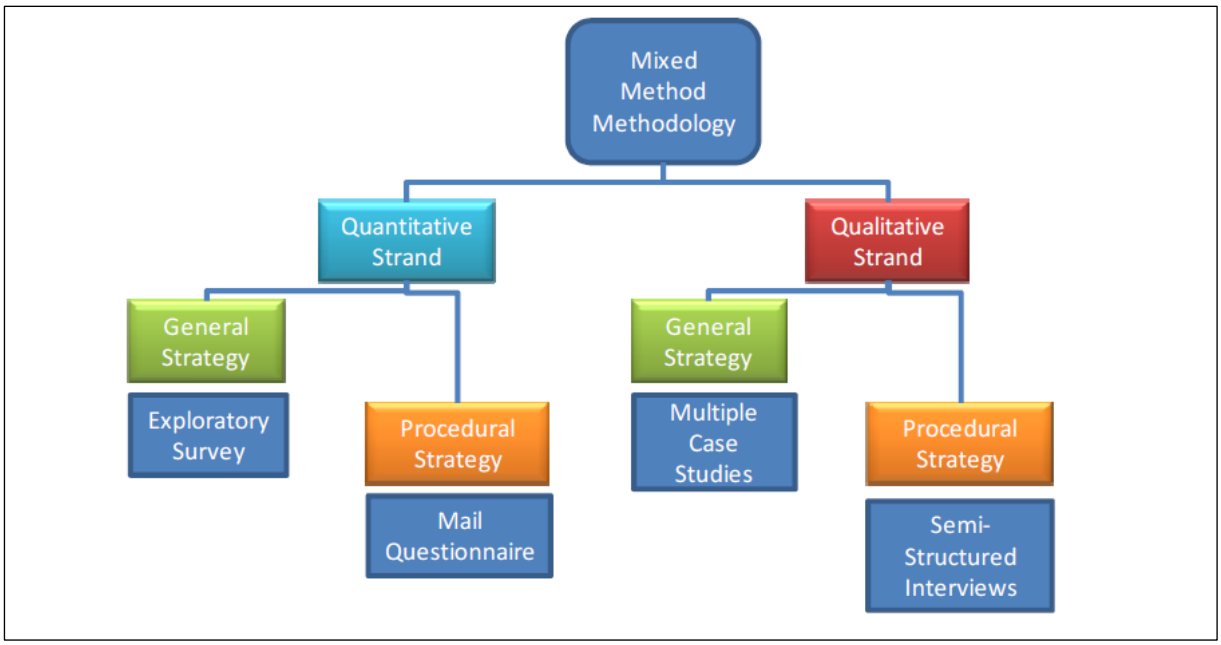

Figure 3.1: Research methodology framework. Source: (Teddlie and Tashakkori, 2011; Punch, 2013).

This combination was advocated by Miles and Huberman (1994). The cautious measurement, generalisation of samples, experimental control, and statistical tools of decent quantitative studies; on their own, are considered valued resources Miles and Huberman (1994) but when merged with the up-close, in-depth, reliable appreciation of complex real world contexts that characterises first-rate qualitative studies, it leads to the emergence of a practical and commanding research tool (Miles and Huberman, 1994).

There is further caution in the use of mixed method about the confusion related to the overlapping of study method boundaries and as such, an appropriate method needs to be identified that will best suit a specific study. To this end a conditional approach with a basic categorisation scheme was proposed where the conditions consist of the type of research question posed, the level of control the researcher has over real events and the level of focus on current compared to past proceedings (Yin, 2009).

3.6. Research methodology

Research methodology is known as the procedural framework in which research takes place while research methods are the ways in which data is collected and analysed (Bhattacherjee, 2012). Quantitative research methods are generally utilised for responses from a vast amount of respondents via questionnaires. This is followed by data collection and analysis by the use of statistical methods (Wisker, 2007). Qualitative data collection can vary from performing interviews with individuals, focus group discussions, the review of existing documentation, and observations (Rowley, 2002; Wisker, 2007; Bhattacherjee, 2012; Hancock and Algozzine, 2017). Yin (2009) also distinguished between the five (5) major research methods of experiments, surveys, archival analyses, histories, and case-studies. This led to the use of a basic categorisation scheme for the form of research questions of "who", "what", "where", "how" and "why" to determine the appropriate method (Yin, 2009).

An exploratory survey was employed for the quantitative strand of this research study. It is evident from Yin (2009) that survey or archival analysis methods are best suited for this purpose. For the qualitative strand, a case-study was used owing to the fact that the aim was not to define the incidence or predominance of a phenomenon. These methods are usually correlated to explanatory cases signified by "how" and "why" questions (Yin, 2009).

When considering the conditions set out by Yin (2009), (1) the level of control an investigator has over actual behavioural events, and (2) the degree of focus on present as opposed to past events; for histories, it is not necessary to control behavioural events, but as expected, it does not focus on current events (Yin, 2009). For an experiment, on the other hand, it is necessary to control behavioural events and it places emphasis on current events (Yin, 2009). The case-study was therefore an appropriate research method on a contemporary set of events; the investigator had little or no control over these (Yin, 2009).

In this research study, given the complex real-world context of data collection, the need to control behavioural events was not required and due to the focus being on contemporary events, the requirement for histories and experiments was eliminated. The condition to develop a relevant foundation and proposal for further inquiry Yin (2009) thus became a requirement. It was therefore concluded that the exploratory case-study was considered the appropriate research method for the qualitative strand of this study.

3.6.1. Case-study

A case-study is defined as "*an in-depth investigation of a problem in one or more real life settings over an extended period of time*" (Yin, 2003; Bhattacherjee, 2012). This research strategy is concerned with the dynamics that exist in single settings and can employ both quantitative and qualitative research methods whilst also being utilised for theory testing and building involving either a single or multiple cases Eisenhardt (1989); Rowley (2002) and various levels of analysis (Eisenhardt, 1989). Multiple data sources can be used during case-studies such as interviews, personal observations and internal or external

documentation (Yin, 1981; Eisenhardt, 1989; Chetty, 1996; Rowley, 2002; Bhattacherjee, 2012; Punch, 2013; Hancock and Algozzine, 2017) with the aim of testing research questions and matters in a contextual and often causal context (Cassell and Symon, 2004). The case-study is useful in answering "how", what and "why" type questions and "…*in this role can be used for exploratory, descriptive or explanatory research"* (Rowley, 2002: 16) and in explaining contextual conditions relevant to the research study (Yin, 2009); they are deliberate because of the ability to excavate entrenched meaning in a contextual setting (Hoepfl, 1997). "…*this method has been tried and found to be a direct and satisfying way of adding to experience and improving understanding.*" (Stake, 1978: 7).

"M*ost case-studies tend to be interpretive in nature"* (Bhattacherjee, 2012: 95) with interpretive being defined as "*the technique where evidence collected from one or more case sites is systematically analysed to allow concepts to emerge for the purpose of building new theory"* (Bhattacherjee, 2012: 95). This approach consists of these stages: defining research questions, selecting a case site, creating tools and protocols, selecting respondents, collection of data, conducting within-case and cross-case data analysis, building and testing hypothesis and compiling case research report (Bhattacherjee, 2012).

Case-study research affords the investigator the opportunity to preserve the complete and significant characteristics of real life events Yin (2003); but they have been regarded as less appropriate than experiments or surveys, owing to their deficiency in rigour. While they provide diminutive basis for scientific generalisation; this can be overcome by employing multiple case-studies. In response to Flyvbjerg (2001; 2006) proposed unsuitability of case-study as a qualitative research tool, (VanWynsberghe and Khan, 2007) illuminate several points in an attempt to show that the opposite is true. One of these points relates to the problem of singularity or inadequacy of units observed in typical research studies and as a result, case-study findings are not generally considered useful for the purposes of building theory or testing hypotheses (VanWynsberghe and Khan, 2007). However, a single case may "*refute a hypothesis*" therefore countering the argument that case-study is without its merits (VanWynsberghe and Khan, 2007).

The use of multiple cases as a preference is dependent on the nature of the research (research question) (Yin, 1994). An increase in the number of cases translate into a good case-study being undertaken and therefore preferred over single case-studies; the benefit of which is the possibility of direct replication. Furthermore, analytic conclusions that independently arise from two cases will be more powerful than those coming from a single case (Yin, 2009). The amount of cases to be used should be such that the richness of the data being collected is not compromised, resulting in a bias towards fewer ones cases in a typical setting (Khan, 2008). Some case-study researchers have drawn criticism for the time amassed and subsequent volumes of documentation leading Yin (2003) to emphasise the importance of the competence of case-study researchers to conduct such research or risk jeopardising the entire study; especially in light of the added challenge of the required skills for conducting a good case-study research not yet being identified (Yin, 2003).

Yin's work on case-study research in qualitative methodology is frequently mentioned in research (Rowley, 2002; Patton and Appelbaum, 2003; Riege, 2003; Creswell, 2007) with Teddlie and Tashakkori (2011) confirming case-studies as the qualitative portion of the overall mixed method research design. Yin (2009) will therefore be utilised to clarify the core values of the case-study method. The amount of cases, unit of analysis, validity and quality of the case-study will be explained. For this study, the research will be conducted at KNPS; the case unit is NPM and the unit of analysis is the projects undertaken in this department.

The use of previous literature to define the case and unit of analysis is recommended by Yin (2009). For this study data was collected from individuals (respondents) and the unit of analysis, NPM. Although Yin (2009) pointed out this setup to be problematic, there is evidence of similar studies where there is distinction between the sources of data and unit of analysis as they differ in levels. To this end, four (4) cases with a collective unit of analysis were used for the qualitative strand of this study with the sources being individual project managers who had successfully completed projects.

a) Advantage of case-studies

The following are advantages of case-studies as listed by various authors:

- Useful in the building of theory and the testing of hypotheses (Stake, 1978; Cassell and Symon, 2004);
- Theory can be developed using both single and multiple sources of evidence (Eisenhardt, 1989);
- A valuable tool for measuring and recording behaviours and data collected from various sources (Chetty, 1996);
- Ideal where current theory about research topics is inadequate (Chetty, 1996);
- An organisation can benefit from the performance and decision making process if they have an improved understanding the research problem (Chetty, 1996);
- A valuable tool for the preliminary, exploratory phases of a research project upon which the development of a more structured tool can be based; a requirement in surveys and experiments (Rowley, 2002);
- Useful in the exploration of new or emerging processes or behaviours and the capturing of an organisation's emergent and changing properties (Cassell and Symon, 2004);
- Useful in understanding daily practices and their meanings to those involved in research studies (Cassell and Symon, 2004); and
- May be crucial in cross-national comparative research (Cassell and Symon, 2004).

b) Disadvantages of case-studies

The following are disadvantages of case-studies as listed by various authors:

- Uses much time and requires more effort to construct readable stories for data elements (Yin, 1981);
- Affords little basis for generalisation; not suitable for scientific and statistical generalisation (Chetty, 1996);and
- Descriptively inexhaustible, any description requires cultural clarifications that are, more often than not, theoretically open to question (Gomm *et al.*, 2009).

3.7. Research design

Research design is the logical sequence of linking the initial study question to the data to be collected and the conclusions to be drawn Yin (2003); Cassell and Symon (2004) ensuring consistency (Cassell and Symon, 2004). It is a plan, structure and strategy of investigation designed to extract answers to research questions or problems Welman *et al.* (2005); Kumar (2018) and can be defined in empirical research as an inclusive data collection plan (Bhattacherjee, 2012). Additionally, as it involves the defining of the primary mechanisms of an investigation (research questions and propositions, establishing validity and reliability and selecting the design for the case-study) it can be utilised as an action plan that takes the researcher from questions to conclusions (Rowley, 2002).

Research design must aim to stipulate three (3) processes; data collection, development of the instrument and sampling; a critical process in answering research questions (Maree, 2007). Five (5) critical components constitute research design; study question, proposition, unit of analysis, logic linking the proposition to the data and the criteria by which findings will be interpreted (Rowley, 2002; Yin, 2009; Bhattacherjee, 2012).

Yin (2009) describes the five (5) components of research design to be as follows:

- **Research design:** The logical sequence of linking the initial study question to the data to be collected and the conclusions to be drawn.
- **The research question:** What factors are considered critical for nuclear project success?
- **Proposition**: Focussing attention to something in the scope of the study that should be examined. The proposition was: An improved understanding of which CSF are applicable to the nuclear industry will contribute to improved project performance.
- **Unit of analysis:** Defining the “case”. There is a challenge in constructing a case-study research design; the questions are related to the selected unit of analysis; this can only be realised when the primary research question is correctly stated. For this case-study, unit of analysis was CSFs that are considered critical for nuclear project success: the case of projects and modifications undertaken at KNPS.
- **Interpretation and findings:** These were linked to the proposition and data.

The main aim of this research study was to progress a model of nuclear CSFs against which nuclear project success is measured. This model was applied to a modification to measure its relative success.

3.8. Research tactics

There are four (4) tests that establish the value of empirical research and determine the quality of research design namely construct validity, internal validity, external validity and reliability. With this being an exploratory study, internal validity, which are for explanatory or causal studies, is not applicable. Construct validity is concerned with identifying appropriate operational measures for the theories being studied. For construct validity researcher must satisfy two (2) steps: define the selection of projects considered successful outside of establishing the CSFs linking them to the original study objectives and identify operational measures that match the concepts (Yin, 2009).

To satisfy the first step, projects that were considered as being completed successfully in the NPP were sampled and their common success factors identified towards creating a framework for CSFs for nuclear projects. In case-studies three (3) tactics are employed to increase the construct validity. First is to collect data from multiple sources of evidence; second is to decide a chain of evidence and the third tactic identify key informants to review the draft case-study. These tactics described by Yin (2009) were employed in this study.

External validity defines the degree to which findings can be generalised outside of the existing case-study. As previously stated, the use of multiple case-studies allows for direct replication of logic proving that if a study is reliable, the processes can be repeated with the same results. Furthermore, when the procedures of the protocols are accurately documented, the reliability of the case-study is improved (Yin, 2009).

3.9. Procedural research strategy

The explanation of how the general strategy will be achieved is detailed in the procedural strategy (Punch, 2013). There are three (3) simultaneous activity flows that form part of qualitative data namely data reduction, data display, and conclusion drawing/verification and they account for both the qualitative and quantitative strands of the study; this is the procedural research strategy. Data was collected from a sample group using precise data collection instruments and repeatedly sharpened, sorted, focused, discarded, and organised. This exercise was performed on a continuous basis following completion of fieldwork up to the compilation of the final report (Miles and Huberman, 1994).

The procedural research strategy is a sequential quantitative, qualitative analysis that includes typology development (Teddlie and Tashakkori, 2011) In this research study the first phase was quantitative with the second phase being qualitative and their analysis were related to each other (Teddlie and Tashakkori, 2011). **Figure 3.2** is a graphical representation of the procedural strategy.

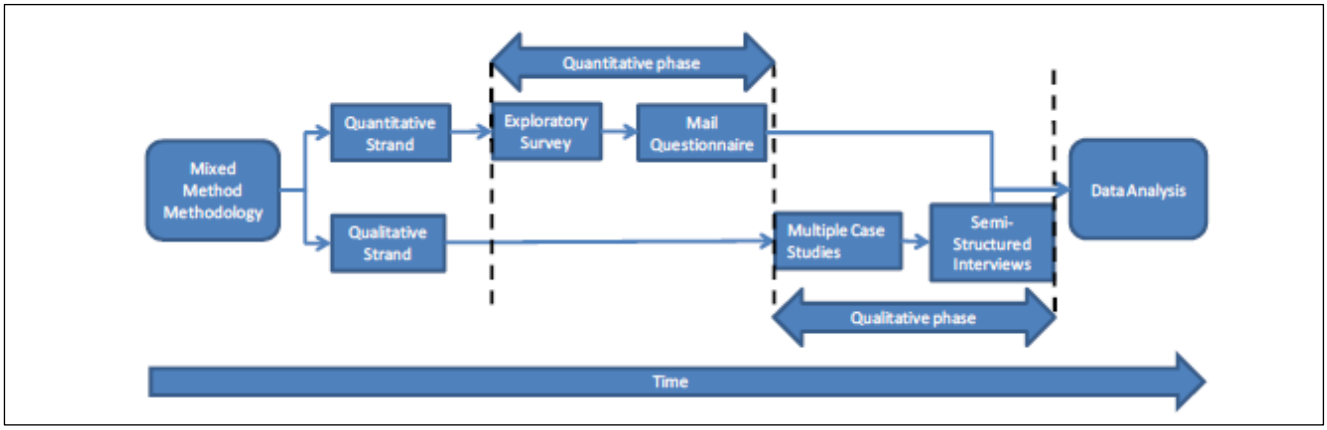

Figure 3.2: Procedural strategy. Source: (Teddlie and Tashakkori, 2011)

3.9.1. Data collection process

Once the case-study is designed, the strategy for the gathering of information related to the research follows. It is therefore advisable that, before data is collected, researchers attain adequate knowledge of the case-study (Rowley, 2002). The case-study project is guided by the data collection process and this may include an overview, various information sources and case-study questions. It must also include proper evidence gathered to support the data collected (Rowley, 2002). There were two (2) categories for the data collection process as follows:

- **Positivist methods:** The testing of theory using experimental data which is primarily reserved for quantitative data but with the ability be also be used with qualitative data (Bhattacherjee, 2012); and
- **Interpretive methods:** This method was used to collect data aiming at building theory which relies on qualitative data (Bhattacherjee, 2012).

3.9.2. Coverage and survey research sampling method

The development of a relevant possible participant sample is essential to ensure that reliable data is obtained. The study employed purposive sampling to select the possible participants to be part of the representative sample of the nuclear industry in South Africa (Tongco, 2007).

3.9.3. Method of data collection

In case-study research there are numerous ways to collect data and six (6) ways were employed in this research study (Yin, 2003):

- **Documentation**: Includes letters, memoranda, agendas, administrative documents, formal studies and articles. The investigator must deduce the information critically and find alternative sources of evidence to substantiate and enhance it. The challenge is that access to information is not always accessible as was the case for this study. Some completed projects were used for this study.
- **Archival records**: This includes computer files and records related to archival records of service records, organisational records, etc. however privacy issues can pose a challenge. For this case-study records and Quality Assurance Data Packages (QADP) of previously completed projects were used.

- **Interview**: This is vital in case-study research with interviews being mainly open-ended in nature, i.e. the investigator can pose questions about the facts of a matter while also asking respondents their opinion of the same. There is also the second type which is focused interview where respondent is engaged for a short period. The third type of interview is more structured along the lines of a survey. In this research case-study project managers whose projects were deemed successful were interviewed to understand which factors led to their success.
- **Direct observation**: Information is collected at the case-study sites and collecting formal or casual data. This method was not used in this study.
- **Participant observations**: The investigator may participate in events being observed. The challenge however is investigator bias. This method was not used in this case-study.
- **Physical artefacts**: Tools such as technological devices, or some other physical evidence is used. This method was not used as the type of study did not lend itself to this type of method.
- **Focus groups**: Bringing together a group of individuals who have an in-depth understanding of the research field. This method was employed in this research study to validate the research findings.

3.9.4.Data collection strategy

Non-random purposive sampling was employed as it is important that the participants have been involved in projects in the South African nuclear industry. The method of data collection was an emailed questionnaire, semi-structured interviews, documentation, archival records and focus group discussions.

3.9.5.Research questionnaire / instrument

Research instrumentation are specific methods of data collection; they may concentrate on quantitative or qualitative and on organised, loosely or tightly structured data (Miles and Huberman, 1994). Miles and Huberman (1994) highlighted planning as being a significant component of data collection if existing information about the data to be collected exists because if not well structured, interviews can retrieve or attract redundant information leading to data overload that misconstrue the effectiveness and rigour of the analysis (Miles and Huberman, 1994). Miles and Huberman (1994) moreover underscored the prudence of using devices employed during previous studies to allow correlation across studies. This satisfies the need for common instruments for theory building, improving explanations or predictions and the recommendations made about practise. An uninformed researcher introduces bias, asks limited questions, takes selective notes, makes variable observations and ultimately skews information (Miles and Huberman, 1994). Against this backdrop, the collection instrument for this research study comprised of a survey questionnaire and semi-structured interviews for the quantitative and qualitative strands respectively; these were used to determine the CSFs relevant to nuclear projects. With the use of prior instrumentation to ensure dependable data Miles and Huberman (1994), completed projects where CSFs could be determined were explored first using a survey questionnaire. Then, the system engineers / client were interviewed to determine if the perceived successful projects yielded the expected results and if the benefits were realised.

The goal of the questionnaire was to determine what the perception of project success was for nuclear projects outside of the establishment of CSFs. This information was used as a baseline towards deriving common CSFs in line with those of the PIP during the interview. Then finally the CSFs were determined for nuclear projects using those of the PIP and others specific to nuclear projects that were not included in the PIP.

The Researcher foresaw that the view of system engineers and clients could be clarified by asking them to state their preference relative to a specific CSF of the PIP. It was logical to assume that not all CSFs would be considered critical to the success of nuclear projects, therefore, participants were asked to assign a weighting to the CSFs in order of importance so that data collected via survey questionnaire and interviews could be triangulated. According to Yin (2009) data triangulation allows for data to be collected from various sources and corroborated with the same phenomenon. A well-designed and well-tested questionnaire was important for accurate data collection and measurement. The questions were clear and unambiguous. It was important that the terms in the questionnaire were understood unilaterally by all the possible respondents, and closed questions had well defined and exhaustive response categories (De Leeuw *et al.*, 2008). The items on the questionnaire were designed to answer the research questions of: *What factors are considered critical for nuclear project success?*

The ordinal data generated from the questions contained in the questionnaire were assessed using a 5-point Likert type questionnaire as the research instrument (Blaikie, 2003; Jamieson, 2004). The ordinal points chosen for the questionnaire, in ascending order, were:

1. Not important at all;
2. Moderately important;
3. Important;
4. Very important; and
5. Absolutely critical.

A survey questionnaire was created to determine what the current factors were that are considered to contribute to nuclear project success. The survey questionnaire, **Appendix A**, consisted of two (2) sections. Section A provided for the respondents' demographic information, which included the department they represented (stakeholder either internal or external to NPM) as well as the respondents' involvement and position in the identified project. Section B listed the CSFs of the PIP and asked that respondents identify their relative importance or not to nuclear project success. This categorisation of factors allowed for the results to be easily interpreted.

Respondents were also asked to assign weights to the CSFs indicating the trade-offs between CSFs. Percentage weights were assigned to CSFs considered important, e.g. if project mission was more important than top management support, but both were considered significant, then project mission was assigned 20% top management support 10%. The main aim was for the percentage weights to equal 100%; this was explained to respondents so that they were familiar with the expectation. The survey questionnaire was accompanied with a cover letter that explained the research study, consent and confidentiality inclusions using the ethical considerations of Miles and Huberman (1994) as guideline; this assisted in maintaining and improving the quality of conclusions. (Miles and Huberman, 1994). The use of mail questionnaires as a data collection instrument was motivated by the low cost that the collection process attracts; the elimination of interviewer bias with interviews; and the mail questionnaire being well suited in getting to those respondents who are spread across a particular area (Oppenheim, 1992).

3.9.6. Interviews

An interview is a research strategy that involves one person (the interviewer) asking questions of another person (the interviewee) where the questions may be open-ended, closed-ended, or both but open-ended qualitative interviews are the more common ones (Teddlie and Tashakkori, 2011). Yin (2009) is of the view and suggested that interviews not be structured queries but rather conversations that are directed. During interviews there are two (2) accountabilities that need to be observed; (1) the interviewer posing their own line of questioning and (2) posing the actual questions that are in line with the original line of enquiry in an unbiased manner (Yin, 2009). In this research study semi-structured (focused interview) Yin (2009) was employed with project managers who had successfully completed projects. With this type of interview it was assumed that the process took place in a conversational manner and respondents were engaged for a short period which is different to an in-depth interview that takes place over an extended period of time. Furthermore, the focused interview is a standardised open sequence of questions that are determined in similar order; with entirely open ended questions (Tashakkori, 2009). Yin (2009) was used to steer the interview. **Figure 3.3** shows the difference between the Likert scale compared to Likert-type questionnaires.

The differences between Likert scale compared to Likert-type questionnaires include:

#	Likert scale		Likert type questionnaires	
1	The scores from a Likert scale can be analyzed using an interval scale.	(Boone and Boone, 2012)	1 The Likert-type items are ordinal measurements.	(Boone and Boone, 2012)
2	The relevant statistical descriptions are mean and standard deviation.	(Boone and Boone, 2012)	2 The relevant statistical descriptions are mode, median and frequency.	(Boone and Boone, 2012)
3	The statistical tests applicable to scale are Pearson's r, the t - test, ANOVA, and regression analysis	(Boone and Boone, 2012)	3 The statistical tests applicable to scale are chi-square, Kendall Tau B, and Kendall Tau C.	(Boone and Boone, 2012)

Figure 3.3: The difference between the Likert scale compared to Likert-type questionnaires.

3.9.7. Questionnaires

There are advantages and disadvantaged to questionnaires and although a questionnaire has numerous disadvantages, not all data collection using this method have these disadvantages. It is for this reason that the case-study usually employs purposive, judgemental, or information-oriented sampling techniques (Kumar, 2018). However, Palys (2008) suggested researchers need to concern themselves with what they want to know and accomplish followed by the appropriate sampling strategy that follows from the responses received from these questions.

3.9.8. Semi-structured Interviews

Semi-structured interviews were conducted with selected participants after the compilation of the preliminary findings from the survey. The purpose of the interviews was to discuss, interpret and validate the results and findings. Face-to-face semi-structured individual interviews with pre-established probing questions as a guideline for the discussion was conducted. Kumar (2011) suggested the following advantages and disadvantages of the interviews:

Advantages of the interview

- The interview is the most appropriate approach for studying complex and sensitive areas as the interviewer has the opportunity to prepare a respondent before asking sensitive questions and to explain complex ones to respondents in person;
- It is useful for collecting in-depth information. In an interview situation, it is possible for an investigator to obtain in-depth information by probing. Hence, in situations where in-depth information is required, interviewing is the preferred method of data collection;
- Information can be supplemented. An interviewer is able to supplement information obtained from responses with those gained from observation of non-verbal reactions;
- Questions can be explained. The interviewer has the opportunity to repeat a question or put it in a form that is understood by the respondent; and
- An interview can be used with almost any type of population; children, the handicapped, illiterate, or aged.

Disadvantages of the interview

- Interviewing is time consuming and expensive, especially when potential respondents are scattered over a wide geographical area;
- The quality of data depends upon the quality of the interaction between the interviewer and the interviewee;
- The quality of data depends upon the interviewer's skill, experience, and commitment of the interviewee;
- The quality of data may vary when many interviewers are used. Use of multiple interviewers may magnify the problems identified in the two previous points; and
- The researcher may introduce his or her bias by the framing of questions and the interpretation of responses.

3.10. Research sample

The population that was sampled were people who had been involved in projects in the nuclear industry in South Africa. The demographics of individuals involved in these projects was very different and had to be established during the data collection. Furthermore, the perception of these different individuals about the success of a nuclear project could be aligned or very different and if there was a major difference in the CSFs used to measure nuclear projects between these groups the perceived outcome of the project could be very conflicting and/or limiting.

3.11. Data analysis

Data analysis involved examining, categorising, tabulating, testing or recombining quantitative and qualitative confirmation that the research question had been addressed (Yin, 2003). Yin (2003) therefore submits that an analytical strategy be selected to so that evidence is fairly treated, yielding a persuasive analytical conclusion; ruling out alternate interpretations. These strategies include:

- Relying on theoretical propositions that led to the case-study;
- Defining and testing rival explanations which is relevant even in the absence of theoretical propositions and is useful in evaluating case-studies; and
- Developing a case description with descriptive framework being derived for the case-study (Yin, 2003).

3.11.1. Data analyses techniques

Once research data was collected; it was analysed and the research findings interpreted; this was paramount in research along with the definition of an analytical method that determines the limits of data collection and distribution of results. Below are the qualitative data analysis techniques (Amaratunga *et al.*, 2002).

Explanation building: This is a special type of pattern matching. The objective of this technique is to analyse the qualitative data by building an explanation about the situation. Explaining the situation means explaining the causal links about it (Amaratunga *et.al.*, 2002).

Time series analysis: This strategy involves conducting a time series analyses, directly analogous to the time series analysis conducted in experiments and quasi experiments. The underlying logic of a time series analyses is the match between trends of data points compared with a theoretically significant trend specified before the onset of investigation. When interpreting data the following steps are recommended (Amaratunga *et.al.*, 2002):

Identify patterns of agreement: across data points, by mediating variables with literature and experience (Amaratunga *et.al.*, 2002);

Identify contradictions: Across data sources, by mediating variables with literature and experience (Amaratunga *et.al.*, 2002)

Try to resolve contradictions: through alternative plausible explanations for a finding, by re-examining the data, by collecting a specific data to test an alternative hypothesis (Amaratunga *et.al*., 2002).

Identification of the important findings, by ranking and organising them (Amaratunga *et.al*., 2002)

Simple presentation of the findings through charts and tables, etc. (Amaratunga *et.al*., 2002)

3.11.2. Data evaluation criteria

An evaluation is often focused on measures to counteract the weaknesses inherent in the chosen research strategy. The value of any research stems from the validity of its results and the extent of its contribution to the body of knowledge. Data evaluation often includes validity, reliability and generalisability (Amaratunga *et al.*, 2002). Validity and reliability have already been addressed under Section 3.8.

3.12. Limitations

The limitations to this research study as a result of the research design and methodology selected included:

1. Low response rates;
2. The completion of the survey requires motivation;
3. The data obtained will be subjective as it is the view of the participant on the projects;
4. The limited time available to complete the data collection; and
5. Multiple replies to the survey.

3.13. Research ethics

Ethics is *"the appropriateness of your behaviour in relation to the rights of those who become the subject of your work, or are affected by it"* (Watkins, 2008: 69). This research study involved human participants, deeming data collection and confidentiality crucial. Therefore ethics were declared, ethics forms **(Appendix C)** completed and ethical approval / clearance sought from the Ethics Board.

The following ethical aspects were considered and implemented with the nature of the research study being explained to the participants, their consent to be involved sought, and their privacy maintained (Bell and Wray-Bliss, 2009). The following ethical considerations were attended to during this research study:

- **Informed consent:** Participants were informed upfront of the nature of the study and afforded the opportunity to either participate or not. They were informed of the time to reflect on their responses with the liberty of changing their information if they choose to.
- **Right to privacy:** Keeping the nature and quality of participants' performances strictly confidential was a requirement.
- **Honesty with professional colleagues:** Findings were reported honestly without any distortion
- **Confidentiality/anonymity:** This applied to questionnaires, resulting in participants providing more open and honest responses.

3.13.1. Ethical code of conduct

Sound ethics principles were upheld throughout this research study. These principles and aspects included: (Bell and Wray-Bliss, 2009)

- No research participants were harmed;
- The participants were informed that their involvement in the study is voluntary;

- The participants were advised that they could withdraw from the study at any time without a negative consequence to them;
- The participants were fully informed about the nature of the research via explanatory covering email;
- The privacy of the participants was guaranteed by making use of an online survey which was answered anonymously;
- The Researcher's affiliation was declared in the request for participation sent to the potential participants;
- The Researcher's contact details was provided;
- The participants were welcomed to contact the Researcher should they have any questions and or queries regarding the survey and study;
- The Researcher and work presented was well prepared to avoid harm or injury;
- The Researcher structured the survey to include both closed and open questions to allow the respondents to think for themselves; and
- The Researcher completed all the research herself without using third party and or unqualified people to conduct the research.

3.13.2. The research process

The following ethical points had relevance to the research process: (Bell and Wray-Bliss, 2009)

- The thesis was written in the third person to ensure anonymity but not at the expense of disempowering minority views; and
- The survey incorporated as many stakeholder groups as possible to ensure that an overall all-inclusive perspective of the CSFs for nuclear projects was captured.
- The Researcher was granted access to project information by virtue of working in the research environment. All company and individual references was not included in the information supplied and used in the thesis in order to protect the company and individuals.

3.13.3. Participant consent and anonymity

Participants were informed that information gathered would be treated with high anonymity, that participation was voluntary and that their personal details were not required and they should not share information they deemed confidential. If at any stage during the process they felt uncomfortable, participants were given the option to withdraw. A consent form **(Appendix B)** was drafted for this purpose and participants requested to sign.

3.13.4. Safety of the participants during information gathering

This research project did not involve physical experiments so there was no harm or danger to the participants.

3.13.5. Ethics clearance

UCT's ethics code requires research clearance when undertaking research involving data collection or living people. To this end, the Researcher submitted an ethics clearance application to the Faculty of the Engineering and Built Environment (EBE) for approval. The application consisted of the research proposal; interview questionnaire (1), application for ethics clearance form, and the information sheet and consent form (2). The Researcher also sought permission from KNPS senior management before conducting the research at the NPP. Furthermore, the Researcher is an Eskom employee, familiar with the ethics code in the protection of Eskom's information.

The role of the Researcher was entrenched within the organisation making the participants mainly peers eliminating the power difference between the participants and the Researcher. No further issues related to the power difference were experienced when interviewing senior managers due to the Researcher maintaining integrity and professionalism. Interviews took place in a secure environment Cassell and Symon (2004), at the KNPS which is also a National Key Point (NKP) where the highest form of security is exercised. Due to the risk of computer viruses being transmitted via an electronic network making people reluctant to open e-mails from unknown sources Cassell and Symon (2004); the departmental secretary was requested to send an introductory e-mail to those who participated in the research study. Additionally the site computer system had been set to high standard, protecting the company and its employees from viruses. There was also the risk that respondents could name other people and/or insult their business therefore confidentiality was maintained and respected at all times.

3.14. Value of research

Very little or no research has been done to determine the CSFs for nuclear projects and where the research has added value to the industry by providing a researched perspective on the CSF specific to nuclear projects. All the participants of the survey will be provided with results of the survey and further invited to contact the Researcher to discuss if they require. The final research findings will also, at the request of the respondents be made available to them.

3.15. Methodology summary

In summary, research to establish the CSFs of nuclear projects in South Africa was conducted at the KNPS. A non-experimental mixed method including both quantitative and qualitative research methods was employed. As respondents required experience in the nuclear project process, non-random purposive sampling was carried out. The method of data collection was the case study via designed questionnaire followed by semi-structured interviews and focus group discussions. A deductive approach was followed with conclusions being drawn from observed results.

4. CHAPTER 4: DATA ANALYSIS AND INTEPRETATION OF RESULTS

4.1. Introduction

Data analysis is defined as "*the process of bringing order, structure and meaning to the mass of collected data"* (De Vos, 2002: 339). It is also a repetitive and continuous process that needs to be validated and legitimised (Miles and Huberman, 1994). This chapter describes the Researcher's choice in data analysis methods for the purpose of determining "*what are the factors considered critical to the success of nuclear projects*?" The purpose was also to explore how stakeholders across the nuclear project lifecycle perceived the CSFs in the PIP and their importance related to nuclear project success while also adding those factors considered critical for nuclear project success but are not included in the PIP. The appropriateness of data analytical methods is vital in research and a link needs to be established with the method chosen and the research problem Walliman (2005) which in Chapter 1 Section 1.3, states: *"The CSFs available in literature are not comprehensively understood nor applied in the nuclear industry*." In order to better understand the research problem, the Researcher used statistical data analysis software.

The previous chapter presented the data gathering baseline and outlined: 1) the different types of mixed methods used for the research; 2) how the sample pool was chosen for the survey research; 3) how the survey research data was going to be collected; 4) the survey research instrument to be used to for data analysis; 5) the way in which the research instrument would be distributed to the selected sample pool; and 6) how the data collected from the survey would be analysed. The data collected through the completed questionnaires is presented and analysed. The presentation of data was systematically linked to the format of the self-developed questionnaire, which is attached in **Appendix A**.

The first part outlines a broad overview of the survey respondents' demographics, indicating their gender, years of nuclear specific / related work experience, stakeholder status, the department that they are representing and the nuclear project lifecycle phase on which they are basing their responses. This data is contained in Section A of the questionnaire. The second part reviews the primary data related to CSFs listed in the PIP as found in Section B of the questionnaire. This data is in two parts with one part looking as the rating of the CSFs (ordinal scale) and the second part consisting of the respondents' ranking and weightings for each CSF. The third part, Section C comprised of open-ended questions posed to respondents and their responses were based on their stakeholder status, the nuclear project lifecycle phase on which their views are based and the department they represent.

The ultimate goal was to determine if the respondents identified with the CSFs of the PIP and if they used these in the determining of CSFs of their nuclear projects. Furthermore, their understanding (or lack thereof) of the PIP was tested and the ultimate question posed of if they identified any additional CSFs they believed needed to be added to the list of CSFs that cater for nuclear projects. This understanding would later be used to develop a framework with CSFs for nuclear projects. The full and unmodified survey results are in **Appendix D**.

This chapter concludes with a discussion of the research findings of the research questions that steered the study. The final section is thus an analysis of the findings and a description of the observations related to the research questions posed in the previous chapter.

4.2. Respondent demographics

The respondents' demographics are shown in **Tables 4.1- 4.6.**

a. Gender

Table 4.1 shows that the respondents were mainly males (58.82%) with females being 41.18%. This is not surprising as the nuclear industry is a highly technical industry that has and is still being dominated by males.

b. Work experience in years

Table 4.2 shows that the work experience of males is mostly more than 25 years (19.1%); no females fall within this category. In females, the most experience in years was 10-15 years (14.7%). Furthermore the most experience per stakeholder status was that of Programme Managers, Project Managers and Project Coordinators.

c. PLCM Stakeholder Status

Table 4.3 shows that different respondents' stakeholder status where Programme Managers, Project Managers and Project Coordinators made up the bulk of the stakeholders (47.06%).

d. Department

Table 4.4 shows the various departments as represented by the respondents. The main department was within NPM; Standard Project Execution (22.06%); Construction Management (20.59%); Complex Projects Execution (10.29%) and Quality Management (8.82%). In total NPM represents 61.7%. The rest are those outside of NPM but involved in projects. 12 other departments account for 38.24%

e. Project Lifecycle Phase

Table 4.5 shows the nuclear project lifecycle on which responses were based. Execution was the main phase at 66.18%.

4.3. Survey Research Results

4.3.1.Description of the sample

The survey questionnaire was distributed to 110 possible respondents. The survey returned 68 responses in total; 39 were completed via the SharePoint link that was created particularly for research study and shared with the potential respondents and 29 completed manually; these respondents either did not have access to the system or they had difficulty logging on successfully so they were requested to complete manual forms and send the completed questionnaire to the Researcher via e-mail for capturing purposes. The breakdown of the possible respondents is shown in **Table 4.3**.

The survey was carried out over 4 weeks, from 10 October 2019 to 07 November 2019 (first period). This timing however proved challenging as it coincided with the planned maintenance shutdown (outage) which ran from 20 September 2019 to 08 December, 2019. An outage is a crucial time for all critical resources across the NPP and most of those targeted were focussed on this activity, including the Researcher. The initial response frequency in the first two (2) weeks accounted for eleven (11) completed surveys being logged, where after the next two (2) weeks showed a slower response rate with seven (7) bringing the total to eighteen (18) completed surveys in the first period.

The Researcher tried to negate the slow response rate by sending out reminder e-mails through the research platform; while being fully aware that a large portion of the potential participants were involved in the outage and could not get to complete the survey. This too presented its own challenges and the numbers did not increase to an acceptable rate. In light of this, the Researcher decided to extend the closing date to 30 December 2019 (second period) but when the outage overran, the date was altered to 31 January 2020 (third period). This was to ensure a representative sample. Unfortunately, during this time some of the critical supplemental staff contracts (stakeholders in NPM) were terminated and they ended up not participating in the survey. The second period thus only accounted for twelve (13) completed surveys. In the third and final period, the Researcher telephonically called the participants to remind them of the survey. These reminders and engagements yielded positive results with 37 completed surveys and a total of 68 completed surveys over all. This equates to a response rate of 61.82%. In total the entire survey period was sixteen (16) weeks with period one (1) being four (4) weeks; period two (2), eight (8) weeks and period three (3) four (4) weeks. Had the outage not had any challenges and experienced the delays that it did; the original planned time would have been sufficient and appropriate.

A representative data set for nuclear projects was achieved as the project respondents' stakeholder statuses represented the various phases across the project lifecycle following the non-random purposive sampling as described in Chapter 3, Section 3.9.4. This allowed for a representative sample of respondents to provide meaningful insights towards assessing current CSFs of the PIP and commenting on their relevance to nuclear projects success while also proposing factors that need to be considered for inclusion if nuclear projects are to be consistently successful.

4.3.2.Data collection: survey questionnaires

As previously discussed, three (3) primary types of data collection (survey) methods were used. Questions were posed to respondents to establish their views and feelings about the research study. To strengthen the data collection process and identify issues (which may not be highlighted using a pure questionnaire) interviews and semi-structure or focus group discussion were used as additional element.

4.3.3.Data collection strategy

Non-random purposive sampling was employed as a data collection strategy as it was important that the respondents in the research had been involved in projects in the South African nuclear industry. **Table 4.3** shows the respondents per survey type. **Table 4.6** is a summary of the data collection via the various data collection strategies.

Table 4.6 Summary of data collection

No of Respondents	Self-administered Surveys		Focus Group
	Online	***Manual Forms***	
68 + 6	39	29	6

4.3.4.Sample frame

The respondents who participated in this research study were invited through e-mail but before access to the research platform was granted. The Researcher e-mailed the cover letter **(Appendix B)** which included the request for their consent along with the explanation of the aim of the research study. Once they agreed to form part of the research study, access was granted and the questionnaire could be completed. For confidentiality reasons explained in the previous chapter, the names of the respondents will not self-administered questionnaires/surveys self-administered questionnaires/surveys will not be disclosed.

The target population was obtained from self-administered questionnaires. The supplemental staff, whose contracts expired during the survey period, while targeted, did not complete questionnaires and are, therefore, excluded from this survey. The sample frame is shown in **Table 4.7**.

Table 4.7: Sample Frame

Respondent Category	Number	Total
Responded	68	
No response	42	
Expired contract	20	**130**

4.4. Survey research results

4.4.1.Primary data related to CSFs

The Researcher, in order to determine what projects were considered successful in the NPP, successfully completed projects were sampled and their common success factors identified towards creating a framework for CSFs for nuclear projects. Furthermore, archival records in the form of QADPs were accessed to determine the reasons why the project was successful. With this research study being conducted at a NPP, there was a challenge to retrieve information due to accessibility, confidentiality and privacy issues. To this end, projects remained unnamed and only the success factors recorded. Four (4) successful projects were sampled and the related project managers interviewed to share insights has to what made their projects successful.

The four (4) projects sampled were all complex and of a huge magnitude from a scope and cost point of view; the total cost for all of them combined was in excess of R1Bn and were of such a crucial nature that failure was not an option. What all project managers attested to was having a project team assigned to the project on a full time basis, committed to the objective and having a full appreciation of the problem statement and preferred solution was one of the main contribution to project success. Senior management commitment and support was also cited as an importance factor. The effective relationship with the NNR and the contractor alike was important as this eliminated much misunderstanding of the rules and regulations with the NNR and unnecessary claims and endless fights with the contractor. What all project managers agreed upon was that respecting the schedule, performing effective monitoring and feedback and communication made their projects successful. With the QADP all documentation was completed on time per phase and this made the project run smoothly from a quality perspective with all designs, drawings, processes and procedures adhered to. What came out strongly however was the concerted effort made by all involved to drive project success.

Two (2) System Engineers (Client) were also interviewed to determine if the effectiveness reviews of the modifications corroborate the information shared by the project managers. They concurred that the effectiveness reviews for two (20 of the three (3) projects can be confirmed while the other was still under review. The fourth was a collaborative effort as NPM needed to implement nine modification during the Outage of 2019. The main leads attributed this success strategy of being inclusive and collaborative with the cross functional teams and focus all on the task at hand. For example, if the maintenance department was implementing a portion of NPM scope, resources from NPM were sent to be part of that team to assist them while achieving the goal of project success. So instead of competing for resources, through collaboration the other organisation was supported. An all hands on deck approach, and no other project took precedence. The leads found that stakeholder management (managing expectations), schedule adherence and effective communication was paramount. Whenever a modification is implemented without negatively impacting the outage; it is a success.

The factors therefore that made these four (4) projects successful were: Senior management support, Teamwork, Schedule adherence, Communication, NNR relationship and Contractor management and Stakeholder management and Client acceptance.

The goal of Section B of the research questionnaire was for the first section to use the ordinal scale ranging from 1. Not important at all to 5. Absolutely critical to decide the relative importance of the CSFs of the PIP to nuclear project success. Secondly, the respondents were requested to apportion weights to the CSFs basing them on trade-offs that would have to be made between CSFs. This information was later used to establish a baseline towards deriving common CSFs for nuclear projects in line with those of the PIP and validated the focus group discussions.

4.4.2. Stakeholder views on CSFs of the PIP and those for nuclear projects success

In Section C, respondents were requested to, based on the CSFs of the PIP and their own experience, provide their views related to what would constitute a successful nuclear project. These questions were all open ended and afforded respondents the opportunity to express themselves freely. Then finally the CSFs were determined for nuclear projects using those of the PIP and others specific to nuclear projects that are not included in the PIP. These would form the basis for a framework for CSFs for nuclear project success and would be a mix of existing CSFs and categories derived from the respondents input.

4.5. Data analysis

4.5.1. Data format

The research respondents included various stakeholder types. This split was necessary as the research needed to establish the views of the stakeholder in the various phases of the nuclear project lifecycle. The questionnaire consisted of 18 questions with an average completion time of 20-30 minutes. Section A (Demographics), Questions 1-5; Section B (CSFs ranking and weightings), Question 6 and Section C (Open-ended), Questions 7-18 allowing respondents to provide different perspectives on CSFs factors for nuclear projects. If there was a need to seek clarity of responses provided, this was done to as to enable effective analysis of information.

The data was coded and captured on a database followed by double verification and checking for correctness and anomalies addressed by the Researcher before analysing the data. The questionnaire was based on the Likert Scale, which set boundaries for the different variables (questions). However, in order for analysis to be meaningful, the Researcher recoded the data.

4.5.2. Methods of data analysis

Walliman (2005) explains that data analysis can be classified as two (2) categories of parametric statistics, descriptive or inferential. Descriptive statistics describe information collected allowing for the quantification data characteristics, the centre, how far they spread and how data aspects are related to each other while inferential statistics tests the assumptions that are made through hypothesis and modelling. Descriptive statistical analysis was utilised to classify the questionnaires according to related response frequencies and percentages. Since not all respondents answered all questions; percentages correspond with the total number of respondents who answered individual questions.

4.5.3. Assistance to the Researcher

Assistance was provided to the Researcher to interpret the outcome of the data and conclusions made were validated and checked by the statistician in order to exclude any misleading interpretations.

4.6. Interpretation of results

4.6.1. Analysis of questionnaires

A total of 110 questionnaires were distributed and 68 questionnaires were returned and used for this study, as they met the required inclusion criteria which was those employees who were in the employ of NPM during the research, whether permanent or seconded project management staff as well as stakeholders involved across the nuclear project lifecycle. As previously mentioned, the 20 staff whose contracts had ended was excluded from this survey. The target population is, therefore, [(130-20) = 110]. This represents [(68/110) = 61.82%] of the expected population.

4.6.2. Descriptive statistics

A total of 68 questionnaires were used to interpret the results. Data that was gathered through the questionnaires was subject to frequency counts. In other words, the respondents' responses for each individual statement were added together to find the highest frequency of occurrence (the number of times that a particular response occurs). These responses to the statements, which are quantified, were then presented in tabular format, while the Researcher used variables in different tables.

4.7. Presentation of data and interpretation of results

This section will focus on the interpretation of the results discussed previously. The information was presented in terms of the respondents' stakeholder status and the phase of the project being responded on. The distribution of stakeholders was already presented in **Table 4.3** where eighteen (18) categories of stakeholders are represented with Programme Managers, Project Managers and Project Coordinators making up 47.06% of the total. This is deemed a good representation considering that they are the target population. Responses that will be analysed were therefore mainly based upon their responses understanding that they would be the ones to influence the design of a framework of CSFs for nuclear projects. The respondents' who do not fall into these categories responses will be used to either validate or

refute the responses of the main respondents as they form part of the project team and in most cases are best place to comment based on their role and related activities. This is also to ascertain if the programme, Project Manager or coordinators do not have a skewed view of that which affects project success.

All phases of the nuclear project lifecycle are represented with seven (7) respondents commenting on the Concept Phase; nine (9) on the Definition Phase; fifty (50) on the Execution Phase and two (2) on the Finalisation (post project) Phase. This is deemed acceptable as most respondents are currently involved in the implementation of modifications. Furthermore, not many Project Managers and Project Coordinators operate in the Concept and Definition Phases as expected as these phases are mainly for System and Design Engineers conducting feasibility studies and the Project Managers ensure the execution of the preferred option.

The next section will present results from questions 6 to 18. For each question the overall result will first be presented and discussed. This will be followed by results per stakeholder status and lastly by project phase. This will provide insight into the views of stakeholders was envisaged in Chapter 1 Section 1.5.

4.7.1. Question 6 rating of the relative importance of the CSFs of the PIP

4.7.1.1. Factor 1: Project Mission

Before anything can happen in implementation; it is important that project goals are clear (Cleland and King, 1983; Morris, 1983; Slevin and Pinto, 1986; 1987). They need to be understood by the project team and the other departments within the organisation (Slevin and Pinto, 1987). It is a statement of where the project will focus its efforts (Pinto and Slevin, 1988b) to ensure that the financial and resource commitments are honoured by top management and that these commitments are used optimally to achieve the project mission (Pinto, 1990; Slevin and Pinto, 1991).

a. Overall result

Table 4.8 below shows that the majority (50%) of respondents were of the view that the project mission was absolutely critical with 47.1% split between very important (25%) and important (22.1%). This is a clear indication that this CSF is vital for nuclear project success; if not clear this can lead to an incorrect focus and ultimately an incorrect solution.

b. Per Stakeholder

Table 4.9 details the views of the different respondents based on their stakeholder status. Of the 50% that agreed that this CSF was absolutely critical, Project Managers (10.3%) and Programme Managers (5.9%) supported this view. Project Coordinators (8.8%) indicated that this CSF was very important. It can therefore be concluded that the respondents mainly agreed that the CSF is either absolutely critical or very important.

c. Per Phase

Table 4.10 details the views of the different respondents based on their project phase and most of the respondents being in the Execution Phase 35% and 19.1% for absolutely critical and very important respectively.

4.7.1.2. Factor 2: Top Management Support

Once the goal of the mission is clear and project benefits are known, it is important to gain top management support; without which, the project may not succeed. If they do not support the project both vocally and visibly, the project may not be seen as important by the rest of the organisation. Early in a project's life, no single factor is as predictive of its success as the support of top management (Schultz and Slevin, 1975a) (Schultz and Slevin, 1975b; Slevin and Pinto, 1986; 1987; Pinto, 1990). It has been observed that this support guarantees allocation of sufficient resources and support in the event of a crisis (Pinto and Slevin, 1987; Rauniar and Rawski, 2012). It has also been implied that a lack of engagement by top management and a lack of attention from the organisation during the early stage of the project are linked to poor performance (Sosa *et al.*, 2007).

a. Overall result

Table 4.11 shows that Top Management Support is absolutely critical (60.29%) and very important (27.94%) and this is in line with what literature speaks to.

b. Per stakeholder

Table 4.12 details the views of the different respondents based on their stakeholder status. Of the 60.29% that agreed that this CSF was absolutely critical, Project Coordinators (14.71%) and Quality Assurance Officers and Construction Safety Officers (5.9% each) supported this view. Project Manager (8.82%) surprisingly indicated that this CSF was very important. It can therefore be concluded that the respondents mainly agreed that the CSF is either absolutely critical or very important. It is of concern that Project Managers rated this CSF as very important rather that critical.

c. Per phase

Table 4.13 details the views of the different respondents based on their project phase and most of the respondents being in the Execution Phase (60.29%) with 47.06% being absolutely critical and 27.94% being very important.

4.7.1.3. Factor 3: Project Schedule/Plan

If project implementation is to be successful, activities need to be scheduled in detail and all the necessary resources such as people, money and time catered for (Cleland and King, 1983; Morris and Hugh, 1986; Pinto, 1990). This detail is required at every stage of the implementation process (Pinto and Slevin, 1988b).

a. Overall result

Table 4.14 shows that Top Schedule and Plans is absolutely critical (54.41%) and very important (35.29%) as agreed by and this is in line with what literature speaks to.

b. Per stakeholder

Most stakeholders (54.41%) indicated that schedule and plans were absolutely critical; something that is of vital importance for nuclear projects where maintenance and outages are run on strict and pre-determined regimes. Any slip in schedule has dire consequences for the South African grid in that it means that we contribute to load shedding each day the unit is delayed. Now with the life of the plant being extended, schedule and plans have become of paramount importance. **Table 4.15** shows the responses per stakeholder.

c. Per phase

Of the 54.41%, 41.18% of respondents indicated that schedule and plans are absolutely critical in the Execution Phase compared to 26.47% saying it is very important. It is a bit disappointing in that planning and scheduling should really be upfront it any success is to be realised. This also speaks to why some projects ultimately fail; it is as a result of appropriate planning not taking place at the appropriate phase. **Table 4.16** shows the responses per project phase.

4.7.1.4. Factor 4: Client Consultation

Factor 4: Client Consultation

The project is for the client and therefore they need to be consulted to ensure the project is on track to meet their needs (Slevin and Pinto, 1986; Pinto and Slevin, 1987). It is for this reason that Pinto (1990) states that the project team must be aware of the need of the client who must be identified at the beginning of the project. It is important that they are consulted throughout the project to ensure that they accept the final project (Pinto and Slevin, 1988b; Pinto, 1990).

a. Overall result

44.12% respondents indicated that client consultation was absolutely critical and 45.59%, very important. This is in line with what should happen in the nuclear project lifecycle and that the client is always consulted through the process. **Table 4.17** shows the overall result.

b. Per stakeholder

The main stakeholders who indicated that this CSF is critical are Project Managers (8.82%) and Programme Managers (7.35%). It is expected that these respondents would indicate in this way as they are the main ones tasked with client consultation and present at the various approval committees where all clients are represented. **Table 4.18** shows the responses per stakeholder.

c. Per phase

The Execution Phase dominates for both absolutely critical (27.94%) and very important (36.76%). There also those who indicated that this CSF is absolutely critical in the Definition Phase (10.29%). This is crucial as it is in the Definition Phase that the feasibility of a project is determined and, as such, the client consultation becomes critical and if they cannot be convinced, the project cannot proceed. **Table 4.19** shows the results per project phase.

4.7.1.5. Factor 5: Personnel

Selection, recruitment and training of key and suitable personnel is crucial so the project does not end up with personnel selected based on convenience; whether they harm or help the project (Slevin and Pinto, 1986; 1987; Pinto and Slevin, 1988a). It was noted that often project team members were selected without a complete understanding of how they would contribute to project implementation success; this factor is overlooked (Slevin and Pinto, 1987). Yet literature has indicated that the success of a project is very dependent on the quality of the project team (Pinto, 1990).

a. Overall result

This is the first CSF where the results range from important to absolutely critical. There is an almost equal split between absolutely critical (39.7%) and very important (41.2%). It is of interest that this result favours very important over absolutely critical. **Table 4.19** shows the overall result.

b. Per stakeholder

While the CSFs of personnel is a contentious one, even from the point of view of literature, it is of particular interest that the Project Manager did not find this an absolutely critical factor (1.47%) when compared to the Programme Manager and Project Coordinator (7.35% equally); they rather found it to be very important (8.82%). So this could be attributed to the fact that Project Managers, for the most part, end up fulfilling multiple roles due to some resource constraints and would conclude that if that is the reality, then in the organisational sense, this is not a critical factor. **Table 4.20** shows the result per stakeholder.

c. Per phase

The Execution Phase, once again is the dominating phase when it comes to personnel (33.82%), absolutely critical and (27.94%) very important. There is an indication of 7.35% being very important. These point to an emphasis being placed on the Execution Phase rather than the rest of the phases. Project teams are ideally meant to be determined during the Definition Phase. **Table 4.21** shows the result per stakeholder.

4.7.1.6. Factor 6: Technical Tasks

People who manage project implementation need to be well versed with it. They also need to ensure the project is supported by the correct technology. Thus, for successful project implementation, skilled people and appropriate technology are equally significant. This includes the required expertise to accomplish those specific technical action steps (Slevin and Pinto, 1986; 1987; Pinto and Slevin, 1988a; Pinto, 1990).

a. Overall result

Technical tasks were found by respondents to vary between important (22.1%), very important (44.1%) and absolutely critical (29.4%). Technical tasks, for a NPP, are the main reason for undertaking projects. All projects stem from a technical deficiency or opportunity that will assist in running a safe plant. These tasks, however, while critical are quite challenging when it comes to new technology this is an ageing plant. This is where improvement or innovation is required. **Table 4.22** shows the overall result.

b. Per stakeholder

Most respondents agreed that technical tasks are either very important or absolutely critical with Project Coordinators finding it very important (8.82%), programme and Project Managers and construction safety officers (5.88% each) and Project Manager (5.88%) finding it important. **Table 4.23** shows the result per stakeholder.

c. Per phase

This CSF was found by respondents to be either absolutely critical or important (17.65% each) or very important (35.29%) in the Execution Phase and 7.35% in the Definition Phase. In general the phase where this CSF is important is in the Concept and Definition Phases. In the Execution Phase, the technical solution is being implemented and while important, should have been paid attention to in the concept and Definition Phases. **Table 4.24** shows the result per project phase.

4.7.1.7. Factor 7: Client Acceptance

Besides client consultation which is crucial; successful implementation can only be declared once the project has been accepted by the client (Slevin and Pinto, 1986; 1987); this is the final stage in the implementation process (Slevin and Pinto, 1987). Many project managers tend to believe that once the other stages have been successfully achieved, the client will accept the project (Slevin and Pinto, 1987). They do this at their own expense since they still need to sell and market the final product to the end user (Pinto and Slevin, 1988a; Pinto, 1990).

a. Overall result

Client acceptance was found by respondents to being mainly absolutely critical (48.53%) of very important (44.1%). This is not surprising as a project can only be deemed successful once the client has accepted the final result. If not, then the project is considered a failed one; this is both in accordance with literature as well as industry norm. **Table 4.25** shows the overall result.

b. Per stakeholder

The Programme Managers and Project Coordinators found this CSF to be absolutely critical (8.82%) with the Project Manager at 5.88% and 10.29% as very important. It is expected that this be the type of response from Programme and Project Managers as client acceptance is more their goal than any other stakeholder. This is because the responsibility of the project is assigned to them and if the project is not successful, this, in turn, can be interpreted as failure of the Programme or Project Manager. **Table 4.26** shows the result per stakeholder.

c. Per phase

Once again, it is the respondents in the Execution Phase who found this CSF to be absolutely critical (33.82%) or very important (32.35%); the split nearly equal. This is indicative of the phase which requires the CSF the most. **Table 4.27** shows the result per project phase.

4.7.1.8. Factor 8: Monitoring and Feedback

With monitoring and feedback, key personnel have insights into the implementation process and project progress. Monitoring and feedback also afford the project manager the mechanism to remain abreast of progress or lack thereof and related challenges. With this he/she can implement corrective actions and avoid the oversight of defects (Slevin and Pinto, 1986; 1987; Pinto and Prescott, 1988; Pinto, 1990).

a. Overall result

The respondents indicated that monitoring and feedback was absolutely critical (47.1%); very important (35.3%) and important (17.6%). This is a very critical factor for nuclear projects. **Table 4.28** shows the overall result.

b. Per stakeholder

Project Coordinators dominate in this category (10.29%) absolutely critical. This makes sense as they are the on the ground and coordinating all works while they are ongoing and have the responsibility of the monitoring and feedback to the greater project teams and management. Programme Managers (7.35%) and Project Managers (8.82%) indicated that it was very important. This too makes sense as they mainly depend on the Project Coordinators to provide progress feedback. **Table 4.29** shows the result per stakeholder.

c. Per phase

The respondents indicated that the Execution Phase is where this CSF is more relevant with 33.82% being absolutely critical and 26.47% being very important. This is relevant and related to the phase in which the project finds itself at this point in time and as such, it makes sense that this CSF is rated as such. **Table 4.30** shows the result per project phase.

4.7.1.9. Factor 9: Communication

The model indicates that communication is key in every factor as it creates an environment to implement projects successfully (Pinto, 1990). As project implementation does take place in a vacuum; communication must be constant with relevant information being available to all project participants (Slevin and Pinto, 1986; 1987; Pinto and Prescott, 1988; Pinto, 1990).

a. Overall result

Communication is the first CSF where respondents indicated more than 50% (57.4%) is absolutely critical and 29.4% (nearly half) is very important. It is evident that communication has been identified as the most important CSF of all in the PIP. **Table 4.31** shows the result overall result.

b. Per stakeholder

Project Managers and Project Coordinators indicated that (10.29%) equally, are absolutely critical. This is in line with what literature cites. **Table 4.32** shows the result per stakeholder.

c. Per phase

Project Managers and Project Coordinators indicated that (10.29%) equally, are absolutely critical. This is in line with what literature cites. **Table 4.33** shows the result per project phase.

4.7.1.10. Factor 10: Trouble-Shooting

Project will have challenges despite them being well planned. Therefore constant amendments, adjusting, and trouble-shooting are required at each step in the implementation process (Carrier, 1983). These mechanisms and contingency plans assist the project manager to react to unforeseen problems as well as foresee and limit potential problem areas in the implementation process (Pinto and Prescott, 1988; Pinto, 1990). So it becomes important for each team member to realise that they need to identify issues as they arise. They must be technically competent in the duties that they are assigned to deal with problems as they occur (Slevin and Pinto, 1986; 1987). The CSFs of the PIP are thus a useful tool for the project manager and the project team to use towards ensuring project success and it is therefore essential that the project team believe the project can succeed (Pinto and Slevin, 1988a).

a. Overall result

Table 4.34 shows the overall result with 50% of respondents indicating that troubleshooting is very important and 27.9%, absolutely critical.

b. Per stakeholder

Table 4.35 shows the result per stakeholder. Most notable are the Project Coordinators who indicated 11.76% (the highest of all categories) are the ones who indicated that this CSF is very important. This is an indication that they are the one dealing with technical issues on the ground and experience the various challenges in the process. So they would be concerned with troubleshooting as this means that something in the process was not done or overlooked, hence they deal with this during implementation.

c. Per phase

Table 4.36 shows the result per project phase. Respondents indicated that this CSF is very important and absolutely critical in the Execution Phase of the project (38.24% and 20.59% respectively). This is the status quo however, it would be ideal for this CSF to also feature in other phases as the phased approach of trouble shooting would assist in identifying and resolving issues upfront and limit troubleshooting during the implementation phase.

4.7.2. Question 6(b) - Ranking of the CSFs of the PIP

With regards to the CSFs of the PIP, the results show that while the respondents did not necessarily recognise the PIP; they were familiar with the individual factors and were exposed to them in one way or another during the nuclear project lifecycle. This made it relatable to respond to. Overall the respondents indicated that the CSFs of the PIP were important to varying degrees. The results shown in **Table 4.37** show the ranking based on the stakeholders' views and **Table 4.38** is the comparison of the two. CSFs of the PIP ranked in order of importance for nuclear projects would be as follows:

Table 4.37 shows the overall result per stakeholder as it relates to CSFs that are absolutely critical in the CSFs of the PIP. Only these were used for analysis purposes. Programme Managers indicated that Client Acceptance and Client Consultation were absolutely critical. This is in line with this level of management where they are close to the client and need to consult towards client acceptance. The committee on which they sit and where information is presented is one where most clients are represented and hence this will be two major CSFs for them.

Project Managers indicated Project Mission and Communication were equally important while Schedule and Plans were next in line. This is indicative of the role they play where if the project mission was not clear, then they could not execute the project and if communication is not effective, the project is likely to not be as successfully as the team would plan nor hope. Schedule and plans, on this level of management

is also crucial. As indicated, if milestones are not met and the schedule not respected, we run the risk of having undesired consequences both to the plant and the country.

Project Coordinators indicated that the most critical CSFs for them were top management support and schedule and plans. This is followed by the equal importance of monitoring and feedback and communication. This level of managing projects indeed is concerned with schedule and plans as they, in essence, are the implementers. It is surprising that they would cite top management support as these issues general get dealt with on a different level. Upon further investigation it was established that because they report to the Project Manager, he or she is their top management. If further expected that monitoring and feedback and communication is absolutely critical to them as this forms the basis of all their day-to-day task and being able to provide accurate feedback on progress requires the correct level of monitoring as well as communication.

Once all results were calculated, the actual ranking of CSFs of the PIP for nuclear projects was as per **Table 4.38** below. Of interest is that schedule and plans are of equal importance for both scenarios and also personnel, scoring even lower than in the PIP.

Table 4.38: Comparison of the ranking of the CSFs of the PIP related to nuclear projects

CSFs of the PIP	%	CSFs Ranking for nuclear projects
1. Project mission	13.71237	1. Top management support
2. Top management support	13.04348	2. Communication
3. Schedule and plans	**12.37458**	**3. Schedule and plans**
4. Client consultation	11.37124	4. Project mission
5. Personnel	11.03679	5. Client acceptance
6. Technical tasks	10.70234	6. Monitoring and feedback
7. Client acceptance	10.03344	7. Client consultation
8. Monitoring and feedback	6.688963	8. Technical tasks
9. Communication	6.354515	9. Trouble Shooting
10. Trouble shooting	4.682274	10. Personnel

4.7.3. Question 7 - Looking at the CSFs of the PIP, which ones are applicable to a nuclear project?

As shown in **Table 4.39**, an overwhelming majority of respondents (66) indicated that all the CSFs of the PIP were applicable to nuclear projects success. Two respondents agreed that only top management support, schedule and plans were applicable with one including client consultation and communication while the other, included technical tasks as important to nuclear project success.

Table 4.39: CSFs applicable to nuclear project success

CSFs applicable to nuclear project success	1	2	3	4	5	6	7	8	9	10
All CSFs are applicable	66	68	68	67	66	67	66	66	67	66
Some CSFs are applicable	2			1	2	1	2	2	1	2
Total	**68**	**68**	**68**	**68**	**68**	**68**	**68**	**68**	**68**	**68**

4.7.4. Question 8 - Factors that influence nuclear project success but not listed in the PIP?

This question sought to understand the respondents view on, after reviewing the CSFs of the PIP, if there were any additional factors that needed to be included or if the existing list was comprehensive enough to `ensure nuclear project success. According to the results captured in **Table 4.40,** 97% respondents were of the opinion that while (to differing degrees) all CSFs of the PIP were applicable, these alone would not ensure nuclear project success and therefore additional factors needed to be considered specifically for nuclear projects success. This is in line with literature indicating that the CSFs of the PIP can be applied to any industry. In this case, however, indications are that not all CSFs were necessarily considered important for nuclear project success and a framework need to be established that are applicable to this industry. Answering yes to this question therefore was an indication that CSFs for nuclear project success would be a combination of those CSFs listed in the PIP and additional factors based on stakeholder views within the nuclear environment. This further illustrates that, while the PIP contained CSFs that are pertinent across all industries, success of nuclear projects could not be measured by only considering these factors.

It is to be noted that while the majority of respondents (97%), across the nuclear project lifecycle found that there are additional CSFs to be considered for nuclear projects; only two (3%) respondents in the Execution Phase found that there were no additional CSFs to be added to the PIP for nuclear projects.

Table 4.40: Are there factors that influence nuclear project success but are not listed in the CSFs of the PIP?

	Yes	%	No	%
Are there CSFs not listed in the PIP but applicable to nuclear project success	66	97	2	3
Total	**66**		**2**	

4.7.5. Question 9 - Additional factors to be included in the implementation of nuclear projects?

This was a follow-up question to the previous one. This would identify those factors that the respondents felt needed to be considered for inclusion in the CSFs if nuclear project success was to be accurately measured and realised. Since these do not necessarily exist in any previous documented framework, these additional factors will form the basis for an emerging framework of CSFs for nuclear projects. The various responses also revealed how different stakeholders across the nuclear project lifecycle viewed the additional factors related to their stakeholder status and as such, the analysis will be based on the particular stakeholder and specific project phase being referred to.

Additional factors have been grouped to form a unique category to be included towards a framework for CSF of nuclear projects. Important to note that the respondents who indicated that no additional factors were required are those not directly involved in projects (radiological waste management, project accounting and occupational hygiene); which possibly makes sense considering that these stakeholders are outside of the project organisation and mainly concerned with factors within their own sphere and for their own mandates.

As there were varying views amongst respondents of what additional CSFs should be considered for nuclear projects, the Researcher grouped these into similar categories so as to not have too many factors featured, making data analysis cumbersome. **Table 4.41 - Table 4.45** shows the additional CSFs to be considered per project phase. Interestingly, Schedule and plans, Personnel (PM Skills), Technical tasks and Monitoring and Feedback were considered by respondents as additional factors. It can be concluded that there may be a misalignment with the understanding of the terminology of the CSFs of the PIP. However, when looking into the data, the factors cited as those to be included under Schedule and Plans, apart from the ones in the PIP of time schedules, milestones, manpower and equipment required; the respondents were more concerned with factors related to integration management for projects and programmes, front end as well as contingency planning.

Where such misinterpretation exists, the Researcher did not analyse the data but rather included it in CSFs that are already in the PIP. It is only where such ambiguity had the potential to skew the data analysis, that the Researcher analysed the data further. Stakeholder Management on the other hand was analysed as this is broader than Client Consultation and Client Acceptance. When the PIP was developed, these CSFs were concerned with the need for the client to be consulted to ensure the project is on track to meet their needs while Client Acceptance is when the client indicates that they are happy with the final product (Slevin and Pinto, 1986; 1987).

The nuclear industry is different as projects need to be accepted by various stakeholders of which the NNR is key; if they are not happy with the installation, then the project cannot be considered successful. Due to this factor being considered evolved in practice and in concept, Stakeholder Management will be analysed.

From the data there were eleven (11) categories that were derived however categories that were the same or similar to those already included in the CSFs of the PIP were not further analysed as show in **Table 4.41.** These were PM skills (Personnel), Monitoring and Feedback, Technical Tasks. Stakeholder management which can be interpreted at Client Consultation, however, was included as an additional CSF since the understanding for nuclear projects is somewhat different form that of the PIP. As explained this was as a result of slight difference in interpretations. Seven (7) additional categories of factors (according to ranking in order of importance) that respondents would like to see included and are related to the following: a) the three tiers of safety for a nuclear plant [Nuclear, Industrial and Radiological Safety)], b) Cross Functional Team and Collaboration + Integration (this is different from Personnel which is concerned with how the team is selected; this speaks to cross functional collaboration towards success); c) Quality [(this includes Plant Systems, Processes and Procedures + Lessons Learnt (OE)]; d) Regulatory + Legal Requirements; e) Funding + Contracts Management; f) Stakeholder Management and g) Risk Management. Before the data is interpreted, a brief description of the additional factors will be discussed.

Table 4.41: Additional CSFs to be included for nuclear projects

Additional CSFs to be included	Number	%
Nuclear Safety + Industrial Safety + Radiological Safety + Security	39	25.56
Cross Functional Team and Collaboration + Alignment + Integration Management	27	15.00
Quality Management (Plant Systems, Processes and Procedures + OE	22	12.22
Legal + Regulatory Requirements	17	9.44
Funding + Contracts Management	16	8.89
PM Skills	**14**	**7.78**
Stakeholder Management	12	6.67
Risk Management	10	5.56
Monitoring and Control / Feedback	**4**	**2.22**
Construction Management	3	1.67
Technical Tasks	**3**	**1.67**
	180	**100**

1. *Nuclear Safety, Industrial Safety, Radiological Safety*

   The nuclear industry is known for the slogan of nuclear safety as the overriding priority. In line with this, Eskom's Nuclear Management Policy Eskom (2018) and the Koeberg Operational Plan Eskom (2019a) requires the promotion of a strong nuclear and occupational safety culture through the development and reinforcement of good safety attitudes and behaviour in individuals and teams, with nuclear and occupational safety being the overriding priority. This is required throughout all phases of the nuclear installation lifecycle. Eskom considers that the health and safety of the employees, suppliers, sub-suppliers, contractors, the general public, and the protection of the environment is of paramount importance when managing its activities (Eskom, 2018).

   The assessment of project nuclear safety performance includes any challenges to nuclear safety that result from project activities. This may include configuration errors, work on the wrong component/system, failure to follow station work practices, and other human performance errors that challenge systems important to safety. Industrial safety performance includes measuring lost-time accidents, regulator recordable events, first-aid reports, and near misses. It is important to monitor the first-aid cases as an early warning trend to a more severe regulator recordable event or lost-time accident. Radiological safety performance compares project performance with established expectations for dose and contamination control. Higher-than-expected doses or personal contaminations negatively affect project performance (WANO, 2017).

2. *Cross Functional Team and Collaboration + Alignment + Integration Management*

   The execution of a nuclear power project is a major undertaking, which cannot be comprehended, directed and controlled by a single person especially when considering the resources required, time span of the project and the complexity involved. The necessary team effort and the highly professional approach, which is necessary for engineering and manufacturing, require specialised direction in many different disciplines under delegation from top management. Furthermore, the Project Manager should

reach agreements with technical and administrative disciplines and departments that are involved, having ultimate authority, courage and knowledge to slow down or speed up activities, where necessary, in given circumstances (IAEA, 1988).

The design development and review of a nuclear project require the successful integration of Operations, Maintenance, Planning, Radiation Protection, Engineering, and other groups. This helps ensure that designs are appropriate and provide a solution or improvement without degrading safety and operating margins. Team members execute all parts of a project but in some cases, nuclear support organisations (such as Licensing, Radioactive Waste Management, Security, and Probabilistic Risk Assessment) are not represented on the project team. However, these groups can be key project stakeholders. A checklist is helpful to ensure that all affected organisations have been considered. Early inclusion of all possible stakeholder groups helps avoid rework, disagreements, and budget shortfalls later in the project life cycle. Project team acquisition can be more challenging with a weaker organisational alignment and with the scarcity of internal resources. In strong functional organisations, significant management sponsor support may be needed to ensure that the Project Manager gets the resource commitments necessary for a successful project. While acquiring project resources through internal sources has advantages, the Project Manager should remain sensitive to the possibility of overtaxing base-load resources. A well-developed, technically skilled project team that acts in a manner consistent with the overall project goals and the management sponsor priorities ensures a high probability of successful project completion. In the nuclear power business, vendor and supplier constraints, regulatory-driven milestones, the complexities created by integrating project activities with outage and non-outage schedules, and the limitations created by certain system availability requirements must be considered (WANO, 2017).

3. *Quality (Plant Systems, Processes and Procedures + Lessons Learnt (OE)*

   Quality of performance concerns all areas in the nuclear project with safety, reliability and economics being positively influenced with the overriding principle being that safety shall not be compromised for reasons of production, economics, and so on. When performance objectives are properly defined and controlled, processes provide the assurance that they will be met, while the nature of the innate interrelationship between performance objectives and processes to achieve them, defines how successful an organisation will be. When there is no balance between performance objectives and processes with an increased focus on processes rather than performance objectives; this vital relationship is destroyed and the ability of the organisation to achieve its performance objectives is lost. This has been a problem for the nuclear industry, as it tends to separate performance objectives from processes. Traditional quality assurance programmes sometimes focus on the fine-grained details of activities, not stressing performance strongly enough (Hawkins and Pieroni, 1991: 31). "*Hence, the credibility of the industry is called into question by a public that does not understand, and often fears, its objectives*" (Hawkins and Pieroni, 1991: 31).

Effective and efficient quality management processes are imperative in the nuclear industry. Nuclear quality requirements demand fidelity among the physical plant, the design and licensing basis, and procedures and training. Nuclear quality controls during design, fabrication, procurement and installation ensure a fully integrated modification to the nuclear unit. Quality management processes help control human performance, engineering, work planning products, materials and field work. Quality management is necessary for managing both the project and the product. Both external and internal policies and procedures impact quality management. The nature of the project determines the quality management processes. Quality management is essential to effective project management. Specific quality standards are defined in and controlled by the technical, regulatory, and administrative processes, procedures, standards and requirements that support project implementation.
The project quality management plan identifies key elements of QA and QC to be tracked to ensure a predictable, successful project outcome. To achieve the greatest project success, perform quality processes continually throughout the project life (WANO, 2017).

Organisations must ensure that procedures, specifications, instructions or drawings include quantitative and/or qualitative acceptance criteria where appropriate with all organisations involved being informed of any revisions of procedures, specifications, instructions or drawings without delay. Moreover, the involved organisations must ensure that tasks are performed in accordance with valid documents; procedures that ensure that adverse quality conditions such as failures, deficiencies, defective material, system deviations and equipment non-conformity are promptly identified and corrected, are established. Where these conditions adversely affect quality significantly, procedures of the organisations must ensure that the root cause is determined and that appropriate corrective action is introduced to prevent recurrence (NNR, 2008).

Operating experience (OE) is used throughout the life cycle of a project. Using OE effectively includes analysing both station and industry experience to identify fundamental weaknesses. The risk management process is then used to evaluate issues that will reduce the likelihood or the consequences of events, schedule perturbations (time), cost overruns (budget), and quality impacts, as well as to reduce risk based on the review of these lessons learned. Project Managers should benchmark similar projects to identify what went well, what went wrong, and beneficial practices that could be applied. Particular attention should be paid to quality, scope, schedule, risk, cost, and safety issues. Lessons learned, both good and bad, should be made visible to other project personnel throughout the industry (WANO, 2017).

As the nuclear industry experiences a turnover of long-time workers and a new generation of nuclear professionals arrives, the significant and often hard-won experience the industry has gained over several decades must be passed on and carried forward. Project team members should maintain regular contact with their counterparts who are executing similar projects, to stay abreast of issues and

experiences that could affect the project. An integral part of OE is the timely sharing of lessons learned from project events with other nuclear stations. A useful criterion for sharing occurrences with the industry is to consider whether it would have been beneficial to know about this information if it had happened elsewhere. The goal of sharing this information is to provide insights to the industry for improving station projects, including the prevention of repeat or similar events. Unique or new solutions to recurring project-related industry problems should also be shared with the industry. Include operating experience, usually in the form of lessons learned, in the post implementation critiques and project closeout report so the experiences are captured for the future. Record both the positive and negative experiences (WANO, 2017). According to NNR (2017) construction experience and best practices from specific nuclear technologies as well as from nuclear and non-nuclear construction should be collected and lessons learned implemented for the enhancement of quality and safety. Criteria should be established for reporting of construction related experience and measures should be put in place to ensure the dissemination of this information to the relevant parties. The licensee should be proactive in sharing relevant safety experiences nationally and internationally. Where new or innovative construction processes are introduced, a comprehensive qualification programme for the process or technique, including training, should be in place. Compared to traditional construction processes, modular construction presents additional challenges that should be appropriately considered in the construction and installation plan.

4. *Regulatory + Legal Requirements*

Regulatory authorities interpret and implement the laws in the form of directives and impose detailed requirements on projects depending on their and the affected environment.

These regulatory requirements should be anticipated and included in the planning phase and when these requirements are not met, they negatively affect projects in the following ways (Ireland, 1991):

- approval delays prohibiting the project from proceeding;
- re-work in order to meet minimum requirements; or
- cancellation of the project;

owing to the inability to meet requirements within the approved schedule and budget constraints (Ireland, 1991).

"…international practice places the sole responsibility for safety on the operator of a NPP. This is a straightforward requirement, but it also carries a subtle contradiction in the assumption that the regulator should not manage the plants, but still influence what they do. Nuclear power is a political technology, which stirs emotional reactions from politicians, media and the general public. This means that the nuclear industry's words and deeds are watched closely. Decision power is also exercised in political processes when power companies apply for building and operation permits. If something unexpected happens during plant construction or operation, scrutiny is started immediately and efforts to restore public confidence and trust may be considerable."(Wahlström, 2011).

5. *Funding + Contracts Management*

The initial funding request starts with an initial concept, idea or initiative for which an organisation sees a need for further study. Initial funding requests are usually funded as a level of effort (LOE) and are terminated when a project is approved and funded. Typically, the project initiator presents the initial funding request to a group of key managers who determine whether the concept merits going forward for project funding or whether funding is needed for further study of the concept. Projects are considered active when funding is authorised and project spending begins (WANO, 2017).

The capital outlay for nuclear modifications is huge and therefore this is seen as a CSF to be added. The application for such funding follows a very rigorous process where arguments need to be sound when applying for such funding. Furthermore, management of such funding is under constant scrutiny as reporting on those are strict. With Eskom facing many financial challenges, it therefore would make sense to add this CSF as it impacts whether modifications can be implemented or not. This also speaks to the strict way in which funding is approved under these trying times.

Contractual relationships must be established between participants to ensure a mutual understanding of customers' requirements, and the ability to meet them. These contractual commitments should be enforced by the Project Manager and project team during implementation (Ireland, 1991). Contract management is defined as the activities of a buyer during a contract period to ensure that all parties to the contract fulfil their contractual obligations. An important aspect of this is managing the relationship between all parties in the most effective way to ensure that the contract meets the optimum combination of cost, time and quality (Baily *et al.*, 2008).

The contract administration process ensures that customer and vendor legal obligations are met and legal rights are protected. Inputs to the contract administration process include the contract, the contract management plan, vendor selection, performance reports, approved change requests, and work performance information. Outputs of the contract administration process are contract documentation, requested changes, recommended corrective actions, updates to organisational process assets, vendor performance evaluation documentation, and updates to the project management plan. It is therefore strongly suggested that the NPP consider onsite or in-process inspections during the contract administration (fabrication) process for critical components, F-O-A-K materials or services, and use of a vendor that is new to the customer or to the nuclear industry. Fabrication in the nuclear environment may require active participation not only by vendor surveillance personnel but also by engineering personnel to ensure a quality product. The use of sub suppliers during fabrication introduces another layer of potential issues that bear close scrutiny (WANO, 2017).

The objective of project procurement management is to ensure that the required materials and services are available, when needed, at each stage of a project and that they reflect the required quality and cost. The procurement requirements of a nuclear organisation are complex and unique; hence, a written project procurement plan may be beneficial, especially for nuclear-safety-related or important-to-schedule commercial-grade materials and services. Many considerations are common to all procurements, such as the following:

- Legal controls - establishing contracts, purchase orders, etc.
- Accounts processing - making payments, establishing currency hedges, etc.
- Contract management - processing change orders, providing vendor feedback, settling accounts,
- Available corporate funding;
- Availability of the required materials – this may require a long-lead procurement plan

Other considerations unique to nuclear procurements include the following:

- The nuclear environment within which the service or product is delivered;
- More rigorous vendor selection and oversight requirements;
- Expanded demands for supplier quality;
- Safety class/quality assurance designation of the procured material/service;
- Commercial-grade dedication of the material if not designed/manufactured according to nuclear standards and regulatory requirements

Nuclear environment considerations include the following:

- Access processing/security environment
- Protected area housing
- Nuclear training
- Radiological environment
- Worker qualifications
- Project cycles synchronised with other plants
- Specialised equipment and services
- Procedure-driven work practices

Vendor selection and oversight requirements include the following:

- Nuclear plant/work process familiarity
- Risk implications (core, generation, personnel safety)
- Standards and precision
- Specifications, procedures, design basis
- Limited and declining supply of vendors
- Commitment to success in the nuclear environment
- Resources' capability to deliver on time (WANO, 2017).

6. *Stakeholder Management*

During the initiation phase, the project initiator or, if appointed, the Project Manager considers all input regarding the project, to form its basis. This includes stakeholder input from appropriate departments, such as Operations, Licensing, and Training. In addition, internal and industry OE for similar projects is reviewed. The ability to visualise every aspect of a project at the beginning leads to a well-defined scope. This visualisation of the project comes from key stakeholder input, including Engineering, Operations, Licensing, Maintenance, Training, Outage and Planning, Radiation Protection, and other departments, depending on the nature of the project. OE and lessons learned from previous modifications can be invaluable. As part of this phase, it is important to clearly identify the performance requirements of the project and the responsibilities of each functional group and of the potential vendors. Project stakeholders, internal and external, are identified and their needs and expectations addressed. As previously stated, in some cases, nuclear support organisations (such as Licensing, Radioactive Waste Management, Security, and Probabilistic Risk Assessment) are not represented on the project team. However, these groups can be key project stakeholders. A checklist is helpful to ensure that all affected organisations have been considered. Early inclusion of all possible stakeholder groups helps avoid rework, disagreements, and budget shortfalls later in the project life cycle (WANO, 2017). The NNR as a stakeholder was already discussed in the previous section. Internal stakeholders for nuclear projects are all represented at the approval committee called the Koeberg Portfolio Management Committee (KPMC) and they have oversight of all projects to be implemented based on the technical arguments presented. Part of their mandate is to optimise nuclear portfolio projects and programmes within KOU to align with Eskom's strategic imperatives, stakeholder's targets and the funding plan as well as to commit sufficient resources to support the initiatives and/or projects. Their sub-committee, Management Review Committee (MRC) take into account the complexity, resource intensity, interdependency, technology, outage requirements, uncertainty, plant condition, risk, dose limits, safety, business impact, and corporate requirement during the approval of project changes for the PIP and they endorse project selected single solution after the feasibility study, both financially and technically. All stakeholders are therefore represented on these forums and have to be in agreement before a project is approved.

Management sponsorship is critical to ensure the project achieves its key goals and objectives. Sponsors provide critical alignment among the senior management team, site organisations, and the project team to break down barriers, resolve issues, and ensure successful project performance. The level and involvement of management sponsors are commensurate with the complexity and size of the project. Management sponsors are typically individuals who can bring multiple organisations together and resolve cross-organisational barriers beyond the ability or authority of the Project Manager. Sponsors are typically selected from the organisation that either receives the benefit of the project or owns the equipment, and they are not typically within the Project Management Department. Sponsors are expected to fulfil the following roles and responsibilities to enable successful project performance and

part of their role is to be champions/advocates of the project from initial approval through closure, ensure key project goals and objectives are achieved, align project objectives with the site leadership team and ensure project stakeholders, internal and external, are identified and their needs and expectations are being addressed and ensure alignment. They help resolve project issues, barriers, and problems that are above the authority of the Project Manager. This includes addressing the challenges of competing priorities in a matrix organisation and issues with contracts (WANO GL-2017).

7. *Risk*

In today's global energy environment, NPP managers need to consider many dimensions of risk in addition to nuclear safety-related risk. In order to stay competitive in modern energy markets, NPP managers must integrate management of production, safety-related, and economic risks in an effective way (De Castro *et al.*, 2001). The nuclear industry has a long history of applying concepts of risk in decision-making due to the environment and public perception of nuclear. The application of probabilistic risk assessment (PRA) studies and techniques forms the cornerstone of improving nuclear safety and reducing operational challenges at NPPs. The nuclear industry has recognised that the risk management must extend beyond the probabilistic and deterministic approaches especially when dealing with projects that modify the plant. This is particularly true for modifications that are being implemented for the first time or after a long while. Studies in nuclear plants show that many of the errors occur during the execution of F-O-A-K projects in which the utilities fail to recognise that the project design is extrapolated beyond the utility existing OE (INPO, 2015).

F-O-A-K projects introduce changes in design, fit, and function of a plant component or system and demand engineering skills, on-hand experience, and currency that may not reside either at the station or with the vendor. Due to the potentially severe consequences posed by such projects, the strategies for risk management in the nuclear industry must be addressed more broadly and at a lower threshold for action to cover a wider range of undesirable outcomes than is typical in other industries (INPO, 2015).

Risk must be identified and managed from inception of the project as a strategic driver to the realisation of a product or process in the execution stage. The Eskom project lifecycle model has stage gates that puts control in place to ensure that rigorous and systematic risk framework is realised. Today, projects are undertaken in an arena of immense dynamism, rapid change, and global competition. The resultant uncertainty and complexity has emphasised the need for effective risk management strategies (Tah and Carr, 2001). Eskom understands the inherent risk that is attached with their only nuclear plant and as such has established a nuclear oversight committee that focuses on nuclear safety and risk management as the reputational damage to the nuclear industry has the potential to increase the proponents against this programme.

Project risk relates to risks within the project that have the potential to affect the project. This would have undesired outcomes to the stakeholders who have an interest in success of the project. In a nuclear plant this can also entail the regulator shutting down the plant or utilities forced to endure long outages due to project delays. The consequence of project risks could impact equipment or service availability; regulatory and operability margins; nuclear, radiological, and personnel safety; and resource management (De Castro *et al.*, 2001). According to De Castro *et al.* (2001) several of the events in the nuclear industry which were identified in the Significant Operating Experience Review (SOER) were caused by weaknesses in risk recognition or assessment of activities during off-normal conditions or in response to emergent issues or F-O-A-K projects.

Risk management framework and attributes include identifying, assessing, monitoring and mitigation of all types of risk on a project. Managers and leaders must demonstrate a questioning attitude, challenging the organisation to proactively ascertain high risk conditions and activities. (De Castro *et al.*, 2001). Successful risk management will reduce the number of significant events that threaten safe and reliable plant operation or that could have an adverse impact on personnel, the public and the environment. Leaders in the organisation are responsible for ensuring that an effective risk management is implemented. The expectations for risk awareness must be defined, communicated and practiced by station leaders on a continuous basis (De Castro *et al.*, 2001). **Figure 4.1** shows the risk management environment model for a NPP operator.

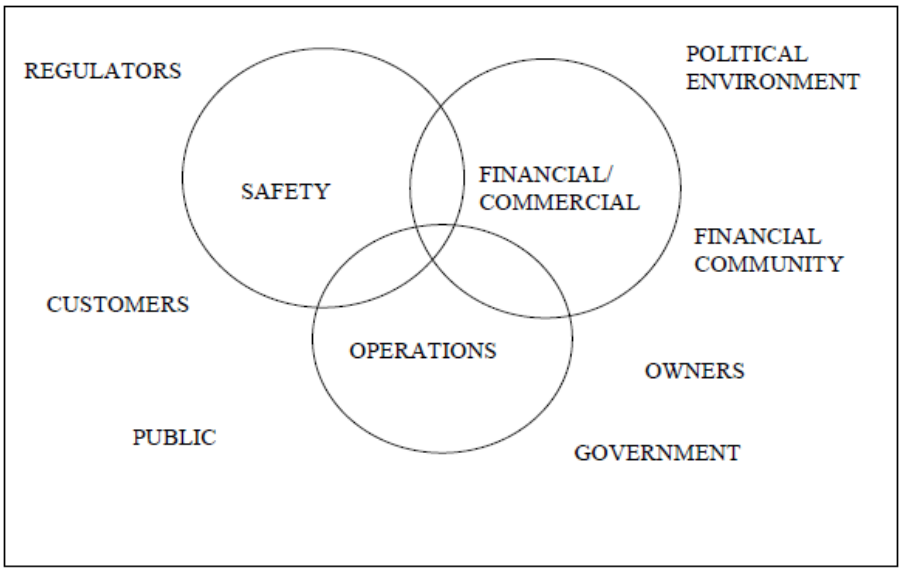

Figure 4.1: Risk management environment model for a NPP operator. Source: (De Castro *et al.*, 2001)

Too often the clients fail to make the best and most correct decisions when looking at F-O-A-K projects in retro perspective. Typically this is true when it comes to formulation of adequate requirements and allocation of risks and responsibilities. Risk management processes consider both positive and negative risks to a project with the probability to reduce the probability and consequences of events that are adverse to the project or the NPP. Some risks are unique to the character projects in the nuclear industry. While quality, schedule, and cost-related risks are similar to other non-nuclear projects, concern for a project impact that adversely affects or degrades the barriers to fission product release is of significance based on potential consequence. Additionally, risk from projects failing to meet their stated objectives can result in regulatory challenges, particularly when those projects were intended to resolve a regulatory issue. The consequences of a project-induced failure can be significant, up to and including regulatory interaction and negative financial impact. To this end, risk management must consider OE, avoid action detrimental to the protection of fission product barriers, and ensure project success through planning and thorough review. The use of a comprehensive risk identification, characterisation, and disposition mechanism is a main factor for consistent project implementation success. It is also critical throughout the project lifecycle so that risks are routinely reviewed with stakeholders as conditions change (WANO, 2017).

Based on the unique challenges and important risk management aspects of planning and performing projects within the nuclear environment, a guideline that closely aligns with best external industry project practices while addressing nuclear industry issues is necessary. When used effectively, this guideline will help close gaps to excellence in nuclear project management performance. It has also been noted that, in many instances, poor project management has led to increased risk, increased costs, and extended outage durations during project execution WANO, 2017.

a. Concept Phase

Table 4.42 shows the breakdown of the additional CSFs per stakeholder status in the Concept Phase. Only four categories were analysed and they included Quality Management, Stakeholder Management (customer relations) and Risk Management (contingency planning) which had 28.57% each with Cross Functional Team + Collaboration +Alignment and Integration Management being 14.29%. With the Concept Phase being the phase where a project is initiated, it stands to reason firstly that the respondents would be as stated, System Engineer, Portfolio, Programme and Project Managers would conclude that these categories be considered purely based on their role and experience. Secondly, it is during this phase where stakeholder management is most critical, as a sponsor needs to be appointed who drives the rest of the stakeholders to be involved. It has been evident in past projects that, where the stakeholders were not adequately identified in this phase, those projects had the highest risk of challenges and, in some cases, failure. Cross Functional Team and Alignment tend to be, as per the results, to a lesser degree of importance as a team is not yet established and risk is more high level and quality is only as per processes that are within the project initiator's control and related to lessons learnt (OE) for consideration before embarking on a solution.

b. Definition Phase

Table 4.43 shows the breakdown of the additional CSFs per stakeholder status (9 respondents) in the Definition Phase. In the Definition Phase, the respondents were more concerned with Cross Function Team Collaboration + Alignment and Integration Management (31.58%) with Quality Management and Regulatory + Legal Requirements (15.79%) and shared importance of Safety, Funding and Commercial and Stakeholder Management (10.53%). The lowest ranked was Risk Management. The stakeholders who mainly responded in this manner were three (33.33%) Programme Managers for the Project Development, Nuclear Project Management Office and Standard Project Execution Departments with one (11.11%) being a Project Manager from the Standard Projects Execution.

Cross Function Team Collaboration + Alignment and Integration Management was viewed as the most critical additional factor in this phase. This is in line with process where the strategic intent and how integration will happen across the organisation is determined. The approval committees where modifications and projects are presented for the Definition Phase consider the entire organisational impact and therefore Cross Function Team Collaboration + Alignment and Integration Management becomes critical. The resources across the organisation not only have to know about the modification or project but also how such project is to be supported and the resources that will need to be employed to deliver successfully. For example, this becomes even more critical when the project is of such a magnitude that the organisation would not be able to recover from its failure (such as the major modifications that are currently being undertaken towards the life extension of the NPP); this will have devastating consequences.

The additional CSF of Regulatory and Legal Requirements is critical at this stage of the project as all nuclear requirements need to be determined and the plan on how the NNR will be engaged based on the project classification; not all projects require intrusive Regulator oversight but those classified accordingly require Regulator influence. These engagements and approvals need to happen prior to execution as per RD-0034 requirements.

Commercial and funding is also of vital importance at this stage as the capital outlay for nuclear projects is huge and as such, it needs to be determined that the possible solution will be commercially and financially viable and that capability exists in the market to implement a possible or proposed solution. The funding being looked at in this phase is not related to this phase only, however, it needs to look as the entire lifecycle and its viability. Contrasting is that, if the solution is of such a nature that it has the possibility to shut the plant down or compromise nuclear safety and plant safety, then commercial and funding is trumped by that condition.

c. Execution Phase

Table 4.45 shows the breakdown of the additional CSFs per stakeholder status (50 respondents) in the Execution Phase. The Execution Phase is where most of the physical implementation takes place. It would therefore make sense that 31.89% of respondents were concerned with including additional factors related to nuclear, industrial and radiological safety. It is in this phase where all planning from the previous two phases in put into practice and as such, the consequences of any type of failure could have catastrophic consequences. Failures in nuclear project around the world have taught the nuclear fraternity how to be extra cautious in the implementation of nuclear projects where careful attention is paid to safety.

Another dominating factor was Cross Functional Team Alignment (17.70%) These are important for nuclear projects and nuclear review bodies have this entrenched in their mandates and expectations of nuclear plants to comply with. While project are being implemented by the project management department, success is only ensured when cross-functional collaboration is given priority as a means of implementing a project successfully.

Quality was 13.27% and Funding and Commercial (12.39%) and Regulatory and Legal (11.5%). These are areas that prove challenging during execution. In most cases, projects have not had sufficient funding owing to challenges such as the lack of proper planning of the actual solution in the Definition Phase. So in those cases, information was not sufficient and only through tendering and clarification of how the solution can be implemented, are these challenges revealed leaving the project having to request additional funding. This factor speaks to a deficiency in the previous phase that then has a knock-on effect on this phase.

Quality on the other hand has always been a challenge. The quality requirements for nuclear projects are, understandably, quite stringent. Most of the challenges here relate to the quality of information, documentation, processes and procedures. Due to the ineffectiveness of closing out of projects with accurate information and project handover, updating of the databases; especially for this ageing plant, lack of information relating to designs and documentation not always being the same as the as found conditions on the plant, makes this a critical success factor to be considered.

Regulatory requirements also have their own challenges during this phase as the NNR is now providing intrusive oversight and their strict requirements need to be met. If their interventions were not properly planned for in the Definition Phase, this places strain on implementation and the NNR cannot exercise effective oversight as per the license requirement; they are governed by very strict rules.

50% of the respondents (Programme Manager, Project Managers, Project Coordinators, and Construction Manager) were from the project management fraternity. These responses make sense as the respondents are directly involved with the activities and types of challenges mentioned previously for this phase.

It is also important to note that the Construction Safety Officers were mainly concerned with safety as a factor as they deal with these on a daily basis. The data indicates this factor, while being the most important factor in project execution, is seen as being more critical by these respondents, while the other respondents have included this factor but somewhat to a lesser degree.

d. Project Close Out / Post Project Phase

Table 4.45 shows the breakdown of the additional CSFs per stakeholder status (50 respondents) in the Execution Phase. The respondents in the Close out Phase are mainly concerned with Quality, particularly documentation for project handover and close out. Previous projects as indicated, is an area that receives the least attention and hence the close out paperwork is one area that continues to be challenge as team members tend to neglect this part of the project and move onto the next one.

The following set of questions (Questions 10-17) speaks to challenges, successes faced by stakeholders in accurately, and consistently identifying CSFs. They are also the reason why the Researcher believes that there should be a framework for inclusion of these additional CSFs for nuclear project rather than mere opinions. These questions further formed a basis to establish a baseline for the understanding or lack of understanding of CSFs of the PIP and relatedness to nuclear projects. These questions further revealed the use of commonly understood CSFs for nuclear projects towards establishing a framework for them that is adhered to by all stakeholders involved in nuclear projects.

4.7.6. Question 10 - What factors did you use to measure / determining the success of your project?

This question sought to ascertain if respondents (knowingly or not) use CSFs to determine their own project success. It is to be noted that while the CSFs of the PIP are known, the respondents did not necessarily know of them in this format. The information provided was based on what each respondent deemed necessary based on their stakeholder status and nuclear project lifecycle phase of the project. Furthermore the responses were of varying degrees, making it evident that there is not a structured way of determining CSFs for nuclear projects. While some factors may be common, they are really based on opinion rather than an existing framework. **Table 4.46** shows the respondents view of the factors they each utilised to determine the success of their projects.

Table 4.46: CSFs used to measure or determine success of a nuclear project

CSFs used to measure success of a nuclear project	Number	%
Project mission	6	4.38
Top management support	5	3.65
Schedule and plans	20	14.60
Client consultation	2	1.46
Personnel	22	16.06
Technical tasks	8	5.84
Client acceptance	8	5.84
Monitoring and feedback	11	8.03
Communication	22	16.06
Troubleshooting	2	1.46
Legal and regulatory requirements	0	0.00
Commercial and Financial requirements	6	4.38
Stakeholder Management	6	4.38
Quality Management	6	4.38
Safety Management	7	5.11
Risk Management	3	2.19
None	3	2.19
	137	**100**

When considering the CSFs of the PIP and the additional factors cited previously, it became import that, if a framework for nuclear project success was to be introduced, the question of which factors were mainly featured for the respondents to determine success of their respective projects. Interestingly the main CSFs used to determine nuclear project success were those of the PIP; with the highest being Personnel and Communication both tied at 16.06% followed by Schedule and Plans (14.60%) and Monitoring and Feedback (8.03%). Of the additional factors, safety once again was the main factors at 5.11%, however it still did not match the influence of the CSFs of the PIP.

a. Concept Phase

In the Concept Phase the pictures is slightly different in that the System Engineers were mainly concerned with Technical Tasks and Client acceptance as the main CSFs. This is in line with their interest that the nuclear project has a technically sound solution in support of the maintaining and improving of the plant. They are also seen as the Client who ultimately has to write a benefits realisation report as acceptance of the final product.

b. Definition Phase

In the Definition Phase Personnel and Communication dominate and this reflect on the nuclear project lifecycle model where the Project Manager now puts together the project team. Communication in this phase of the project is mainly related to the internal project team and how they will be working together to produce a successful project. The CSFs highlighted as being important correlate with those for the overall survey.

c. Execution Phase

In the Execution Phase Personnel and Communication again feature as the main CSFs. However, it must be noted that factors such as monitoring and feedback are not that high up and they form the crux of the matter when executing a project.

4.7.7. Question 11 - What were the challenges in determining CSFs for nuclear projects?

This question sought to understand the challenges experienced by stakeholders in the determining of agreement of CSFs for their projects. The Researcher, based on the previous questions and being aware that this is no common framework, expected that there would be challenges in determining CSFs as different stakeholders were guided by different factors and some were not guided by any structured format (like the PIP), but rather, each respondent and project team experience was based on the scope of work to be achieved. Time, cost and quality did not necessarily feature as obvious CSFs hence each team was left to their own devices. Furthermore, no attention was given to KPA of the organisation and filtered through to project level, hence the struggle. **Table 4.47** lists the challenges experienced in determining CSFs for nuclear projects.

Table 4.47: Challenges in determining CSFs for a nuclear project

Challenges in determining CSFs for a nuclear project	Number	%
Project mission	13	12.62
Top management support	4	3.88
Schedule and plans	5	4.85
Client consultation	0	0.00
Personnel	22	21.36
Technical tasks	10	9.71
Client acceptance	0	0.00
Monitoring and feedback	2	1.94
Communication	8	7.77
Troubleshooting	0	0.00
Legal and regulatory requirements	1	0.97
Commercial and Financial requirements	7	6.80
Stakeholder Management	10	9.71
Quality Management	11	10.68
Safety Management	0	0.00
Risk Management	2	1.94
None	8	7.77
	103	**100**

The respondents indicated that the main challenges in determining CSFs for nuclear projects were Personnel (21.36%), Project Mission (12.62%), Quality Management (10.68%) with Technical Tasks and Stakeholder Management being tied at (9.71%).

Personnel was mainly attributed to the lack of team cohesiveness and alignment, lack of knowledge due to differing experience level (refer to previous work experience) or even possibly the incorrect selection of team members for the task at hand. The NPM department has lost critical skills with people leaving the organisation for better opportunities. Furthermore, many of the staff currently is non-permanent supplemental staff and this exacerbates the issue as there in no stability and succession planning with staff

contracts' being short term in nature. Evidence of this is when the survey was being conducted and respondents who could have participated in it did not as a result of their contracts being terminated.

Project Mission was the second CSFs that was challenging in determining CSFs for nuclear projects. Elements such as the project scope or requirements not being clearly understood leading to the team not agreeing or determining CSFs for the project. In recent times the NPP has and is implementing firs-of-a-kind projects meaning that there is not sufficient knowledge or operating experience to be able to clearly determine CSFs for those types of projects. The last item cited is that of time pressure where those projects have to be fast-tracked; leaving a gap in planning and determining CSFs.

Quality Management (10.68%); also posed some challenges. This is mainly related to the processes and procedures that govern the implementation of nuclear projects. It is part of existing challenges within the organisation that in the execution of the works, the requirements related to adherence to processes and procedures and the completion of all relevant paperwork as the project progresses remains. This can also be attributed to Personnel (lack of process knowledge) which is the main CSF.

Furthermore, this CSF speaks to bureaucracy and red tape especially related to the new Requirements Document (RD-0034) that was introduced by the NNR in 2012 and places much more requirements on the nuclear installer from a manufacturing stand point where the NNR, in some instance justified by the project or product quality level, have a more intrusive role to play in the manufacturing process. Previously, this was not a requirement.

Technical Tasks and Stakeholder Management (9.71%) are tied. The understanding of technical tasks in crucial for a highly technical environment, and once this is lacking, then CSFs cannot be accurately determined. This has to do with the understanding of the NPP systems, structures and components. It is for this reason that a system engineer would insist that a project team working on modifying the nuclear plant must have undergone the required training such as nuclear Engineer's Programme as an example.

Stakeholder Management is another challenge as it has been stated that not all stakeholders understand their role in the nuclear project. Furthermore, the project team needs to make a concerted effort in involving all stakeholders so they can understand the CSFs.

It is also important to note that while all these challenges have been revealed, there are respondents (7.77%) who indicated that there were no challenges in determining CSFs for nuclear projects.

a. Concept Phase

In the Concept Phase the respondents agreed that the understanding of the scope was the main challenge along with the understanding of the project management processes. Plant knowledge and communication were additional challenges.

b. Definition Phase

In the Definition Phase there is agreement in line with the overall picture that Personnel is the main area where there is a challenge. This is attributed to knowledge of the NPP, the lack of subject matter experts in some cases to guide and influence what CSFs would be applicable as well as team alignment. While Commercial requirements and Funding did not feature in the overall picture as a challenge, in the Definition Phase they were mentioned. This is mainly because it is in this phase where the capital outlay is determined and depending on the solution proposed, funding may be an issue owing to the current financial constraints being face by the organisation. When this happens it means that the while prioritisation do not favour a particular solution, maintenance regimes need to be increased.

c. Execution Phase

The respondents in this phase are completely aligned to the overall picture.

d. Finalisation Phase

The respondents in this phase are divided with 50% agreeing with the overall picture and the other 50% not having experienced any challenges in the determining of CSFs for nuclear projects.

4.7.8. Question 12 - How and when were CSFs determined for your project and by whom?

This question sought to understand whether the respondents established CSFs for their project. This question had three (3) parts to it, how, when and by whom. There is no consistent manner in which CSFs are determined and, for the most part, they were determined in a non-structured way. **Table 4.48** shows these responses.

Table 4.48: How were CSFs determined for the nuclear project?

How were CSFs determined for the nuclear project	Number	%
Focus Areas / Key Performance Areas (KPIs)	8	11.76
Lessons Learnt (OE)	11	16.18
Scope review	21	30.88
Schedule review	3	4.41
Processes and Procedures	5	7.35
Not done / Not Applicable	20	29.41
	68	**100**

The majority of respondents (30.88%) stated that CSFs were determined by conducting a detailed scope review. Alarmingly though, is that 29.41% of respondents indicated that CSFs were not being determined for nuclear projects. It points to the fact that Personnel (Team cohesiveness and alignment) play a huge part in how CSFs are determined. Determining CSFs by using Lessons Learnt (OE) is vital for the nuclear business which is heavily reliant on learning from each other. This information is shared across the nuclear fraternity so that good practices are replicated and failure not repeated. It would have been out of character for this CSF not to have been added. Focus Areas is what would have been expected to feature higher on the list as a crucial way in which CSFs can be determined for nuclear projects. The NPM Focus Areas and the Koeberg Focus Areas are very clearly stated and it is expected that project teams adhere to these in the implementation of projects. It is therefore reasonable to conclude that the project team is not always consulting or considering these when determining CSFs for their projects.

a. Concept Phase

In the Concept Phase Project Mission (objectives), scope review (user requirements specifications) and lessons learnt in the form of brainstorming were all considered as avenues to pursue when determining CSFs for nuclear projects.

b. Definition Phase

In the Definition Phase the ways in which CSFs were determined for nuclear projects aligned to the overall picture with Project Mission (scope review) being the main method. This was closely followed by lessons learnt.

c. Execution Phase

It is in the Execution Phase where many respondents indicated that they were not sure if CSFs were determined for nuclear projects. This raises concerns considering that this the phase where it is assumed that all planning was done and the direction in the form of CSFs and focus had already been provided. This would mean that the project is bound to have challenges as the correct direction has not been provided. For those who responded positively to the question elements such as project mission, problem statement, scope and constructability review and lessons learnt were used to determine CSFs for nuclear projects.

d. Finalisation Phase

KPIs and lessons learnt were the main focus here and it is in line with this phase where effectiveness of the project and the processed followed is determined. **Table 4.49** shows these responses.

Table 4.49 When were CSFs determined for the nuclear project?

When were CSFs determined for the nuclear project	Number	%
Concept Phase	31	45.59
Definition Phase	12	17.65
Execution Phase	12	17.65
Finalisation Phase	0	0
All phases	3	4.41
Not Applicable / Not Sure / Not at all	10	14.71
	68	**100**

Literature dictates that CSFs should be determined at all phases of the project lifecycle as the requirements and focus of any particular phase is different from the next one. Most respondents (45.59%) indicated that CSFs are determined in the Concept Phase with 17.65% confirming them being determined in the definition and Execution Phases equally; with none in the finalisation phase. 14.71% of respondents were either not sure if CSFs were determined for nuclear projects and some indicating that these are not determined at all. This is a concerning thought if nuclear projects ae to be successful.

It can be concluded that the respondent responded from the view point of when CSFs are determined in relation to the various phases. So while the majority indicated the Concept Phase, it means that those CSFs determined in the following phases are determined too late and hence contribute to the project not being as successful as intended. This also speaks to the lack of process and procedure adherence where is the stage gate approval process was followed strictly, CSFs would be determined at all phases as intended. This is evident with the result where only 4.41% of responded indicated that CSFs are determined at all phased of the project lifecycle.

The last leg of the question was to understand who determined CSFs for nuclear projects. To this end 42.65% indicated that CSFs were determined by the project team, 25% by the Project Manager, 14.71% were not sure and 11.76% by all stakeholders. **Table 4.50** shows these responses.

Table 4.50 Who determined the CSFs the nuclear project?

Who determines for the nuclear project	Number	%
Project Manager	17	25.00
Project Team	29	42.65
Client	2	2.94
All Stakeholders	8	11.76
Senior Management	1	1.47
Stage gate owners	1	1.47
None / Not Sure	10	14.71
	68	**100**

a. Concept Phase

In the Concept Phase there is agreement amongst respondents that the CSFs are determined mainly by the project team; this agrees to the overall statement.

b. Definition Phase

In the Definition Phase the respondents indicated that the CSFs are determined mainly and equally by the project team and the Project Manager; this agrees to the overall statement.

c. Execution Phase

It was also evident that respondents for this phase agreed that the project team and Project Manager determined the CSFs for nuclear projects.

d. Finalisation Phase

It was also evident that respondents for this phase agreed that the project team and Project Manager determined the CSFs for nuclear projects.

4.7.9. Question 14 - What are the benefits of having CSFs known for a nuclear project?

In order to design a framework of CSFs for nuclear projects; it needed to be determined whether the respondents saw any benefit in knowing or having CSFs determined for nuclear projects and what those benefits would be. **Table 4.51** shows these benefits respondents saw fit to mention. If no benefit was seen, then no framework would be required.

Table 4.51: What are the benefits of having CSFs known for a nuclear project

What are the benefits of having known CSFs for a nuclear project	Number	%
Clear goals, objectives and targets	17	22.08
Focus all involved towards a common goal	21	27.27
Quality and successful execution	14	18.18
Legal and regulatory requirements	3	3.90
Commercial and Financial	4	5.19
Quality Management	8	10.39
Risk Management	8	10.39
Safety Management	2	2.60
	77	**100**

The results indicate that overall, there is benefit is having CSFs known for nuclear projects with 27.27% indicating that they would focus all involved in a nuclear project towards a common goals. 22.08% cited that they would determine clear goals, objectives and targets while 18.18% said that it would contribute towards quality and successful execution. Interestingly are those (10.39%) who responded that it would contribute positively to the management of and control of risks which is a huge factor for nuclear projects.

a. Concept Phase

Respondents in the Concept Phase felt that the benefits would contribute to standardisation and alignment across departments, continuous learning (OE) and the common mission of fixing the ageing plant.

b. Definition Phase

The benefits as indicated by respondents in this phase are focussing the team on a common goal, meeting project objectives and problem identification and risk anticipation.

c. Execution Phase

The responses in this phase are directly in line with the overall concept of aligning the team towards a common goal and determining clear goals and objectives with others calling it the provision of a road map to nuclear project success. The CSFs will also ensure effective scheduling and planning, accountability and compliance.

d. Finalisation Phase

The responses in the phase are related to having a common goal while also ensuring effective monitoring and feedback.

4.7.10. Question 15 - Do stakeholders understand their role in ensuring a successful project?

The understanding of the stakeholders understanding on both CSFs and how they ensured success was tested with this question. **Table 4.52** shows the responses.

Table 4.51: Do all stakeholders understand CSFs and their role in ensuring a successful project?

	Yes	%	No	%
Do all stakeholders understand the CSFs and their role in ensuring a successful project?	21	31	47	69
Total	**21**		**47**	

As shown in **Table 4.52** above, 69% of respondents felt that stakeholders understood their role in ensuring nuclear project success and 47% indicated that stakeholder understood their role. There is focus required to be placed on stakeholder engagement towards ensuring that they understand their role in nuclear project success. Where misalignment and ambiguity exists, it can be deduced that the project will not be as successful as planned. It is evident in the lack of stakeholder commitment to projects that they do not understand and this result supports that notion.

4.7.11. Question 16 - Do you measure success at all the phases of the lifecycle? If so, then how?

This question dealt with the measuring of CSFs during all phases of the nuclear project lifecycle. Respondents needed to demonstrate an understanding that CSFs may be similar of different for the different phases. They also needed to indicate that if they were measured during all phases, how this was done. This would also reveal the link between questions 10 and 13 in that they could only measure CSFs if respondent knew what to measure and how to measure CSFs for nuclear projects. **Table 4.53** shows if CSFs are measured at all phases of the nuclear project lifecycle.

Table 4.53 Do you measure success at all phases of the lifecycle

	Yes	%	No	%
Do you measure success at all phases of the lifecycle	42	61.76	26	38.24
Total				

As shown in **Table 4.53** above, 61.76% of respondents indicated that success is measured at all phases of the project lifecycle while 38.24% indicated that this does not happen in practice. This is owing to the stage gate reviews that are performed for nuclear projects and with research concluding that not all projects undergo this review. There must be focus place on measuring project success at all phases of the project lifecycle as this would allow the team to understand what went right or not for the phase they are leaving and learning and taking those critical lessons into the next phase. This would also allow for an OE database to be developed as projects move through the phases which is ultimately the reason for implementing nuclear projects. More than having successful nuclear projects; it is important to share all the lessons learnt with the greater nuclear fraternity. It is therefore vital to ensure that success is measured at all phases of the project. **Table 4.54** shows how the CSFs are measured during the lifecycle of the project.

Table 4.54 If so, then how?

	Number	%
Stage gate reviews	22	25.88
Key Performance Indicators (KPIs)	10	11.76
Milestone Ruler	14	16.47
Audits	5	5.88
Status Feedback	7	8.24
Not done / Not applicable / Not sure	27	31.76
	85	**100**

The way in which project success is measured according to the respondents is mainly through stage gate reviews (25.8%), the milestone ruler (16.47%) and Key Performance Indicators (11.76%). 31.76% indicated that these were not being measured and this correlated with the previous part of this question that project success is not measured at all phased of the project.

4.7.12. Question 17 - What difference did you identify between normal projects and nuclear projects?

In this question, the respondents were asked to compare the differences between conventional (normal) projects and nuclear projects. This would reveal why the CSFs of the PIP alone would not ensure nuclear project success. It would also reveal come distinct differences which point to why CSFs of the PIP alone could not ensure nuclear project success. **Table 4.55** shows the difference between conventional projects and nuclear projects. Only relevant factors were analysed.

Table 4.55: What difference did you identify between normal projects and nuclear projects?

What are the benefits of having known CSFs for a nuclear project	Number	%
Technology	4	4.88
Schedule and plans	5	6.10
Personnel	8	9.76
Red Tape	16	19.51
Regulatory requirements	32	39.02
Commercial and Funding	5	6.10
Safety Management	12	14.63
	82	**100**

The main difference between nuclear and conventional projects is mainly the stringent regulatory requirements (39.02%), red tape (19.51%), safety requirements which are stricter (14.63%). This is evident of the nuclear environment where and incident or unsuccessful project has dire consequences. Important to note that while commercial and funding (outlay) are important, they are not the drivers in the main difference but rather the ones listed as they are the ones cited when a project is non-compliant.

4.7.13. Question 18 - Any other comments

The Researcher only analysed factors and comments that were not already mentioned previously. These formed part of the overall concluding statements.

4.8. Discussion of research results

4.8.1. Survey Research Results related to additional factors the need to be added to the CSF list

While the respondents rated the CSFs of the PIP, they indicate that those alone would not ensure nuclear project success. To this end, additional CSFs needed to be added for nuclear projects and they are as follows:

1. Safety (Nuclear Safety + Industrial safety + Radiological Safety + Security)
2. Cross Functional Team and Collaboration + Alignment + Integration Management
3. Quality Management (Plant Systems, Processes and Procedures + OE)
4. Legal + Regulatory Requirements
5. Funding + Contracts Management
6. Stakeholder Management
7. Risk Management

4.8.2. Primary research findings

Primary research findings indicated that the CSFs of the PIP were not necessarily known in the existing format. But responses provided an indication that these factors are known, but not in the PIP framework format. The results indicated that the CSFs of the PIP were understood by respondents and relevant rankings were presented in Section 4.7.

4.8.3. Additional research findings

System dynamics is a methodological way of thinking with a set of tools based on systems thinking and can be summarised as follows:

- Systems are a collection of connected things or set of elements that influence one another;
- The things may be easily quantifiable;
- The structure of a system reflects how many elements can accumulate and affect each other; and
- Much of the system structure and the underlying relationships can be drawn using causal loop diagrams (Toole, 2005).

"In the field of Systems Thinking it has been demonstrated that different paradigms and methodologies are appropriate for different contexts and effective in reaching different ends" (Pollack, 2007: 3). Systems methodology or the system approach is a set of conceptual and analytical methods used for systems thinking and modelling (Cavana and Maani, 2000). The authors found that there have been many others who have contributed to the development of systems thinking but they prefer the definition by (Wolstenholme, 1997) who described it as follows:

- *What*: a rigorous way to help thinking, visualisation, sharing, and communication of the future development of complex organisations and issues over time;
- *Why*: for the purpose of solving problems and creating more robust designs, which minimise the likelihood of unpleasant surprises and unintended consequences;

- *How*: by creating operational maps and simulation models which externalise mental models and capture the interrelationship of physical and behavioural processes, organisational boundaries, policies, information feedback and time delays; and by using these architectures to test the holistic outcomes of alternative plans and ideas;
- *Within:* a framework which respects and fosters the needs and values of awareness, openness, responsibility and equality of individual teams (Cavana and Maani, 2000).

4.8.3.1. Analysis of CSFs in the nuclear industry

In order to validate the data collected and analysed from respondents earlier in the chapter, the Researcher decided to employ focus group discussion by towards a systems thinking approach. The six members were selected based on their stakeholder status within the nuclear project lifecycle. These members were or have been involved in project that have been completed so that they could provide a holistic view and comments on the CSFs of the PIP and is those identified by respondents as additional factors were relevant and could influence nuclear project success accordingly. Furthermore, they had not formed part of the initial research study so as to eliminate any bias. In order to get the selection right, the six thinking intentions (Hats) of (De Bono, 1987) was used. **Table 4.56** shows the members and their related hat.

Table 4.56: Members selected for the focus group discussion

Stakeholder Status	Hat	Role	Role/Purpose
Portfolio Manager	White	Neutral and objective	Presentation of facts Make sure what is assumed to be a fact is really a fact
Project Manager - Complex	Red	Emotional views	Get feelings out of the way Ask for and record emotional feeling about the issue
Senior Advisor - Projects	Black	Negative aspects	Identify risks and downside
Project Manager – Standard Execution	Yellow	Positive aspects	Develop the ideas potential
Project Coordinator	Green	Creative idea generation	Brainstorm the issue for ideas
Senior Advisor - Projects	Blue	Control and facilitation	Explain rules, procedures ranking and presenting outcomes

These members were presented with both the CSFs of the PIP and the findings of the research. A "system thinking approach" was selected to analyse the CSFs in case of nuclear projects. Based on the focus areas of NPM, and the research results, the following parameters have been selected to measure the nuclear project success. These were used as the basis for the systems thinking and determining if the research findings could be validated. **Table 4.57** shows different CSFs.

Table 4.57: Nuclear CSFs and CSFs of the PIP

Nuclear Project CSF	Project Success Factors (Slevin and Pinto, 1986)	NPM Focus Area
1. Safety (Nuclear + Industrial + Radiological Safety)	1. Project Mission	1. Nuclear and industrial safety
2. Cross functional team and collaboration + Integration	2. Top Management Support	2. Project quality (Including Contractor Managemetn)
3. Quality Management (PSP+ OE)	3. Project Schedule/Plan	3. Schedule adherence
4. Legal + Regulatory Requirements	4. Client Consultation	4. Documentation readiness
5. Funding + Contracts Management	5. Personnel	5. Project closeout (QADP/FRA)
6. Stakeholder Management	6. Technical Tasks	6. Project handover
7. Risk Management	7. Client Acceptance	7. Collaboration (team work)
8. Communication	8. Monitoring And Feedback	8. Cost effective project execution
9. Schedule Adherence	9. Communication	
	10. Trouble-Shooting	

From the situation described above, the following interrelationship diagram of CSFs that need to be considered for nuclear project success is analysed and shows how the factors are related to each other. Toole (2005) explains that to create a causal loop diagram one needs to identify the variables associated with a system, identify which of these variables are causally related to other variables within the system, and decide whether the effect of one variable on another is positive or negative. **Figure 4.2** below shows all the variables and how they are interrelated.

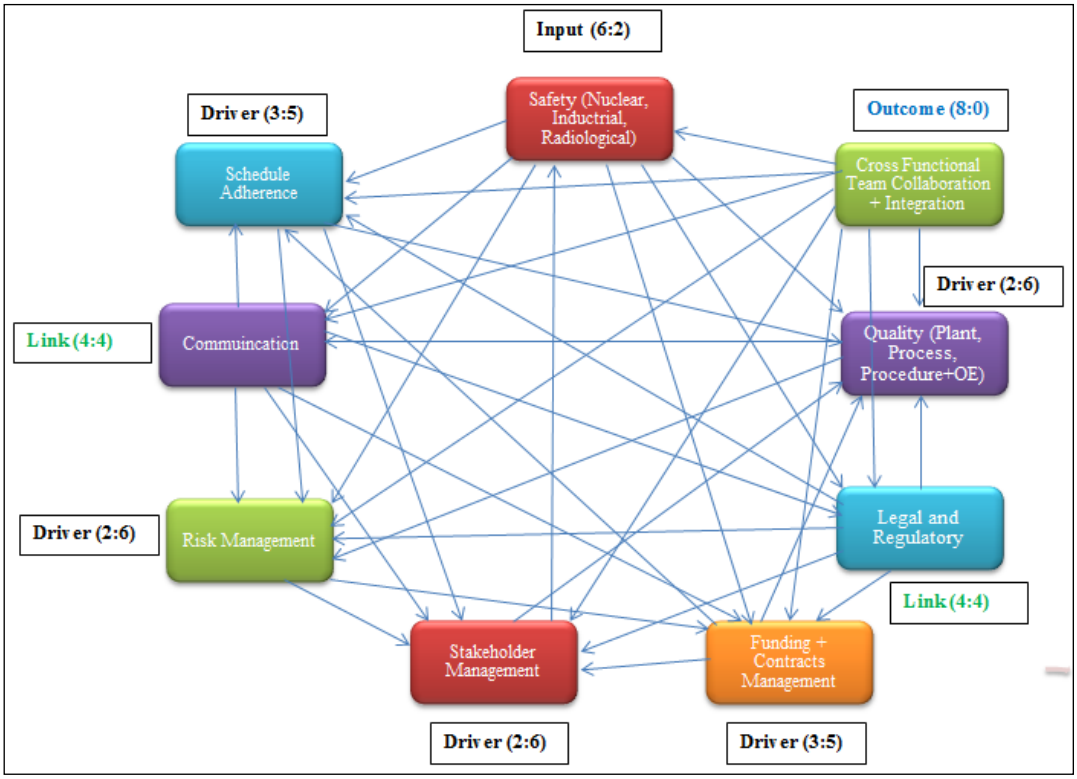

Figure 4.2: Interrelationship diagram

In this case, the focus group (bearing in mind the various roles they were assigned for this discussion) looked at how many arrows go into or out of a variable and how those variables in turn affect each variable. From the interrelationship diagram above it became clear that the **"Cross Functional Team Collaboration + Alignment + Integration Management"** is the focus outcome as it has the most arrows coming into it and that **Nuclear Safety** was the input; meaning that it is aligned to the nuclear industry focus of nuclear safety being the overriding factor. Based on the causal loop analysis, the framework is defined as follows: In using the methodology as explained in (Day, 2003) where the theory has two broad components:

a) Project elements (nouns): states what needs to be managed **(bold type)**

b) Project interventions (verbs): activity needed to improve nuclear project success *(italics).*

Communication *establishes* **Cross Functional Collaboration + Alignment + Integration Management** which *facilitates* **Funding and Contract Management** *strategises* **Schedule Adherence** *which directs* **Stakeholder Management. Communication** *initiates* **Quality (Processes, Procedures + OE)** which *focuses* **Nuclear Safety,** and *considers* **Risk Management** which *updates* **Legal and Regulatory Requirements** and *requires* **Communication. Nuclear Safety** *impacts* **Schedule Adherence and** *considers* **Risk Management**

The next step was to develop the causal loop diagram as shown in **Figure 4.3**

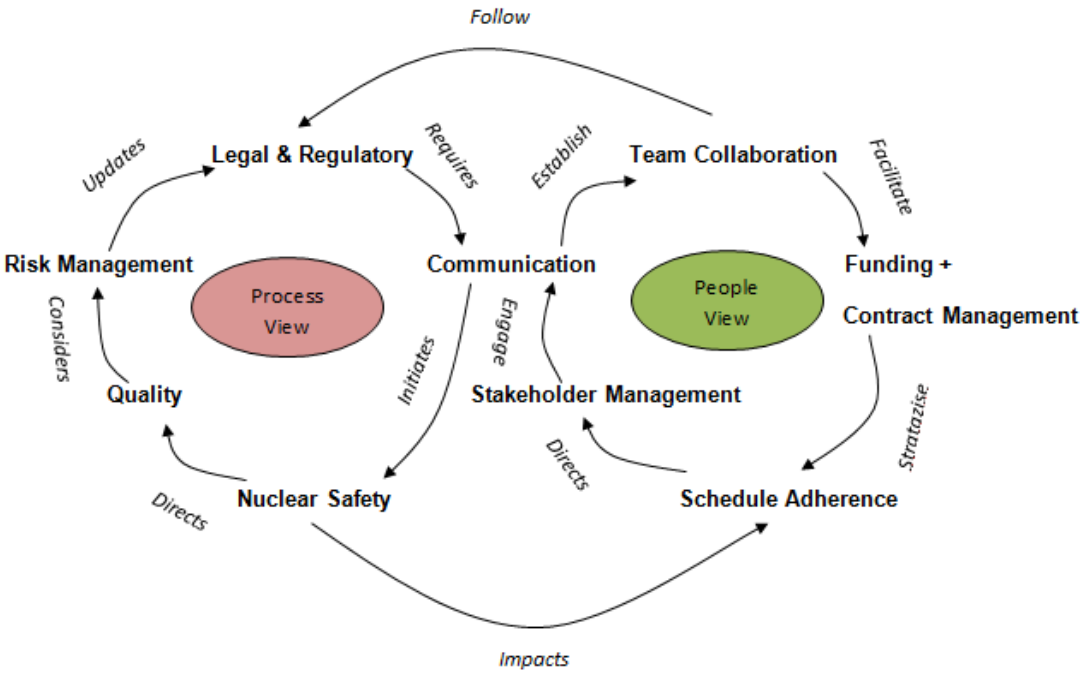

Figure 4.3: Causal loop diagram

The next step was to comparing the CSFs of the PIP with those of nuclear as depicted in **Figure 4.4.**

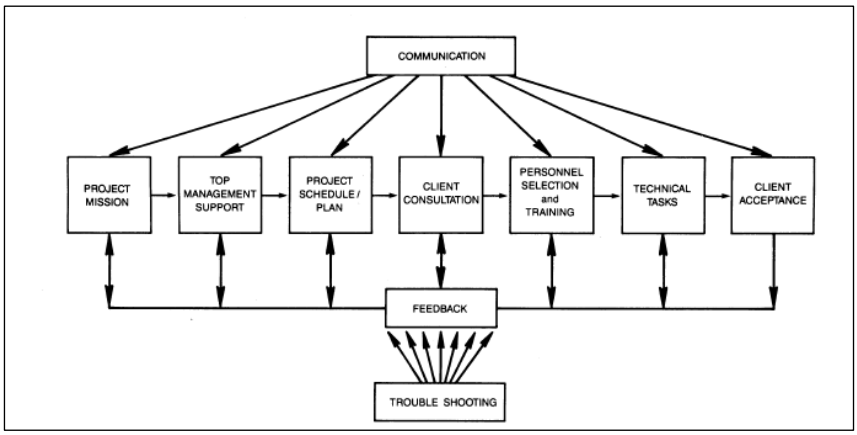

Figure 4.4: CSFs of the Project Implementation Profile

4.9. Conclusions

When looking at the factors as listed in **Table 4.57**, the research findings covered all the factors listed in the NPM focus areas, however three (3) additional factors need to be included and they are Legal and Regulatory Requirements, Stakeholder Management and Risk Management. Furthermore according to the causal loop diagram in **Figure 4.3 Schedule Adherence** *directs* **Stakeholder Management and Risk Management** *update* **Legal and Regulatory Requirements** from which **Cross Functional Team Collaboration + Alignment + Integration Management** *follows.* This is confirmation that these factors need to form part of the nuclear CSFs framework.

Schedule Adherence / Schedule and Plans and **Communication** are common to the CSF of the PIP and nuclear project success. It has been established that Communication is the main link between the two systems (Process View and Respondents' View). **Communication** *establishes* **Cross Functional Collaboration + Alignment + Integration Management and Communication** *initiates* **Quality (Processes, Procedures + OE)** which *focuses* **Nuclear Safety,** and *considers* **Risk Management** which *updates* **Legal and Regulatory Requirements** and *requires* **Communication.**

Figure 4.2 which shows the interrelationship diagram depicts **Nuclear Safety** as the input and this is in line with nuclear safety being the overriding priority. Based on these conclusions the following can be considered as a CSFs Framework for nuclear projects as shown in **Table 4.57** and **Figure 4.5**.

Table 4.57: Nuclear CSFs and CSFs of the PIP

Nuclear Project CSF	Project Success Factors (Slevin and Pinto, 1986)
Safety (Nuclear + Industrial + Radiological Safety)	Project Mission
Cross functional team and collaboration + Integration	Top Management Support
Quality Management (PSP+ OE)	Project Schedule/Plan
Legal + Regulatory Requirements	Client Consultation
Funding + Contracts Management	Personnel
Stakeholder Management	Technical Tasks
Risk Management	Client Acceptance
Communication	Monitoring And Feedback
Schedule Adherence	Communication
	Trouble-Shooting

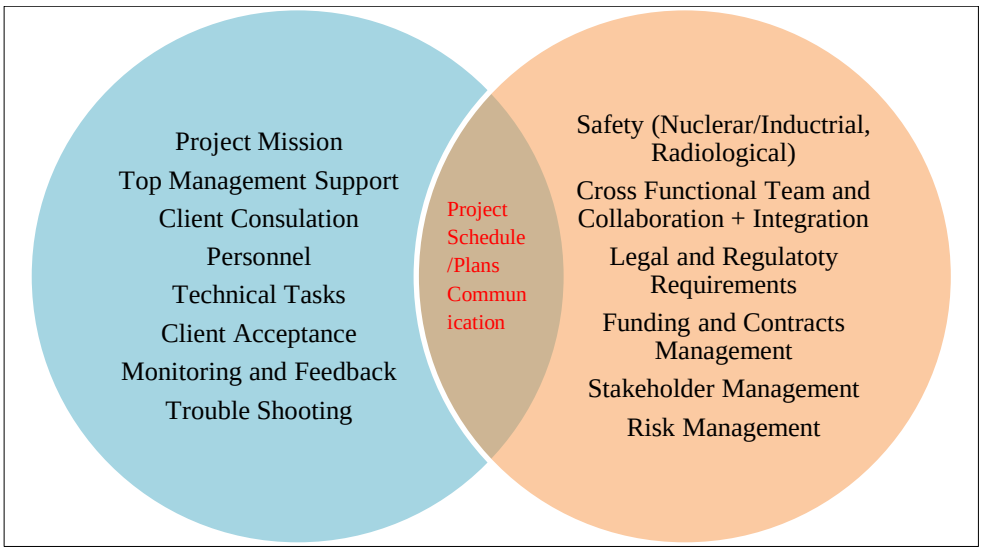

Table 4.5: Framework for nuclear project success

The data analysis done in this chapter, shows that there is a need for nuclear project success framework. The question the Researcher sought to answer was as follows:
The CSFs available in literature are not comprehensively understood nor applied in the nuclear industry.
The research found that these CSFs were comprehensively understood however there was a bit of discrepancy with some terminology and that showed in the way some responses were received. Some of these CSFs are applied in the nuclear industry; however a formalised framework had not been developed.

The research aimed to analyse the CSFs of the PIP and identify those which are applicable to the nuclear industry. After the analyses it was concluded that while all factors were applicable, in varying degrees, to nuclear only project schedule and plans and communication were main CSFs that could be linked to nuclear projects.

In terms of the research objectives; the CSFs important to nuclear projects were identified and the stakeholders indicated what they perceived as pertinent CSFs. The research question of "Are there any factors that need to be added to the CSFs of the PIP which will be considered critical for nuclear project success"; the final contribution was a CSFs framework for nuclear projects as found through the research this was after mapping CSFs of the PIP onto nuclear project success criteria.

An improved understanding of which CSF are applicable to the nuclear industry will contribute to improved project performance is therefore determined.

The next chapter will give the conclusions of this research study by giving recommendations and pointing out areas that may need to be improved in the future in this field of study.

5. CHAPTER 5: RECOMMENDATIONS AND CONCLUSION

5.1. Introduction

This chapter will outline whether the objectives and aims of this research study were achieved and summarise and conclude the research study undertaken. Conclusions will be drawn by explaining and outlining whether the findings analysed in the previous chapter addressed and answered the research questions identified in Chapter 1 Section 1.6 (a). The purpose and approach of the study will be revisited, where after the findings and a conclusion for the study including the research limitations will be explained. At the end of the chapter some recommendations will be provided in terms of future research in the field.

5.2. The research background and approach

The PIP is a self-assessment methodology that allows the project's implementation performance to be measured through the use of a fifty item questionnaire, in relation to ten CSFs (Pinto, 1990). The purpose of the PIP is to allow the project manager to focus on both the 'hard' technical issues of the project, as well as the 'softer' behavioural issues that form part of the CSFs. The PIP further gives the project manager an opportunity to look at the strategic issues of the projects development (Pinto, 1990).

The research looked at the PIP and its relevance to nuclear projects undertaken at the NPP in South Africa. The report aimed to refine the CSFs of the PIP, in order to align them with nuclear projects. The approach followed for the research study was to do an in-depth literature review to filter out and identify the CSFs that are already known in the nuclear industry, but which do not form part of the current CSFs of the PIP. These additional factors were added to the CSFs list and evaluated for their applicability to nuclear projects through a questionnaire survey of various stakeholders in the South African NPP, KNPS. The data obtained from this survey was used to develop a modified list of CSFs which is specific to measure implementation performance on nuclear projects.

5.3. Problem statement revisited

The problem that will be examined in this proposed research can be stated as:

"The CSFs available in literature are not comprehensively understood nor applied in the nuclear industry."

The unit of analysis for this research study were projects that were completed successfully using the finalisation package called the QADP. The research found that the CSFs of the PIP were understood however there was a bit of discrepancy with some terminology and that showed in the way some responses were received. Some of these CSFs are applied in the nuclear industry; however CSFs of the PIP alone would not ensure nuclear project success.

Of the four (4) projects sampled, Personnel, Top management support, Schedule adherence Regulatory requirements, effective Contracts management, Stakeholder management and Cross-functional team collaboration and alignment were the main contributors to the projects' success. Two (2) System Engineers who were interviewed to confirm successful implementation from a client perspective confirmed that while not all projects were submitted for an effectiveness review, those sampled for the research study were indeed successful. The one project that they considered a success was based on the fact that the financial and commercial approvals were completed in record time and that component is still operational and defect free. This was a project that was implemented previously and that had failed three times while in operation; contributing to national blackouts.

The findings of this research study shows that a there is a general understanding of the CSFs of the PIP, however CSFs related to nuclear project success were not included in the PIP, deeming it not inclusive.

5.4. Research question revisited

The research question in this research study was defined in Chapter 1 Section 1.6 (a) as:

"What factors are considered critical for nuclear project success?"

This research question has been addressed during the data collection process with respective research respondents. The findings of this research study shows that while some of the CSFs are considered critical for nuclear project success, additional factors pertinent to nuclear projects were required for inclusion. The next section is going to outline whether these sub-questions were addressed and answered by the findings of this research study.

5.4.1. How is project success measured in the nuclear industry?

As discussed in the literature review in Chapter 2; for nuclear projects, an outage, for example, is considered successful if the units are returned to service on schedule and the modifications are completed on time (Morcos and Taylor, 1988). A successful nuclear power project is designed, constructed and put online within the established parameters of schedule, budget and technical performance (IAEA, 1988; INPO). Furthermore the WANO POCs are clear that successful project implementation should have the elements of project selection and initiation, project resources, project planning and implementation. "*A high-quality project is one that meets performance requirements, satisfies its stakeholders and society at large, and causes no harm to the environment* (Nicholas and Steyn, 2017: 320)".

This research study revealed that project stakeholders have an understanding of what constitutes nuclear project success; there was however a lack in consistency on how to measure project success even though the criteria is clearly set out in the WANO POCs and the NPM Focus Areas. This is attributed to the fact that different stakeholders view success differently and therefore these differing views leads to each focussing on different factors towards project success. It can therefore be concluded that there are clear guidelines on how nuclear project success ought to be measured for nuclear projects, however the application is lacking. It is for this reason that a framework needs to be introduced to ensure consistent nuclear project success; up to now only some projects with pockets of success have been completed.

This question of how project success is measured for nuclear projects was therefore answered.

5.4.2. Which of the CSFs in the PIP are perceived as adequately catering for nuclear projects?

Chapter 4 Section 4.7.3 presented the results in Table 4.39 indicating that 97% however upon further investigation Chapter 5 Section 5.2.3.1 Table 4.57 shows that only Schedule/Plans and Communication adequately cater for nuclear projects. This is directly linked to the statement made by (IAEA, 1988) that "*If project management is to derive maximum benefit, scheduling must be much more than just setting target dates and monitoring accomplishments. A well-developed schedule in the hands of a skilful manager can pay for itself many times over when it is used to spotlight problems and analyse various ways of solving them*." From the respondents the following comments illustrate the importance of schedule and plans:
"*Based on the long turnaround time to prepare a project for execution, more upfront planning is needed from other departments to determine the impact, not so close to the actual execution* and "*Comprehensive planning within a collaborative approach will reduce the inherent uncertainties associated with complex nuclear projects. It requires the project manager to gather all relevant parties together to share their knowledge*."

Communication management affects all aspects of communication within a project. It ranges from the generation of information to the distribution of information. Effective communication creates a bridge between diverse stakeholders involved in a project, thereby connecting various cultural and organisational backgrounds, different levels of expertise, and various perspectives and interests in the project execution or outcome. Communication management enables the project manager and the project team to determine the communication requirements of a project, which are the sum of the information needs and expectations of the project stakeholders. Project personnel focus on communicating information that contributes to project success, including types of things that lead to failure (for example, equipment selection) or where the lack of communication can lead to failure (WANO, 2017).

The findings of this research study showed some of the CSFs of the PIP that adequately cater for nuclear project success. This question was therefore answered.

5.4.3. Are there any factors that need to be added to the CSFs of the PIP which will be considered critical for nuclear project success?

When this question was posed to respondents, 97% indicated that additional factors were required to be added to the CSFs of the PIP to cater for nuclear project success. Chapter 4 Sections 4.7.4 and 4.7.5. Nine addition factors were identified and these were mainly based on the NPM focus areas. Of the nine, only seven were put forward as additional factors since two were already included in the CSFs of the PIP (Schedule and plans and communication). These have been tested with the focus group discussions and were verified to be included in the list of CSFs for nuclear projects.

The research study concluded that additional factors need to be included to ensure nuclear project success. This question was also answered.

5.5. Fulfilment of aims and research objectives

The aim of the research as stated in Chapter 1 Section 1.4 was to analyse the CSFs of the PIP and identify those applicable to the nuclear industry. The findings of this research study showed some of the CSFs applicable to nuclear project success while introducing additional factors towards having a framework for nuclear project success; this has been covered in detail in Chapter 5 Section 5.3 in Table 4.57. **Table 6.1** outlines the progression of research problem, the research aims, objectives the research questions and the methods that were used in the study and which culminates into the research findings. The next section will summarise the research findings and confirm that the research questions were answered.

Table 6.1: The progression and inter-relationship between the problem statement, research questions, aims, objectives, research methods and findings for the study

Research Aims	Research Objectives	Research Questions	Research Methodology	Research Results
Analyse the CSFs of the PIP and identify those which are applicable to the nuclear industry	To understand which CSFs in the PIP are important for nuclear projects	What factors are considered critical for nuclear project success?	A mixed method approach was used for this research study with both at qualitative and quantitative stand	CSFs considered critical for nuclear project success were schedule and plans and communication (from the CSFs of the PIP) with additional factors that are unique to nuclear projects.
	To evaluate which of the CSFs in the PIP are perceived by various stakeholders to be important to nuclear project success	How is project success measured in the nuclear industry?	Multiple case-studies and emailed questionnaires were used to collect data and data verified through focus group discussions.	Chapter 4 presented the results using the questionnaire as to form a baseline. The research findings concluded that the CSFs of the PIP were important but to varying degrees. Section 4.7 presents these results. In Chapter 5 Section 5.2. The primary research findings indicate that the CSFs of the PIP were not necessarily known in the existing format. But responses provide an indication that these factors are known, but not in the PIP framework format. The results indicate that the CSFs of the PIP are understood by respondents and relevant rankings were presented in Section 4.7
	To analyse some of the CSFs relevant to the nuclear industry while identifying other factors that are not included in the PIP but that are pertinent to nuclear project success	Which of the CSFs in the PIP are perceived as adequately catering for nuclear projects?	Systems Thinking was used in Focus Group Discussions to verify the research results	Systems Thinking was employed to verify the findings of Chapter 4. The focus group discussion concurred with the findings and then inclusion of the additional factors identified for nuclear project success.
	Map CSFs in the PIP onto success criteria for nuclear projects	Are there any factors that need to be added to the CSFs of the PIP which will be considered critical for nuclear project success?		The additional factors were mapped onto the success criteria listed in the NPM Focus Areas and found to be aligned to those. However when superimposing them on the WANO POCs; there are some factors not being addressed.

5.6. The research findings and Conclusions Drawn

The results for the research study were presented in Chapter 4 and discussed in detail in Chapter 5. The overall findings from the survey was that the ten (10) CSFs included in the PIP tool are generic and not specifically geared to measure implementation performance on nuclear projects. The results from this study shows that only 20% (two CSFs; Schedule and plans and Communication) adequately cater for nuclear projects. The results also showed that there are seven (7) additional factors to be included and these are more closely aligned to nuclear project success; these are explained in Chapter 5 Section 5.2.3.1 as being Safety (Nuclear + Industrial + Radiological Safety); Cross functional team and collaboration + Integration; Quality Management (PSP+ OE); Legal + Regulatory Requirements; Funding + Contracts Management; Stakeholder Management; Risk Management. These factors are closely linked to the factors as discussed in Chapter 2.1.6 that discussed nuclear specific factors in detail and as such, are not surprising.

The above recommended list of seven (7) additional factors constitutes the refined CSF list for use in the PIP tool to make it specific to measure nuclear project success. This finding means that the research objectives were met and that the research aim was achieved.

The overall contribution of this study from an academic perspective is that very little research has been done on CSFs and the PIP on nuclear projects. This research will add to the knowledge base on the subject. The PIP has been tested and verified to a number of different industries in previous studies but with little application to nuclear projects. The practical implication is that the study has generated a framework by which CSFs for nuclear projects can be measured and that Project Managers in the nuclear industry can use to evaluate their projects. It is recommended that Project Managers utilise the framework towards ensuring project success and aligning the rest of the project team, the organisation and stakeholders towards successful implementation. This is for common understanding and an aligned focus to success

5.7. Limitations of the research

A major limitation for the study was the timing of the distribution of the survey. The Researcher allowed four (4) weeks for the distribution and response of the survey questionnaire but this period ended up being sixteen (16) weeks; four (4) times more than the planned period. This, as explained in Chapter 4 Section 4.3.1, was due to this survey taking place over an outage period (which overran) as well as potential respondents having their contracts terminated during the extended survey period. The response rate was slow and required a lot of work to ensure that a rate above 50% was achieved.

Another major limitation for the study was the uneven distribution of responses in the various phases of the nuclear project lifecycle with the Execution Phase being the dominating phase. This uneven distribution of results meant that the overall findings would be governed by the Execution Phase.

5.8. Recommendations for further studies

This field of study would benefit from research being carried out in terms of the recommendation made of mapping the nuclear CSF framework to other nuclear projects and testing the framework for practical implementation. Further research can also be done focussing on the Concept, Definition and Finalisation Phases to ascertain if the same factors are applicable in those phases.

It is also recommended that further research be undertaken to identify those CSFs that may hold relevance to nuclear projects but were not explicitly noted in this research and were therefore omitted from the formal surveys used.

With a refined CSFs list specific to nuclear project being proposed as per this research study, there would be benefit in the continuation of the revision of the PIP tool by investigating the associated set of the seven (7) additional factors.

5.9. Conclusion

In conclusion, the research carried out in this study has provided a framework towards ensuring consistent nuclear project success; one that is uniform and to which all Project Managers can subscribe. The research study has also been demonstrated that while some projects were deemed successful, this was based on the view and actions of the individual Project Manager and not based on a uniform approach that is understood by all; stakeholders and project team members alike. It could, to some extent, be concluded that this success was based on chance. So, if chance is to be eliminated, then the framework is to be used as an assurance of nuclear project success.

A pattern of non-conformance has been established with a recent self-assessment that identified that within NPM, of the nineteen (19) WANO POCs, only four (4) were adhered to in its entirety. To this end an initiative was put together to close this gap; this is still a work in progress with great strides being made towards aligning the project management team towards a common goal and ultimately successful project implementation. It is therefore fitting that the framework be introduced to aid this initiative.

There is an opportunity for the CSFs for nuclear projects to be re-introduced and the reinforced in order to improve nuclear project success rates and increase confidence in the NPM Department, the rest of the organisation as well as internal and external stakeholders especially the NNR that consistent nuclear project success is not an elusive target but can actually be achieved. It will also increase the confidence of the possibility of successful implementation of nuclear projects towards plant life extension which is the direction that the nuclear fraternity is moving in with some NPPs already in an advanced stage of this initiative. This confidence, in the South African context, extends to investors remaining interested and government targets being met. The framework, if implemented, can lead to nuclear project success; which is an essential requirement if nuclear is to remain a viable option for the longer term.

6. BIBLIOGRAPHY

Agarwal, N. and Rathod, U. (2006) Defining 'success' for software projects: An exploratory revelation. *International journal of project management*, **24**(4), 358-370.

Amaratunga, D., Baldry, D., Sarshar, M. and Newton, R. (2002) Quantitative and qualitative research in the built environment: application of "mixed" research approach. *Work study*.

Andersen, E. and Jessen, S.A. (2000) Project evaluation scheme: a tool for evaluating project status and predicting project results. *Project management journal*, **6**(1), 61-69.

Andersen, E.S., Birchall, D., Jessen, S.A. and Money, A.H. (2006) Exploring project success. *Baltic journal of management*.

Angus, G.Y., Flett, P.D. and Bowers, J.A. (2005) Developing a value-centred proposal for assessing project success. *International journal of project management*, **23**(6), 428-436.

Atkinson, R. (1999) Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International journal of project management*, **17**(6), 337-342.

Avots, I. (1969) Why does project management fail? *California management review*, **12**(1), 77-82.

Baccarini, D. (1999) The logical framework method for defining project success. *Project management journal*, **30**(4), 25-32.

Baily, P., Farmer, D., Crocker, B., Jessop, D. and Jones, D. (2008) *Procurement principles and management*. Pearson Education.

Baker, B.N., Murphy, D.C. and Fisher, D. (1997) Factors affecting project success. *Project management handbook*, 902-919.

Belassi, W. and Tukel, O.I. (1996) A new framework for determining critical success/failure factors in projects. *International journal of project management*, **14**(3), 141-151.

Bell, E. and Wray-Bliss, E. (2009) Research ethics: Regulations and responsibilities. *The Sage handbook of organizational research methods*, 78-92.

Belout, A. (1998) Effects of human resource management on project effectiveness and success: toward a new conceptual framework. *International journal of project management*, **16**(1), 21-26.

Belout, A. and Gauvreau, C. (2004) Factors influencing project success: the impact of human resource management. *International journal of project management*, **22**(1), 1-11.

Berssaneti, F.T. and Carvalho, M.M. (2015) Identification of variables that impact project success in Brazilian companies. *International journal of project management*, **33**(3), 638-649.

Bhattacherjee, A. (2012) Social science research: Principles, methods, and practices.

Blaikie, N. (2003) *Analyzing quantitative data: From description to explanation*. Sage.

Boynton, A.C. and Zmud, R.W. (1984) An assessment of critical success factors. *Sloan management review*, **25**(4), 17-27.

Brown, A. and Adams, J. (2000) Measuring the effect of project management on construction outputs: a new approach. *International journal of project management*, **18**(5), 327-335.

Bryde, D. (2008) Perceptions of the impact of project sponsorship practices on project success. *International journal of project management*, **26**(8), 800-809.

Bryman, A. and Bell, E. (2003) Breaking down the quantitative/qualitative divide. *Business Research Methods*, **2**(1), 465-478.

Bullen, C.V. and Rockart, J.F. (1981) A primer on critical success factors.

Cassell, C. and Symon, G. (2004) *Essential guide to qualitative methods in organizational research*. Sage.

Cavana, R. and Maani, K. (2000) A methodological framework for integrating systems thinking and system dynamics. *In, Proceedings of the 18th International Conference of the System Dynamics Society*. Citeseer, 6-10.

Cerpa, N. and Verner, J.M. (2009) Why did your project fail? *Communications of the ACM*, **52**(12), 130-134.

Chan, A.P. and Chan, A.P. (2004) Key performance indicators for measuring construction success. *Benchmarking: an international journal*, **11**(2), 203-221.

Chan, A.P., Ho, D.C. and Tam, C. (2001) Design and build project success factors: multivariate analysis. *Journal of construction engineering and management*, **127**(2), 93-100.

Chan, A.P., Scott, D. and Chan, A.P. (2004) Factors affecting the success of a construction project. *Journal of construction engineering and management*, **130**(1), 153-155.

Chetty, S. (1996) The case study method for research in small-and medium-sized firms. *International small business journal*, **15**(1), 73-85.

Chua, D.K.H., Kog, Y.-C. and Loh, P.K. (1999) Critical success factors for different project objectives. *Journal of construction engineering and management*, **125**(3), 142-150.

Clarke, A. (1999) A practical use of key success factors to improve the effectiveness of project management. *International journal of project management*, **17**(3), 139-145.

Cleland, D. and King, W. (1983) A conceptual framework for systems analysis. *Systems analysis and project management*, 127.

Cleland, D. and Ireland, L. (2006) R., 2006. *Project management: strategic design and implementation*.

Cleland, D.I. and King, W.R. (1975) *Systems analysis and project management*. McGraw-Hill.

Cooke-Davies, T. (2002) The "real" success factors on projects. *International journal of project management*, **20**(3), 185-190.

Cresswell, J. (2007) Qualitative inquiry Thousands Oak. In: CA: Sage.

Creswell, J.W. (2007) *Qualitative Inquiry & Research Design: Choosing Among Five Approaches*. 2nd ed. Thousand Oaks, California: Sage Publications, Inc.

Davis, K. (2014) Different stakeholder groups and their perceptions of project success. *International journal of project management*, **32**(2), 189-201.

De Bono, E. (1987) *Letters to thinkers: Further thoughts on lateral thinking*. Harrap.

De Castro, S., Gasper, J., Gasper, J., Gessler, A., Gomez-Cobo, A., Labroille, S., Langlois, L., Lawrence, G., Mazour, T. and Nettleship, D. (2001) Risk management: A tool for improving nuclear power plant performance, 2001. *International Atomic Energy Agency (IAEA): Vienna, Austria*.

De Leeuw, E.D., Hox, J.J. and Dillman, D.A. (2008) *International handbook of survey methodology*. Taylor & Francis Group/Lawrence Erlbaum Associates.

De Vos, A.S. (2002) Scientific theory and professional research in de Vos, A.S. Strydom, H. Fouché, C.S.L. & Delport, C.S.L. (eds) Research at grass roots: for the Social Sciences and Human Service Professions, 2 nd edn. Pretoria: Van Schaik.

De Wit, A. (1988) Measurement of project success. *International journal of project management*, **6**(3), 164-170.

Denzin, N. and Lincoln, Y. (2005) *Paradigms and perspectives in transition' in the Sage: Handbook of Qualitative Research.* Vol. 3, Thousand Oaks, CA: Sage.

Dvir, D., Lipovetsky, S., Shenhar, A. and Tishler, A. (1998) In search of project classification: a non-universal approach to project success factors. *Research Policy*, **27**(9), 915-935.

Eisenhardt, K.M. (1989) Building theories from case study research. *Academy of management review*, **14**(4), 532-550.

Engwall, M. (2003) No project is an island: linking projects to history and context. *Research Policy*, **32**(5), 789-808.

Eskom (2018) *Eskom's Nuclear Management Policy*

Eskom, K.N.P.S. (2017) *Koeberg Nuclear Power Station: Business Priorities*.

Eskom, K.N.P.S. (2019a) *Koeberg Nuclear Power Station: Operational Plan*.

Eskom, K.N.P.S. (2019b) *Koeberg Nuclear Power Station Operational Plan*. Koeberg Nuclear Power Station.

Eskom, K.N.P.S. (2019c) *Eskom's Nuclear Objectives*.

Finch, P. (2003) Applying the Slevin-Pinto project implementation profile to an information systems project. *Project management journal*, **34**(3), 32-39.

Flyvbjerg, B. (2001) *Making social science matter: Why social inquiry fails and how it can succeed again*. Cambridge university press.

Flyvbjerg, B. (2006) Five misunderstandings about case-study research. *Qualitative inquiry*, **12**(2), 219-245.

Fortune, J. and White, D. (2006) Framing of project critical success factors by a systems model. *International journal of project management*, **24**(1), 53-65.

Freeman, M. and Beale, P. (1992) Measuring project success. *In*. Project Management Institute.

Futrell, R.T., Shafer, L.I. and Shafer, D.F. (2001) *Quality software project management*. Prentice Hall PTR.

Gemuenden, H.G. and Lechler, T. (1997) Success factors of project management: the critical few-an empirical investigation. *In, Innovation in Technology Management. The Key to Global Leadership. PICMET'97*. IEEE, 375-377.

Gepp, M., Hellmuth, A., Schäffler, T. and Vollmar, J. (2014) Success factors of plant engineering projects. *Procedia engineering*, **69**, 361-369.

Gioia, D.A. and Pitre, E. (1990) Multiparadigm perspectives on theory building. *Academy of management review*, **15**(4), 584-602.

Gomes, J. and Romão, M. (2016) Improving project success: A case study using benefits and project management. *Procedia Computer Science*, **100**, 489-497.

Gomm, R., Hammersley, M. and Foster, P. (2009) Case study method: Case study and generalization. In: Sage Research Methods online version: http://srmo. sagepub. com/view/case ….

Hancock, D.R. and Algozzine, B. (2017) *Doing case study research: A practical guide for beginning researchers*. Teachers College Press.

Hawkins, F. and Pieroni, N. (1991) Quality assurance at nuclear power plants: Basing programmes on performance. *IAEA Bulletin*, **33**(4), 29-33.

Hoegl, M. and Gemuenden, H.G. (2001) Teamwork quality and the success of innovative projects: A theoretical concept and empirical evidence. *Organization science*, **12**(4), 435-449.

Hoepfl, M.C. (1997) Choosing qualitative research: A primer for technology education researchers. *Volume 9 Issue 1 (fall 1997)*.

Hyväri, I. (2006) Success of projects in different organizational conditions. *Project management journal*, **37**(4), 31-41.

IAEA (1988) *Technical Series Reports No. 279, Nuclear Power Project Management: A Guidebook*. Vienna: International Atomic Energy Agency.

IAEA (2007) *IAEA-TECDOC-1555: Managing the first nuclear power plant project*. Vienna: International Atomic Energy Agency.

Ika, L.A. (2009) Project success as a topic in project management journals. *Project management journal*, **40**(4), 6-19.

INPO (2015) *Principles for Excellence in Integrated Risk Management*.

Institute, P.M. (2013) A Guide to the Project Management Body of Knowledge: PMBOK (R) Guide. *In*. Project Management Institute.

Ireland, L.R. (1991) *Quality management for projects and programs*. Project Management Inst.

Iyer, K. and Jha, K. (2005) Factors affecting cost performance: evidence from Indian construction projects. *International journal of project management*, **23**(4), 283-295.

Jamieson, S. (2004) Likert scales: How to (ab) use them? *Medical education*, **38**(12), 1217-1218.

Jha, K. and Iyer, K. (2006) Critical factors affecting quality performance in construction projects. *Total Quality Management and Business Excellence*, **17**(9), 1155-1170.

Johnson, R.B. and Onwuegbuzie, A.J. (2004) Mixed methods research: A research paradigm whose time has come. *Educational researcher*, **33**(7), 14-26.

Johnson, R.B., Onwuegbuzie, A.J. and Turner, L.A. (2007) Toward a definition of mixed methods research. *Journal of mixed methods research*, **1**(2), 112-133.

Joslin, R. and Müller, R. (2015) Relationships between a project management methodology and project success in different project governance contexts. *International journal of project management*, **33**(6), 1377-1392.

Jugdev, K. and Müller, R. (2005) A retrospective look at our evolving understanding of project success. *Project management journal*, **36**(4), 19-31.

Kagioglou, M., Cooper, R., Aouad, G. and Sexton, M. (2000) Rethinking construction: the generic design and construction process protocol. *Engineering construction and architectural management*, **7**(2), 141-153.

Kandelousi, N.S. (2011) Key success factors for managing projects. *International Journal of Economics and Management Engineering*, **5**(11), 1541-1545.

Kerzner, H. (1987) In search of excellence in project management. *Journal of Systems Management*, **38**(2), 30.

Kerzner, H. (2009) Project Management: A Systems Approach to planning, scheduling, and controlling. John Wiley & Sons, Inc.

Khan, S. (2008) The case in case-based design of educational software: A methodological interrogation. *Educational Technology Research and Development*, **56**(4), 423-447.

Kumar, R. (2018) *Research methodology: A step-by-step guide for beginners*. Sage.

Kuruppuarachchi, P.R., Mandal, P. and Smith, R. (2002) IT project implementation strategies for effective changes: a critical review. *Logistics information management*.

Lim, C. and Mohamed, M.Z. (1999) Criteria of project success: an exploratory re-examination. *International journal of project management*, **17**(4), 243-248.

Lipovetsky, S., Tishler, A., Dvir, D. and Shenhar, A. (1997) The relative importance of project success dimensions. *R&D Management*, **27**(2), 97-106.

Maltz, A.C., Shenhar, A.J. and Reilly, R.R. (2003) Beyond the balanced scorecard:: Refining the search for organizational success measures. *Long range planning*, **36**(2), 187-204.

Maree, K. (2007) *First steps in research*. Van Schaik Publishers.

Maylor, H. (2001) Beyond the Gantt chart:: Project management moving on. *European management journal*, **19**(1), 92-100.

Meredith, J. and Mantel, S.J. (2009) *Project Management: A Managerial Approach, (W/Cd)*. John Wiley & Sons.

Meredith, J.R. and Mantel Jr, S.J. (2011) *Project Management: A Managerial Approach: A Managerial Approach*. Wiley Global Education.

Meredith, J.R. and Mantel, S. (2012) Project Management, Hoboken. In: NJ, USA: Wiley.

Miles, M.B. and Huberman, A.M. (1994) *Qualitative data analysis: An expanded sourcebook*. sage.

Milosevic, D. and Patanakul, P. (2005) Standardized project management may increase development projects success. *International journal of project management*, **23**(3), 181-192.

Mir, F.A. and Pinnington, A.H. (2014) Exploring the value of project management: linking project management performance and project success. *International journal of project management*, **32**(2), 202-217.

Morcos, A. and Taylor, H. (1988) Quality assurance considerations for nuclear plant modifications. *Nuclear Engineering and Design*, **107**(1-2), 235-242.

Morris, P.W. (1983) Managing project interfaces: key points for project success. *Project management handbook*, **2**, 16-55.

Morris, P.W. and Hugh, G. (1986) Preconditions of Success and Failure in Major Projects Templeton College. In: the Oxford Centre for Management Studies, Kinnington Oxford, Technical paper.

Morris, P.W. and Hough, G.H. (1987) The anatomy of major projects: A study of the reality of project management.

Muijs, D. (2010) *Doing quantitative research in education with SPSS*. Sage.

Müller, R. and Turner, R. (2007) The influence of project managers on project success criteria and project success by type of project. *European management journal*, **25**(4), 298-309.

Müller, R. and Jugdev, K. (2012a) Critical success factors in projects: Pinto, Slevin, and Prescott-the elucidation of project success. *International Journal of Managing Projects in Business*, **5**(4), 757-775.

Müller, R. and Jugdev, K. (2012b) Critical success factors in projects: Pinto, Slevin, and Prescott–the elucidation of project success. *International Journal of Managing Projects in Business*, **5**(4), 757-775.

Munns, A.K. and Bjeirmi, B.F. (1996) The role of project management in achieving project success. *International journal of project management*, **14**(2), 81-87.

Murphy, D.C., Baker, B.N. and Fisher, D. (1974) Determinants of project success.

Nicholas, J.M. and Steyn, H. (2017) *Project management for engineering, business and technology*. Taylor & Francis.

NNR (2008) *RD-0034 Quality and Safety Management Requirements for Nuclear Installations*.

NNR (2017) *Regulatory Guide: Interim Guidance on Construction Management for Nuclear Facilities*.

Oppenheim, A.N. (1992) Questionnaire design. *Interviewing and Attitude measurement*, **24**.

Palys, T. (2008) Purposive sampling. *The Sage encyclopedia of qualitative research methods*, **2**(1), 697-698.

Papke-Shields, K.E., Beise, C. and Quan, J. (2010) Do project managers practice what they preach, and does it matter to project success? *International journal of project management*, **28**(7), 650-662.

Patton, E. and Appelbaum, S.H. (2003) The case for case studies in management research. *Management research news*.

Pinkerton, W.J. and Pinkerton, W.J. (2003) *Project Management: Achieving Project Bottom-line Succe*. McGraw-Hill.

Pinto, J.K. (1990) Project Implementation Profile: a tool to aid project tracking and control. *International journal of project management*, **8**(3), 173-182.

Pinto, J.K. and Slevin, D.P. (1987) Critical factors in successful project implementation. *IEEE transactions on engineering management*(1), 22-27.

Pinto, J.K. and Slevin, D.P. (1988a) 20. Critical Success Factors in Effective Project implementation*. *Project management handbook*, **479**, 167-190.

Pinto, J.K. and Prescott, J.E. (1988) Variations in critical success factors over the stages in the project life cycle. *Journal of management*, **14**(1), 5-18.

Pinto, J.K. and Slevin, D.P. (1988b) Critical Success Factors in Effective Project implementation*. *Project management handbook*, **479**.

Pinto, J.K. and Slevin, D.P. (1989a) The project champion: Key to implementation success. *In*. Project Management Institute.

Pinto, J.K. and Covin, J.G. (1989) Critical factors in project implementation: a comparison of construction and R&D projects. *Technovation*, **9**(1), 49-62.

Pinto, J.K. and Slevin, D.P. (1989b) Critical success factors in R&D projects. *Research-Technology Management*, **32**(1), 31-35.

Pinto, J.K. and Mantel, S.J. (1990) The causes of project failure. *IEEE transactions on engineering management*, **37**(4), 269-276.

Pinto, J.K. and Prescott, J.E. (1990) Planning and tactical factors in the project implementation process. *Journal of Management studies*, **27**(3), 305-327.

PMI, A. (2013) guide to the project management body of knowledge (PMBOK guide). *In*, *Project Management Institute*, Vol. 5.

Pollack, J. (2007) The changing paradigms of project management. *International journal of project management*, **25**(3), 266-274.

Prabhakar, G.P. (2008) What is project success: a literature review. *International Journal of Business and Management*, **3**(9).

Punch, K.F. (2013) *Introduction to social research: Quantitative and qualitative approaches*. sage.

Radujković, M. and Sjekavica, M. (2017) Project management success factors. *Procedia engineering*, **196**, 607-615.

Rauniar, R. and Rawski, G. (2012) Organizational structuring and project team structuring in integrated product development project. *International Journal of Production Economics*, **135**(2), 939-952.

Riege, A.M. (2003) Validity and reliability tests in case study research: a literature review with "hands-on" applications for each research phase. *Qualitative market research: An international journal*.

Rockart, J.F. (1979) Chief executives define their own data needs. *Harvard business review*, **57**(2), 81-93.

Rockart, J.F. and Bullen, C. (1981) A primer on critical success factors. *Center for Information Systems Research Working Paper*(69).

Rockart, J.F., Ball, L. and Bullen, C.V. (1982) Future role of the information systems executive. *MIS quarterly*, 1-14.

Rowley, J. (2002) Using case studies in research. *Management research news*.

Rugg, G. and Petre, M. (2007) A Gentle Guide to Research Methods. 1st. In: Maidenhead, Berkshire: Open University Press.

Saunders, M.L., P. Thornhill, A. (2016) *Understanding research philosophies and approaches*. Harlow: Pearson Education Limited.

Sauser, B.J., Reilly, R.R. and Shenhar, A.J. (2009) Why projects fail? How contingency theory can provide new insights–A comparative analysis of NASA's Mars Climate Orbiter loss. *International journal of project management*, **27**(7), 665-679.

Sayles, L. and Chandler, M. (1971) The project manager: organizational metronome. *Managing Large Systems*, 204-226.

Schultz, R.L. and Slevin, D.P. (1975a) *Implementing operations research/management science*. American Elsevier Pub. Co.

Schultz, R.L. and Slevin, D.P. (1975b) Implementation and management innovation, *Implementing operations research/management science*, pp. 14-15: American Elsevier Publishing Company New York.

Schultz, R.L., Slevin, D.P. and Pinto, J.K. (1987) Strategy and tactics in a process model of project implementation. *Interfaces*, **17**(3), 34-46.

Sebestyen, Z. (2017) Further considerations in project success. *Procedia engineering*, **196**, 571-577.

Serrador, P. and Turner, R. (2015) The relationship between project success and project efficiency. *Project management journal*, **46**(1), 30-39.

Shenhar, A., Levy, O. and Dvir, D. (1997) Mapping the dimensions of project success. *Project management journal*, **28**(2), 5-13.

Shenhar, A.J. (2001) One size does not fit all projects: Exploring classical contingency domains. *Management science*, **47**(3), 394-414.

Shenhar, A.J. and Dvir, D. (1996) Toward a typological theory of project management. *Research Policy*, **25**(4), 607-632.

Shenhar, A.J. and Dvir, D. (2007) Project management research—The challenge and opportunity. *Project management journal*, **38**(2), 93-99.

Shenhar, A.J., Dvir, D., Levy, O. and Maltz, A.C. (2001) Project success: a multidimensional strategic concept. *Long range planning*, **34**(6), 699-725.

Shenhar, A.J., Tishler, A., Dvir, D., Lipovetsky, S. and Lechler, T. (2002) Refining the search for project success factors: a multivariate, typological approach. *R&D Management*, **32**(2), 111-126.

Slevin, D.P. and Pinto, J.K. (1986) The project implementation profile: new tool for project managers. *In*. Project Management Institute.

Slevin, D.P. and Pinto, J.K. (1987) Balancing strategy and tactics in project implementation. *Sloan management review*, **29**(1), 33-41.

Slevin, D.P. and Pinto, J.K. (1991) Project leadership: understanding and consciously choosing your style. *In*. Project Management Institute.

Sosa, M., Gargiulo, M. and Rowles, C. (2007) Component connectivity, team network structure and the attention to technical interfaces in complex product development. *INSEAD Business School Research Paper*(2007/68).

Stake, R.E. (1978) The case study method in social inquiry. *Educational researcher*, **7**(2), 5-8.

Tah, J. and Carr, V. (2001) Knowledge-based approach to construction project risk management. *Journal of computing in civil engineering*, **15**(3), 170-177.

Tashakkori, A. (2009) Are we there yet? The state of the mixed methods community. In: SAGE Publications Sage CA: Los Angeles, CA.

Teddlie, C. and Tashakkori, A. (2011) Mixed methods research. *The Sage handbook of qualitative research*, **4**, 285-300.

Thomas, G. and Fernández, W. (2008) Success in IT projects: A matter of definition? *International journal of project management*, **26**(7), 733-742.

Tishler, A., Dvir, D., Shenhar, A. and Lipovetsky, S. (1996) Identifying critical success factors in defense development projects: A multivariate analysis. *Technological forecasting and social change*, **51**(2), 151-171.

Tongco, M.D.C. (2007) Purposive sampling as a tool for informant selection. *Ethnobotany Research and applications*, **5**, 147-158.

Toole, T.M. (2005) A project management causal loop diagram. Department of Civil & Environmental Engineering Bucknell University, Lewisburg, PA. *In*, *arcom Conference*, 5-7.

Tsiga, Z., Emes, M. and Smith, A. (2016) Critical success factors for the construction industry. *PM World Journal*, **5**(8), 1-12.

Tsiga, Z., Emes, M. and Smith, A. (2017) Critical success factors for projects in the petroleum industry. *Procedia Computer Science*, **121**, 224-231.

Tukel, O.I. and Rom, W.O. (2001) An empirical investigation of project evaluation criteria. *International Journal of Operations & Production Management*.

Turner, J.R. (2004) Five necessary conditions for project success. *International journal of project management*, **5**(22), 349-350.

Turner, J.R. and Cochrane, R.A. (1993) Goals-and-methods matrix: coping with projects with ill defined goals and/or methods of achieving them. *International journal of project management*, **11**(2), 93-102.

Turner, J.R. and Müller, R. (2003) On the nature of the project as a temporary organization. *International journal of project management*, **21**(1), 1-8.

Turner, J.R. and Müller, R. (2005) The project manager's leadership style as a success factor on projects: A literature review. *Project management journal*, **36**(2), 49-61.

Turner, J.R. and Müller, R. (2006) Choosing appropriate project managers: Matching their leadership style to the type of project. *In*. Project Management Institute.

Turner, R. and Zolin, R. (2012) Forecasting success on large projects: developing reliable scales to predict multiple perspectives by multiple stakeholders over multiple time frames. *Project management journal*, **43**(5), 87-99.

Turner, R., Zolin, R. and Remington, K. (2009) Monitoring the performance of complex projects from multiple perspectives over multiple time frames. *In, Proceedings of the 9th International Research Network of Project Management Conference*. IRNOP.

Van Niekerk, S. and Steyn, H. (2011) Defining'project success' for a complex project-The case of a nuclear engineering development. *South African Journal of Industrial Engineering*, **22**(1), 123-136.

VanWynsberghe, R. and Khan, S. (2007) Redefining case study. *International Journal of Qualitative Methods*, **6**(2), 80-94.

Wahlström, B. (2011) Organisational learning–reflections from the nuclear industry. *Safety science*, **49**(1), 65-74.

Walliman, N. (2005) *Your research project: a step-by-step guide for the first-time researcher*. Sage.

WANO (2013) *Performance objectives and criteria*. World Organisation of Nuclear Operators.

WANO (2017) *Excellence in Nuclear Project Management*. World Organisation of Nuclear Operators.

Wateridge, J. (1995) IT projects: a basis for success. *International journal of project management*, **13**(3), 169-172.

Watkins, J. (2008) Theses/Dissertations/Research Reports: a Practical guide for students to the preparation of written presentations of academic research. *Cape Town: Content Solutions*.

Welman, C., Kruger, F. and Mitchell, B. (2005) Research Methodology. Southern Africa. In: Oxford University Press.

Westerveld, E. (2003) The Project Excellence Model®: linking success criteria and critical success factors. *International journal of project management*, **21**(6), 411-418.

Wisker, G. (2007) *The postgraduate research handbook: Succeed with your MA, MPhil, EdD and PhD*. Macmillan International Higher Education.

WNA (2009) *Structuring Nuclear Projects for Success: An Analytic Framework*. World Nuclear Association.

Yin, R.K. (1981) The case study crisis: Some answers. *Administrative science quarterly*, **26**(1), 58-65.

Yin, R.K. (1994) Discovering the future of the case study. Method in evaluation research. *Evaluation practice*, **15**(3), 283-290.

Yin, R.K. (2003) Design and methods. *Case study research*, **3**.

Yin, R.K. (2009) Case study research: Design and methods 4th edition. *In, United States: Library of Congress Cataloguing-in-Publication Data*.

Young, T.L. (2007) *The handbook of project management: a practical guide to effective policies, techniques and processes*. Kogan Page Publishers.

Zwikael, O. (2008) Top management involvement in project management. *International Journal of Managing Projects in Business*.

Appendix A: Research Questionnaire

Appendix A: Research Questionnaire

Section A: Respondent Demographics

1. Gender

Male ○ Female ○

2. Work experience (in years)

0-5	5-10	10-15	15-20	20-25	> 25
○	○	○	○	○	○

3. Kindly indicate your Project Life Cycle Model (PLCM) stakeholder status?

Project initiator/System Engineer/Client	
Portfolio manager	
Programme manager	
Project manager	
Project coordinator	
Construction manager	
Construction supervisor	
Project engineer	
Design engineer	
Buyer	
Project accountant	
Project controller	
Project scheduler	
Quality (please specify QA or QC)	
Safety (please specify officer, manager or occupational hygiene)	
Other (please specify)	

4. Please indicate the Department in which you work.

Nuclear project management (please specify group)	
Plant engineering	
Nuclear engineering	
Procurement	
Finance	
Quality assurance	
Quality control	
Maintenance	
Safety	
Technical documentation and records management	
Other (please specify)	

5. Please indicate the project phase on which your response is based

Concept phase	
Definition phase	
Execution phase	
Finalisation phase	
Benefits realisation assessment phase	

Section B: Critical Success Factors as listed in the Project Implementation Profile (Ranking and Weighting)

The Researcher would like you to answer the following section based on your personal experience with regard to projects you were or are involved in (your role in the nuclear project lifecycle), as it relates to nuclear projects critical success factors. To this end, think of the last time that you were involved in a project or modification, and respond accordingly.

From your experience with nuclear projects and your own professional opinion, how do you rank the importance of each of the listed critical success factors from literature? Please rank the importance of the critical success factors that, in your opinion could improve project success at the nuclear power plant in South Africa.

	1. Not important at all; 2. Moderately important; 3. Important; 4. Very important;5. Absolutely critical.				
CSFs as listed in the PIP					
1. Project mission - Clearly defined goals	1 O	2 O	3 O	4 O	5 O
2. Top management support - Resources, authority and power for implementation	1 O	2 O	3 O	4 O	5 O
3. Schedule and plans - Detailed specification of implementation process	1 O	2 O	3 O	4 O	5 O
4. Client consultation - Communication with and consultation of all stakeholders	1 O	2 O	3 O	4 O	5 O
5. Personnel - Recruitment, selection, training of competent personnel	1 O	2 O	3 O	4 O	5 O
6. Technical tasks - Ability of the required technology and expertise	1 O	2 O	3 O	4 O	5 O
7. Client acceptance - Selling of the final product to the end users	1 O	2 O	3 O	4 O	5 O
8. Monitoring and feedback - Timely and comprehensive control	1 O	2 O	3 O	4 O	5 O
9. Communication - Provision of timely data to key players	1 O	2 O	3 O	4 O	5 O
10. Troubleshooting - Ability to handle unexpected problems	1 O	2 O	3 O	4 O	5 O

6. Rank the CSFs of the PIP in order of importance and assign a weight to each

Critical Success Factor (CSF)	Weighting in %
1. Project mission	
2. Top management support	
3. Schedule and plans	
4. Client consultation	
5. Personnel	
6. Technical tasks	
7. Client acceptance	
8. Monitoring and feedback	
9. Communication	
10. Troubleshooting	

Section C: Open-ended Questions and Responses

7. Looking at the CSFs of the PIP, which ones are applicable to a nuclear project?
8. Are there factors that influence nuclear project success but are not listed in the CSFs of the PIP?
9. What are the additional factors that you would consider important for inclusion in the implementation of nuclear projects?
10. What factors did you use to measure / determining the success of your project?
11. What were the challenges in determining critical success factors for nuclear projects?
12. How and when were critical success factors determined for your project and by whom?
13. What factors made your project a success?
14. What are the benefits of having critical success factors known for a nuclear project?
15. In your view, do all stakeholders understand the critical success factors and their role in ensuring a successful project?
16. Do you measure success at all the phases of the lifecycle? If so then how?
17. What difference did you identify between normal projects and nuclear projects?
18. Any other comments

Thank you for your participation in the survey. Your contribution to the improvement of the information available on critical success factors for projects undertaken at a nuclear power plant in South Africa is appreciated.

Appendix B: Cover Letter and Consent Form

Appendix B: Cover Letter and Consent Form

Good day,

My name is **Aretha Galetta** and, as part of my Master's Degree, I am researching the factors considered critical for the success of projects executed at a nuclear power plant in South Africa.

Over the years literature mainly focussed on time, cost and quality, also known as the triple constraint or 'iron triangle', as the main factors to be considered as important for project success. Since then, many other factors were considered by various authors with the most cited being the work of Pinto and Slevin in 1988 who produced the Project Implementation Profile (PIP) which expanded on the triple constraint and listed ten Critical Success Factors (CSF) to be considered toward project success.

The indication was that the success of projects can be improved if these factors were considered across the lifecycle of the project and they can be tailor-made to be specific to a particular industry. To this end, many studies have been conducted by various researchers to test these CSFs for specific industries; most notable the construction and IT industries. To date there is a lack of evidence supporting that a similar study was undertaken to test these in the nuclear industry. The aim of this research study, therefore, is to gain and understanding from various stakeholders of what will constitute CSFs for projects undertaken at a nuclear power plant in South African; testing if those listed in the PIP would suffice or if additional factors need to be included specifically for nuclear projects.

You, as a respondent in the nuclear project environment at the nuclear power plant in South Africa, can contribute to the understanding of the CSFs to be considered for nuclear projects. This can add value to the way nuclear projects are executed and contribute to improving the success rate of projects implemented at a nuclear power plant. Also note that by participating in this research study (survey), you will provide vital insight into successes can be enhanced in order for nuclear project success and its benefits to be realised.

Please note that your participation in this research is voluntary and all information will be treated as strictly confidential. The survey is anonymous hence, responses cannot be traced to any individual, so please do not write your name on the survey form. The information shared will only be used for this research study. You are welcome to withdraw from the survey at any time while completing it. There are no right or wrong answers to any question, as it is your opinion on each that matters, hence feel free to express your opinion, as this will be most helpful. Should you at any time and for any reason become uncomfortable to answer any question, you are welcome to either omit that question or withdraw from the research study completely.

If you would want to obtain the results of the survey or any additional information about the research study, you can contact me at gltwil001@myuct.ac.za. I will be happy to share the research results with you.

Before you start the survey; do you give consent that the information you share can be used for this research study?

YES ○

Appendix C: Ethics Clearance Form

Appendix C: Ethics Clearance Form

Application for Approval of Ethics in Research (EIR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

ETHICS APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. **Please ensure that you have read, and understood the EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		Wilhelmina Galetta
Department		Construction Management & Economics
Preferred email address of applicant:		galetta@eskom.co.za
If Student	Your Degree: e.g., MSc, PhD, etc.	MSc
	Credit Value of Research: e.g., 60/120/180/360 etc.	60
	Name of Supervisor (if supervised):	Ian Jay
If this is a researchcontract, indicate the source of funding/sponsorship		
Project Title		Critical Success factors: An analysis of some factors to nuclear power ability

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

APPLICATION BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Wilhelmina Galetta	Signature Removed	2019 [illegible]
SUPPORTED BY	**Full name**	**Signature**	**Date**
Supervisor (where applicable)	C.I. JAY	Signature Removed	16/09/2019

APPROVED BY	Full name	Signature	Date
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (including Honours).	NIEN-TSU TUAN	Signature Removed	30 Sept 2019
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the questions in Section 1.		Signature Removed	

Page 1 of 1

Appendix D: Unedited Data

Appendix D: Unedited Data

1. Welcome to the Survey!	1.1 Do you give consent	1.2 Gender	1.3 Work experience	1.4 PLCM stakeholder status?	1.5 Department in which you	1.6 Project Phase	2.1 Project Misssion	2.2. Top Management Support	2.3 Schedule and Plans	2.4 Client Consultation	2.5 Personnel	2.6 Technical tasks	2.7 Client Acceptance	2.8 Monitoring and feedback	2.9 Communication	2.10 Troubleshooting	4. Are there factors that influence	5. What are the additional	6. What were the challenges	7. How and when were critical	8. What critical success	9. What are the benefits of having	10.1 Do all stakeholders understand	10.2 Do you measure success at	10.3 If so, then how	11. What difference can you	11. Any other comments that you fe
Before you start t	Yes	Female	10-15	Project Admin	Execution	D. Definition P	3. Important	2. Moderately	4. Very import	4. Very import	4. Very import	3. Important	5. Absolutely	5. Absolutely	4. Very import	2. Moderately	Yes	-	- When the				Yes	No				N/a
Before you start t	Yes	Female	10-15	Assistant Offi	Quality Assuri	G. Post Projec	4. Very import	4. Very import	3. Important	3. Important	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	3. Important	Yes			- The Project	- All relevant	- The goal has	- No, because	No	N/a	Nuclear		
Before you start t	Yes	Male	>25	14. Quality (pl	Quality Assuri	C. Concept Ph	1. Not importa	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import	4. Very import	3. Important	4. Very import	3. Important	Yes					- You know	No	Yes		Regulatory	Experience
Before you start t	Yes	Male	20-25	3. Programme	Strategic proj	E. Execution P	5. Absolutely	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	3. Important	Yes		- Project			- You can	Not all	Yes	By evaluating		
Before you start t	Yes	Male	20-25	3. Programme	PDD and NP M	D. Definition P	3. Important	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	Yes		- Should be			- Provides	- Not always,	Yes	KPIs aligned	Nuclear	
Before you start t	Yes	Male	>25	3. Programme	Contracts Man	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	3. Important	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	Yes		Contracts			Support	No	Yes	By using the	Additional	
Before you start t	Yes	Male	20-25	5. Project lead	Construction I	E. Execution P	5. Absolutely	5. Absolutely	4. Very import	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	3. Important	Yes	Costruction	Plant	At the start		They ensure	N/a	No			
Before you start t	Yes	Female	15-20	4. Project man	Strategic proj	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	Yes			During the	All 10 CSFs	Implement	Yes	Yes	Project status	Nuclear	Please
Before you start t	Yes	Female	20-25	Commercial	Supplier Deve	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	Yes		Upfront	At the		Cost savings	Mostly	No			Better
Before you start t	Yes	Male	>25	5. Project lead	Execution	C. Concept Ph	3. Important	5. Absolutely	4. Very import	4. Very import	3. Important	2. Moderately	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	Yes		Communicati	Using key	Client	Standardisati	Yes	No		The	None
Before you start t	Yes	Female	10-15	4. Project man	8. Maintenanc	E. Execution P	3. Important	4. Very import	4. Very import	4. Very import	4. Very import	3. Important	4. Very import	4. Very import	5. Absolutely	5. Absolutely	Yes			At the initial		It provides	Yes, if this is	No	This is not	Nuclear	None
Before you start t	Yes	Male	5-10	5. Project lead	Strategic Proj	E. Execution P	4. Very import	5. Absolutely	5. Absolutely	4. Very import	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	3. Important	Yes		None	By	Top	Everyone	Not always	Yes	By breaking	The safety	
Before you start t	Yes	Female	20-25	5. Project lead	6. Quality assu	E. Execution P	4. Very import	5. Absolutely	4. Very import	4. Very import	3. Important	3. Important	5. Absolutely	4. Very import	4. Very import	4. Very import	Yes		Team	By the		To deliver	No	Yes	By doing	Nuclear	Not at this
Before you start t	Yes	Male	>25	3. Programme	SGR Project	E. Execution P	3. Important	3. Important	4. Very import	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import	4. Very import			-	N/A - Each	A good	Allows to	No	No		The	A good
Before you start t	Yes	Female	10-15	5. Project lead	Execution	E. Execution P	3. Important	2. Moderately	5. Absolutely	4. Very import	4. Very import	3. Important	3. Important	4. Very import	3. Important	3. Important	Yes	Decision mak	Sticking to	Determined	Contractor	There is	No	Yes	By reviewing	Conventional	No
Before you start t	Yes	Male	20-25	3. Programme	SGR	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import			Experienced	During		Alignment of	No	No	N/a	Duration of	None
Before you start t	Yes	Male	15-20	14. Quality (pl	Construction	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	3. Important	4. Very import	2. Moderately	5. Absolutely	3. Important	5. Absolutely	1. Not importa	Yes	Quality	Not	Using the key	Understandin	A more	Not always	No	N/a	The codes	None
Before you start t	Yes	Male	15-20	4. Project man	SGR	E. Execution P	5. Absolutely	4. Very import	5. Absolutely	4. Very import	3. Important	4. Very import	5. Absolutely	4. Very import	4. Very import	3. Important			Bureaucracy	By		Clear roles	Often not the	Yes	Using the	Safety	Awareness
Before you start t	Yes	Female	15-20	13. Project sch	Monitoring an	E. Execution P	5. Absolutely	3. Important	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import				by	Planning and	Decrease the	Yes	No	Entire PLCM		If CSFs
Before you start t	Yes	Female	5-10	14. Quality (pl	Quality Assur	E. Execution P	5. Absolutely	5. Absolutely	4. Very import	4. Very import	3. Important	3. Important	5. Absolutely	4. Very import	4. Very import	4. Very import	Yes			Standardised		Having a	No	No			None
Before you start t	Yes	Male	>25	16. Other (ple	Radiation Prot	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	Yes		Various	We work to	Good	To use as OE	Yes	No		With the	I feel that at
Before you start t	Yes	Male	>25	4. Project man	Monitoring an	C. Concept Ph	4. Very import	4. Very import	2. Moderately	4. Very import	3. Important	3. Important	4. Very import	3. Important	3. Important	4. Very import			Evaluate	CSF were	Performing a	It would	No.	Yes		Difference	- Adequate
Before you start t	Yes	Female	5-10	5. Project lead	Execution	E. Execution P	2. Moderately	3. Important	5. Absolutely	2. Moderately	5. Absolutely	1. Not importa	5. Absolutely	3. Important	5. Absolutely	4. Very import			Ignorance to	Using the		Knowledge	Not quite	No		The	Stakeholders
Before you start t	Yes	Female	20-25	3. Programme	Nuclear Safet	E. Execution P	3. Important	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	3. Important	5. Absolutely	4. Very import	3. Important	4. Very import	Yes		N/a	At the start	Cross	All groups	No	Yes	Through	Additional	Develop
Before you start t	Yes	Female	15-20	4. Project man	Execution	D. Definition P	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	3. Important	4. Very import	4. Very import	4. Very import	5. Absolutely	5. Absolutely			Miscommuni				Sometimes	Yes			
Before you start t	Yes	Male	>25	Planning Mana	Planning	D. Definition P	4. Very import	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import			Commercial	Was		A succesfull	No	Yes	Ensure that	The	Align the
Before you start t	Yes	Male	>25	Outage Execut	Outage Contr	E. Execution P	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely				Before the	Understandin	Quality is	I believe	Yes		For nuclear	Based on the
Before you start t	Yes	Male	>25	14. Quality (pl	Quality Assur	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	Yes		Miscommuni	Using OE,	Personnel	Adequate	There seems	Yes	In the quality	Nuclear	
Before you start t	Yes	Female	0-5	16. Other (ple	Construction !	E. Execution P	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	3. Important	Yes		Skilled	Proper		- Compliance	Yes	Yes			Comprehensi
Before you start t	Yes	Male	5-10	7. Constructio	Construction	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	Yes	Strong	Decision	Project	Effective	Successful	I highly	Yes	Through	Full risk	Full
Before you start t	Yes	Male	15-20	11. Project acc	5. Finance	D. Definition P	4. Very import	3. Important	4. Very import	3. Important	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	3. Important	Yes			At the start	Communicati		Not always	Yes	Measure by		Communicati
Before you start t	Yes	Male	15-20	6. Constructio	Construction	E. Execution P	3. Important	4. Very import	3. Important	3. Important	4. Very import	3. Important	4. Very import	4. Very import	5. Absolutely	5. Absolutely	Yes		Making it	Determined	Focussing on	Consistency	No	Yes	Through	- The level of	If I had to
Before you start t	Yes	Male	5-10	QC	Construction	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	3. Important	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	Yes	Client		At project	Having Client	For OE	No	Yes	When it gets	Conventional	
Before you start t	Yes	Female	10-15	2. Portfolio ma	NP MO	C. Concept Ph	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	3. Important	3. Important	5. Absolutely	5. Absolutely	5. Absolutely	2. Moderately			None	From	Earn Value		No	Yes	Ensure that	There are	Commercial
Before you start t	Yes	Male	10-15	QC	Construction	E. Execution P	3. Important	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	4. Very import	Yes	Quality	Not all	Using the		A quallity	Yes	No		There are	None
Before you start t	Yes	Male	>25	1.Project initia	3. Nuclear eng	C. Concept Ph	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	4. Very import	5. Absolutely	4. Very import	5. Absolutely	4. Very import	5. Absolutely				Not sure		Focus on	Yes, when	Yes	Monthly	RD0034	No
Before you start t	Yes	Male	>25	Materials SME	3. Nuclear eng	E. Execution P	3. Important	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	5. Absolutely		- NNR						No			
Before you start t	Yes	Female	10-15	4. Project man	Quality Engin	D. Definition P	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Male	20-25	4. Project man	NP MO	D. Definition P	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	4. Very import	3. Important	5. Absolutely	3. Important	5. Absolutely	4. Very import								No			
Before you start t	Yes	Female	15-20	3. Programme	Project Devel	D. Definition P	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import	5. Absolutely		Strategic		The project				Yes			
Before you start t	Yes	Male	15-20	5. Project lead	Construction	E. Execution P	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	4. Very import	3. Important	5. Absolutely	4. Very import	5. Absolutely								No			
Before you start t	Yes	Male	>25	8. Project engi	Project Engine	E. Execution P	5. Absolutely	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	Fundament							No			
Before you start t	Yes	Male	20-25	4. Project man	Contracts Man	D. Definition P	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	3. Important	3. Important	5. Absolutely	4. Very import	3. Important	3. Important								No			
Before you start t	Yes	Male	10-15	5. Project lead	Monitoring an	E. Execution P	4. Very import	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	4. Very import	4. Very import								Yes			
Before you start t	Yes	Female	15-20	3. Programme	Project Devel	C. Concept Ph	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import	5. Absolutely	4. Very import	4. Very import								Yes			
Before you start t	Yes	Male	15-20	1.Project initia	2. Plant engin	C. Concept Ph	5. Absolutely	3. Important	4. Very import	3. Important	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import	5. Absolutely								No			
Before you start t	Yes	Male	5-10	13. Project sch	SGR Office	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely								Yes			The amount
Before you start t	Yes	Male	10-15	Safety Officer	Nuclear Servic	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	3. Important	3. Important	4. Very import		nuclear						Yes			
Before you start t	Yes	Female	10-15	Radiological W	Radiation Prot	E. Execution P	5. Absolutely	3. Important	4. Very import	3. Important	4. Very import	5. Absolutely	4. Very import	3. Important	3. Important	4. Very import								Yes			
Before you start t	Yes	Male	10-15	7. Constructio	Construction	E. Execution P	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import								No			
Before you start t	Yes	Male	15-20	4. Project man	8. Maintenanc	E. Execution P	4. Very import	4. Very import	5. Absolutely	3. Important	4. Very import	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import								No			
Before you start t	Yes	Female	5-10	Safety Officer	Construction	E. Execution P	3. Important	5. Absolutely	4. Very import	5. Absolutely	3. Important	3. Important	4. Very import	3. Important	3. Important	5. Absolutely					Operational			Yes			
Before you start t	Yes	Female	0-5	Safety Officer	Construction	E. Execution P	3. Important	5. Absolutely	4. Very import	5. Absolutely	3. Important	3. Important	4. Very import	3. Important	4. Very import	5. Absolutely					Base on the			No			
Before you start t	Yes	Female	0-5	Safety Officer	Construction	E. Execution P	3. Important	5. Absolutely	4. Very import	3. Important	4. Very import	3. Important	4. Very import	3. Important	4. Very import	4. Very import								Yes			
Before you start t	Yes	Female	10-15	Radiation Prot	Radiation Prot	E. Execution P	4. Very import	3. Important	4. Very import	4. Very import	5. Absolutely	5. Absolutely	3. Important	4. Very import	4. Very import	3. Important								Yes			
Before you start t	Yes	Male	15-20	QA	6. Quality assu	G. Post Projec	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	4. Very import	3. Important	3. Important	3. Important								Yes			
Before you start t	Yes	Male	20-25	5. Project lead	Construction	E. Execution P	4. Very import	5. Absolutely	5. Absolutely	4. Very import	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import								Yes			
Before you start t	Yes	Male	5-10	Occupational	Nuclear Servic	E. Execution P	4. Very import	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	3. Important	5. Absolutely	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Female	5-10	7. Constructio	Construction	E. Execution P	4. Very import	3. Important	4. Very import	3. Important	3. Important	3. Important	4. Very import	3. Important	3. Important	4. Very import								Yes			
Before you start t	Yes	Male	5-10	9. Design engi	3. Nuclear eng	D. Definition P	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import					-Project			Yes			
Before you start t	Yes	Female	10-15	5. Project lead	Outage Contr	E. Execution P	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Female	0-5	4. Project man	Execution	D. Definition P	5. Absolutely	4. Very import	5. Absolutely	4. Very import	5. Absolutely	4. Very import	5. Absolutely	4. Very import	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Male	0-5	1.Project initia	System Engin	C. Concept Ph	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Female	10-15	7. Constructio	Construction	E. Execution P	3. Important	5. Absolutely	4. Very import	4. Very import	4. Very import	5. Absolutely	4. Very import	4. Very import	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Female	5-10	Construcion St	Construction !	E. Execution P	3. Important	4. Very import	3. Important	4. Very import	4. Very import	4. Very import	4. Very import	4. Very import	5. Absolutely	5. Absolutely								No			- Most of the
Before you start t	Yes	Male	15-20	5. Project lead	Construction	E. Execution P	5. Absolutely	4. Very import	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import								Yes			
Before you start t	Yes	Female	20-25	Commercial	Front end plan	D. Definition P	5. Absolutely	4. Very import	5. Absolutely	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import								No			
Before you start t	Yes	Male	>25	3. Programme	Execution	D. Definition P	4. Very import	4. Very import	5. Absolutely	5. Absolutely	4. Very import	4. Very import	5. Absolutely	5. Absolutely	5. Absolutely	4. Very import								Yes			

Appendix E: DATA ANALYSIS TABLES AND FIGURES

Appendix E: Data Analysis - Tables and Figures

Table 4.1: Gender

		Data	
1.2 Gender	1.3 Work experie	Count of 1.2	% Total
Female	0-5	4	5.9%
Female	10-15	10	14.7%
Female	15-20	5	7.4%
Female	20-25	4	5.9%
Female	5-10	5	7.4%
Female Total		**28**	**41.18%**
Male	>25	13	19.1%
Male	0-5	1	1.5%
Male	10-15	4	5.9%
Male	15-20	9	13.2%
Male	20-25	7	10.3%
Male	5-10	6	8.8%
Male Total		**40**	**58.82%**
Grand Total		**68**	**100.00%**

Table 4.2: Work Experience

Count of 1.3 Work experience (in years)	1.3 Work						
1.4 PLCM stakeholder	>25	0-5	10-15	15-20	20-25	5-10	Grand Total
2. Portfolio Manager				1			**1**
6. Construction Manager					1		**1**
8. Project Engineer		1					**1**
10. Outage Execution Manager		1					**1**
11. Design Engineer						1	**1**
12. Contract Manager		1					**1**
13. Project Scheduler					1	1	**2**
16. Radiation Protection Advisor				1			**1**
16. Radiation Protection Manager				1			**1**
16. Radiation Protection Monitor		1					**1**
17. Materials SME		1					**1**
18. Commercial Manager						1	**1**
18. Project Accountant					1		**1**
17. Safety Manager					1	1	**2**
8. Quality Controller				1	1	1	**3**
1. System Engineer		1	1		1		**3**
9. Quality Assurance Officer		2			1	1	**4**
7. Project Administrator		1		2		1	**4**
10. Construction Safety Officer			3	1		2	**6**
3. Programme Manager		2			2	4	**8**
4. Project Manager		2	1	2	4	2	**11**
5. Project Coordinator				5	1	3	4 **13**
Grand Total		**13**	**5**	**14**	**14**	**11**	**11** **68**

Table 4.3: PLCM Stakeholder Status

1.4 PLCM stakeholder	Data Count of 1.4	% Total	% Accum.
2. Portfolio Manager	1	1.47%	1.47%
6. Construction Manager	1	1.47%	2.94%
8. Project Engineer	1	1.47%	4.41%
10. Outage Execution Manager	1	1.47%	5.88%
11. Design Engineer	1	1.47%	7.35%
12. Contract Manager	1	1.47%	8.82%
13. Project Scheduler	2	2.94%	11.76%
16. Radiation Protection Advisor	1	1.47%	13.24%
16. Radiation Protection Manager	1	1.47%	14.71%
16. Radiation Protection Monitor	1	1.47%	16.18%
17. Materials SME	1	1.47%	17.65%
18. Commercial Manager	1	1.47%	19.12%
18. Project Accountant	1	1.47%	20.59%
17. Safety Manager	2	2.94%	23.53%
8. Quality Controller	3	4.41%	27.94%
1. System Engineer	3	4.41%	32.35%
9. Quality Assurance Officer	4	5.88%	38.24%
7. Project Administrator	4	5.88%	44.12%
10. Construction Safety Officer	6	8.82%	52.94%
3. Programme Manager	8	11.76%	64.71%
4. Project Manager	11	16.18%	80.88%
5. Project Coordinator	13	19.12%	100.00%
Grand Total	**68**	**100.00%**	

Table 4.4: Department

1.5 Department	Data Count of 1.4 PLCM stakeholder	% Total	% Accum.
5. Finance	1	1.47%	1.47%
14. Commercial Management	1	1.47%	2.94%
15. Monitoring and Support	1	1.47%	4.41%
10. Outage	2	2.94%	7.35%
12. Plant Engineering	2	2.94%	10.29%
13. Nuclear Services OH&S	2	2.94%	13.24%
16. Project Development	2	2.94%	16.18%
8. Maintenance	2	2.94%	19.12%
9. Nuclear PMO	3	4.41%	23.53%
7. Contracts Management	3	4.41%	27.94%
11. Radiation Protection	3	4.41%	32.35%
3. Nuclear Engineering	4	5.88%	38.24%
6. Quality Management	6	8.82%	47.06%
2. Complex Projects Execution	7	10.29%	57.35%
4. Construction Management	14	20.59%	77.94%
1. Standard Project Execution	15	22.06%	100.00%
Grand Total	**68**	**100.00%**	

Table 4.5: Project Lifecycle Phase

1.6 Project Phase	Data Count of 1.4	% Total	%Accum.
G. Post Project Phase	2	2.94%	2.94%
C. Concept Phase	8	11.76%	14.71%
D. Definition Phase	13	19.12%	33.82%
E. Execution Phase	45	66.18%	100.00%
Grand Total	**68**	**100.00%**	

Table 4.8: Project Mission - Overall Picture

2.1 Project Misssion	Count of Rating	% Total	% Accum.
1. Not important at all	1	1.5%	1.5%
2. Moderately important	1	1.5%	2.9%
3. Important	15	22.1%	25.0%
4. Very important	17	25.0%	50.0%
5. Absolutely critical	34	50.0%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.9: Project Mission - Results per stakeholder status

2.1 Project Misssion	1.4 PLCM stakeholder	Data Count of Rating	% Total	%Accum per Stak.
1. Not important at all	9. Quality Assurance Officer	1	1.5%	100.00%
1. Not important at all Total		**1**	**1.47%**	
2. Moderately important	5. Project Coordinator	1	1.5%	100.00%
2. Moderately important Total		**1**	**1.47%**	
3. Important	17. Materials SME	1	1.5%	6.67%
3. Important	6. Construction Manager	1	1.5%	13.33%
3. Important	8. Quality Controller	1	1.5%	20.00%
3. Important	5. Project Coordinator	2	2.9%	33.33%
3. Important	7. Project Administrator	2	2.9%	46.67%
3. Important	3. Programme Manager	3	4.4%	66.67%
3. Important	10. Construction Safety Officer	4	5.9%	93.33%
3. Important	4. Project Manager	1	1.5%	100.00%
3. Important Total		**15**	**22.06%**	
4. Very important	2. Portfolio Manager	1	1.5%	5.88%
4. Very important	10. Outage Execution Manager	1	1.5%	11.76%
4. Very important	16. Radiation Protection Advisor	1	1.5%	17.65%
4. Very important	17. Safety Manager	1	1.5%	23.53%
4. Very important	18. Project Accountant	1	1.5%	29.41%
4. Very important	5. Project Coordinator	6	8.8%	64.71%
4. Very important	7. Project Administrator	1	1.5%	70.59%
4. Very important	3. Programme Manager	1	1.5%	76.47%
4. Very important	10. Construction Safety Officer	1	1.5%	82.35%
4. Very important	4. Project Manager	3	4.4%	100.00%
4. Very important Total		**17**	**25.00%**	
5. Absolutely critical	8. Project Engineer	1	1.5%	2.94%
5. Absolutely critical	11. Design Engineer	1	1.5%	5.88%
5. Absolutely critical	12. Contract Manager	1	1.5%	8.82%
5. Absolutely critical	16. Radiation Protection Manager	1	1.5%	11.76%
5. Absolutely critical	16. Radiation Protection Monitor	1	1.5%	14.71%
5. Absolutely critical	17. Safety Manager	1	1.5%	17.65%
5. Absolutely critical	18. Commercial Manager	1	1.5%	20.59%
5. Absolutely critical	8. Quality Controller	2	2.9%	26.47%
5. Absolutely critical	13. Project Scheduler	2	2.9%	32.35%
5. Absolutely critical	9. Quality Assurance Officer	3	4.4%	41.18%
5. Absolutely critical	1. System Engineer	3	4.4%	50.00%
5. Absolutely critical	5. Project Coordinator	4	5.9%	61.76%
5. Absolutely critical	7. Project Administrator	1	1.5%	64.71%
5. Absolutely critical	3. Programme Manager	4	5.9%	76.47%
5. Absolutely critical	10. Construction Safety Officer	1	1.5%	79.41%
5. Absolutely critical	4. Project Manager	7	10.3%	100.00%
5. Absolutely critical Total		**34**	**50.00%**	
Grand Total		**68**	**100.00%**	

Table 4.10: Project Mission - Results per project phase

2.1 Project Misssion	1.6 Project Phase2	Count of Rating	% Total	% Accum.
1. Not important at all	C. Concept Phase	1	1.5%	100.00%
1. Not important at all Total		**1**	**1.47%**	
2. Moderately important	E. Execution Phase	1	1.5%	100.00%
2. Moderately important Total		**1**	**1.47%**	
3. Important	C. Concept Phase	1	1.5%	6.67%
3. Important	D. Definition Phase	2	2.9%	20.00%
3. Important	E. Execution Phase	12	17.6%	100.00%
3. Important Total		**15**	**22.06%**	
4. Very important	G. Post Project Phase	1	1.5%	5.88%
4. Very important	C. Concept Phase	2	2.9%	17.65%
4. Very important	D. Definition Phase	1	1.5%	23.53%
4. Very important	E. Execution Phase	13	19.1%	100.00%
4. Very important Total		**17**	**25.00%**	
5. Absolutely critical	G. Post Project Phase	1	1.5%	2.94%
5. Absolutely critical	C. Concept Phase	3	4.4%	11.76%
5. Absolutely critical	D. Definition Phase	6	8.8%	29.41%
5. Absolutely critical	E. Execution Phase	24	35.3%	100.00%
5. Absolutely critical Total		**34**	**50.00%**	
Grand Total		**68**	**100.00%**	

Table 4.11: Top management support - Overall result

2.2. Top Management Suppo	Data Count of Rating	% Total	% Accum.
2. Moderately important	2	2.94%	2.94%
3. Important	6	8.82%	11.76%
4. Very important	19	27.94%	39.71%
5. Absolutely critical	41	60.29%	100.00%
Grand Total	**68**	**100.00%**	

Table 4.12: Top management support - Results per stakeholder

2.2. Top Management Support	1.4 PLCM stakeholder	Data Count of Rating	% Total	%Accum.
2. Moderately important	5. Project Coordinator	1	1.47%	7.69%
2. Moderately important	7. Project Administrator	1	1.47%	25.00%
2. Moderately important Total		**2**	**2.94%**	**2.94%**
3. Important	3. Programme Manager	1	1.47%	12.50%
3. Important	5. Project Coordinator	1	1.47%	15.38%
3. Important	13. Project Scheduler	1	1.47%	50.00%
3. Important	16. Radiation Protection Advis	1	1.47%	100.00%
3. Important	16. Radiation Protection Mana	1	1.47%	100.00%
3. Important	18. Project Accountant	1	1.47%	100.00%
3. Important Total		**6**	**8.82%**	**11.76%**
4. Very important	1. System Engineer	1	1.47%	33.33%
4. Very important	3. Programme Manager	3	4.41%	50.00%
4. Very important	4. Project Manager	6	8.82%	54.55%
4. Very important	5. Project Coordinator	1	1.47%	23.08%
4. Very important	6. Construction Manager	1	1.47%	100.00%
4. Very important	7. Project Administrator	1	1.47%	50.00%
4. Very important	8. Quality Controller	1	1.47%	33.33%
4. Very important	10. Construction Safety Office	2	2.94%	33.33%
4. Very important	17. Materials SME	1	1.47%	100.00%
4. Very important	17. Safety Manager	1	1.47%	50.00%
4. Very important	18. Commercial Manager	1	1.47%	100.00%
4. Very important Total		**19**	**27.94%**	**39.71%**
5. Absolutely critical	1. System Engineer	2	2.94%	100.00%
5. Absolutely critical	2. Portfolio Manager	1	1.47%	100.00%
5. Absolutely critical	3. Programme Manager	4	5.88%	100.00%
5. Absolutely critical	4. Project Manager	5	7.35%	100.00%
5. Absolutely critical	5. Project Coordinator	10	14.71%	100.00%
5. Absolutely critical	7. Project Administrator	2	2.94%	100.00%
5. Absolutely critical	8. Project Engineer	1	1.47%	100.00%
5. Absolutely critical	8. Quality Controller	2	2.94%	100.00%
5. Absolutely critical	9. Quality Assurance Officer	4	5.88%	100.00%
5. Absolutely critical	10. Construction Safety Office	4	5.88%	100.00%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	100.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	100.00%
5. Absolutely critical	12. Contract Manager	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	1	1.47%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	17. Safety Manager	1	1.47%	100.00%
5. Absolutely critical Total		**41**	**60.29%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.13: Top management support - Results per project phase

2.2. Top Management Support	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
2. Moderately important	D. Definition Phase	1	1.47%	50.00%
2. Moderately important	E. Execution Phase	1	1.47%	100.00%
2. Moderately important Total		**2**	**2.94%**	
3. Important	E. Execution Phase	6	8.82%	100.00%
3. Important Total		**6**	**8.82%**	
4. Very important	G. Post Project Phase	1	1.47%	5.26%
4. Very important	C. Concept Phase	3	4.41%	21.05%
4. Very important	D. Definition Phase	4	5.88%	42.11%
4. Very important	E. Execution Phase	11	16.18%	100.00%
4. Very important Total		**19**	**27.94%**	
5. Absolutely critical	G. Post Project Phase	1	1.47%	2.44%
5. Absolutely critical	C. Concept Phase	4	5.88%	12.20%
5. Absolutely critical	D. Definition Phase	4	5.88%	21.95%
5. Absolutely critical	E. Execution Phase	32	47.06%	100.00%
5. Absolutely critical Total		**41**	**60.29%**	
Grand Total		**68**	**100.00%**	

Table 4.14: Schedule and plans - Overall result

2.3 Schedule and Plans	Data Count of Rating	% Total	%Accum.
2. Moderately important	1	1.5%	1.5%
3. Important	6	8.8%	10.3%
4. Very important	24	35.3%	45.6%
5. Absolutely critical	37	54.4%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.15: Schedule and plans – Results per stakeholder

2.3 Schedule and Plans	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
2. Moderately important	4. Project Manager	1	1.47%	9.09%
2. Moderately important Total		**1**	**1.47%**	**1.47%**
3. Important	1. System Engineer	1	1.47%	33.33%
3. Important	5. Project Coordinator	1	1.47%	7.69%
3. Important	6. Construction Manager	1	1.47%	100.00%
3. Important	7. Project Administrator	1	1.47%	25.00%
3. Important	10. Construction Safety Office	2	2.94%	33.33%
3. Important Total		**6**	**8.82%**	**10.29%**
4. Very important	1. System Engineer	1	1.47%	66.67%
4. Very important	3. Programme Manager	5	7.35%	62.50%
4. Very important	4. Project Manager	4	5.88%	45.45%
4. Very important	5. Project Coordinator	3	4.41%	30.77%
4. Very important	7. Project Administrator	2	2.94%	75.00%
4. Very important	8. Project Engineer	1	1.47%	100.00%
4. Very important	8. Quality Controller	1	1.47%	33.33%
4. Very important	10. Construction Safety Office	3	4.41%	83.33%
4. Very important	16. Radiation Protection Advis	1	1.47%	100.00%
4. Very important	16. Radiation Protection Mana	1	1.47%	100.00%
4. Very important	17. Materials SME	1	1.47%	100.00%
4. Very important	18. Project Accountant	1	1.47%	100.00%
4. Very important Total		**24**	**35.29%**	**45.59%**
5. Absolutely critical	1. System Engineer	1	1.47%	100.00%
5. Absolutely critical	2. Portfolio Manager	1	1.47%	100.00%
5. Absolutely critical	3. Programme Manager	3	4.41%	100.00%
5. Absolutely critical	4. Project Manager	6	8.82%	100.00%
5. Absolutely critical	5. Project Coordinator	9	13.24%	100.00%
5. Absolutely critical	7. Project Administrator	1	1.47%	100.00%
5. Absolutely critical	8. Quality Controller	2	2.94%	100.00%
5. Absolutely critical	9. Quality Assurance Officer	4	5.88%	100.00%
5. Absolutely critical	10. Construction Safety Office	1	1.47%	100.00%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	100.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	100.00%
5. Absolutely critical	12. Contract Manager	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	2	2.94%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	17. Safety Manager	2	2.94%	100.00%
5. Absolutely critical	18. Commercial Manager	1	1.47%	100.00%
5. Absolutely critical Total		**37**	**54.41%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.16: Schedule and plans - Results per project phase

2.3 Schedule and Plans	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
2. Moderately important	C. Concept Phase	1	1.47%	100.00%
2. Moderately important Total		**1**	**1.47%**	
3. Important	G. Post Project Phase	1	1.47%	16.67%
3. Important	C. Concept Phase	1	1.47%	33.33%
3. Important	E. Execution Phase	4	5.88%	100.00%
3. Important Total		**6**	**8.82%**	
4. Very important	C. Concept Phase	3	4.41%	12.50%
4. Very important	D. Definition Phase	3	4.41%	25.00%
4. Very important	E. Execution Phase	18	26.47%	100.00%
4. Very important Total		**24**	**35.29%**	
5. Absolutely critical	G. Post Project Phase	1	1.47%	2.70%
5. Absolutely critical	C. Concept Phase	2	2.94%	8.11%
5. Absolutely critical	D. Definition Phase	6	8.82%	24.32%
5. Absolutely critical	E. Execution Phase	28	41.18%	100.00%
5. Absolutely critical Total		**37**	**54.41%**	
Grand Total		**68**	**100.00%**	

Table 4.17: Client consultation - Overall result

2.4 Client Consultation	Data Count of Rating	% Total	% Accum.
2. Moderately important	1	1.47%	1.47%
3. Important	6	8.82%	10.29%
4. Very important	31	45.59%	55.88%
5. Absolutely critical	30	44.12%	100.00%
Grand Total	**68**	**100.00%**	

Table 4.18: Client consultation - Results per stakeholder

2.4 Client Consultation	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
2. Moderately important	5. Project Coordinator	1	1.47%	7.69%
2. Moderately important Total		**1**	**1.47%**	**1.47%**
3. Important	4. Project Manager	1	1.47%	9.09%
3. Important	6. Construction Manager	1	1.47%	100.00%
3. Important	7. Project Administrator	1	1.47%	25.00%
3. Important	8. Quality Controller	1	1.47%	33.33%
3. Important	16. Radiation Protection Mana	1	1.47%	100.00%
3. Important	18. Project Accountant	1	1.47%	100.00%
3. Important Total		**6**	**8.82%**	**10.29%**
4. Very important	1. System Engineer	2	2.94%	66.67%
4. Very important	3. Programme Manager	3	4.41%	37.50%
4. Very important	4. Project Manager	4	5.88%	45.45%
4. Very important	5. Project Coordinator	8	11.76%	69.23%
4. Very important	7. Project Administrator	2	2.94%	75.00%
4. Very important	8. Project Engineer	1	1.47%	100.00%
4. Very important	8. Quality Controller	1	1.47%	66.67%
4. Very important	9. Quality Assurance Officer	1	1.47%	25.00%
4. Very important	10. Construction Safety Office	4	5.88%	66.67%
4. Very important	12. Contract Manager	1	1.47%	100.00%
4. Very important	16. Radiation Protection Advis	1	1.47%	100.00%
4. Very important	17. Materials SME	1	1.47%	100.00%
4. Very important	17. Safety Manager	2	2.94%	100.00%
4. Very important Total		**31**	**45.59%**	**55.88%**
5. Absolutely critical	1. System Engineer	1	1.47%	100.00%
5. Absolutely critical	2. Portfolio Manager	1	1.47%	100.00%
5. Absolutely critical	3. Programme Manager	5	7.35%	100.00%
5. Absolutely critical	4. Project Manager	6	8.82%	100.00%
5. Absolutely critical	5. Project Coordinator	4	5.88%	100.00%
5. Absolutely critical	7. Project Administrator	1	1.47%	100.00%
5. Absolutely critical	8. Quality Controller	1	1.47%	100.00%
5. Absolutely critical	9. Quality Assurance Officer	3	4.41%	100.00%
5. Absolutely critical	10. Construction Safety Office	2	2.94%	100.00%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	100.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	2	2.94%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	18. Commercial Manager	1	1.47%	100.00%
5. Absolutely critical Total		**30**	**44.12%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.18: Client consultation - Results per project phase

2.4 Client Consultation	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
2. Moderately important	E. Execution Phase	1	1.47%	100.00%
2. Moderately important Total		**1**	**1.47%**	
3. Important	G. Post Project Phase	1	1.47%	16.67%
3. Important	E. Execution Phase	5	7.35%	100.00%
3. Important Total		**6**	**8.82%**	
4. Very important	C. Concept Phase	4	5.88%	12.90%
4. Very important	D. Definition Phase	2	2.94%	19.35%
4. Very important	E. Execution Phase	25	36.76%	100.00%
4. Very important Total		**31**	**45.59%**	
5. Absolutely critical	G. Post Project Phase	1	1.47%	3.33%
5. Absolutely critical	C. Concept Phase	3	4.41%	13.33%
5. Absolutely critical	D. Definition Phase	7	10.29%	36.67%
5. Absolutely critical	E. Execution Phase	19	27.94%	100.00%
5. Absolutely critical Total		**30**	**44.12%**	
Grand Total		**68**	**100.00%**	

Table 4.19: Personnel - Overall result

2.5 Personnel	Data Count of Rating	% Total	% Accum.
3. Important	13	19.1%	19.1%
4. Very important	28	41.2%	60.3%
5. Absolutely critical	27	39.7%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.20: Personnel - Result per stakeholder

2.5 Personnel	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
3. Important	1. System Engineer	1	1.47%	33.33%
3. Important	2. Portfolio Manager	1	1.47%	100.00%
3. Important	4. Project Manager	4	5.88%	36.36%
3. Important	5. Project Coordinator	2	2.94%	15.38%
3. Important	7. Project Administrator	1	1.47%	25.00%
3. Important	10. Construction Safety Office	3	4.41%	50.00%
3. Important	12. Contract Manager	1	1.47%	100.00%
3. Important Total		**13**	**19.12%**	**19.12%**
4. Very important	1. System Engineer	1	1.47%	66.67%
4. Very important	3. Programme Manager	3	4.41%	37.50%
4. Very important	4. Project Manager	6	8.82%	90.91%
4. Very important	5. Project Coordinator	6	8.82%	61.54%
4. Very important	6. Construction Manager	1	1.47%	100.00%
4. Very important	7. Project Administrator	2	2.94%	75.00%
4. Very important	8. Quality Controller	1	1.47%	33.33%
4. Very important	9. Quality Assurance Officer	2	2.94%	50.00%
4. Very important	10. Construction Safety Office	3	4.41%	100.00%
4. Very important	16. Radiation Protection Mana	1	1.47%	100.00%
4. Very important	17. Safety Manager	1	1.47%	50.00%
4. Very important	18. Commercial Manager	1	1.47%	100.00%
4. Very important Total		**28**	**41.18%**	**60.29%**
5. Absolutely critical	1. System Engineer	1	1.47%	100.00%
5. Absolutely critical	3. Programme Manager	5	7.35%	100.00%
5. Absolutely critical	4. Project Manager	1	1.47%	100.00%
5. Absolutely critical	5. Project Coordinator	5	7.35%	100.00%
5. Absolutely critical	7. Project Administrator	1	1.47%	100.00%
5. Absolutely critical	8. Project Engineer	1	1.47%	100.00%
5. Absolutely critical	8. Quality Controller	2	2.94%	100.00%
5. Absolutely critical	9. Quality Assurance Officer	2	2.94%	100.00%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	100.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	2	2.94%	100.00%
5. Absolutely critical	16. Radiation Protection Advis	1	1.47%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	17. Materials SME	1	1.47%	100.00%
5. Absolutely critical	17. Safety Manager	1	1.47%	100.00%
5. Absolutely critical	18. Project Accountant	1	1.47%	100.00%
5. Absolutely critical Total		**27**	**39.71%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.21: Personnel - Result per project phase

1.6 Project Phase2	2.5 Personnel	Data Count of Rating	% Total	% Accum.
C. Concept Phase	3. Important	4	5.88%	30.77%
C. Concept Phase	4. Very important	3	4.41%	10.71%
C. Concept Phase Total		**7**	**10.29%**	**10.29%**
D. Definition Phase	3. Important	1	1.47%	38.46%
D. Definition Phase	4. Very important	5	7.35%	28.57%
D. Definition Phase	5. Absolutely critical	3	4.41%	11.11%
D. Definition Phase Total		**9**	**13.24%**	**23.53%**
E. Execution Phase	3. Important	8	11.76%	100.00%
E. Execution Phase	4. Very important	19	27.94%	96.43%
E. Execution Phase	5. Absolutely critical	23	33.82%	96.30%
E. Execution Phase Total		**50**	**73.53%**	**97.06%**
G. Post Project Phase	4. Very important	1	1.47%	100.00%
G. Post Project Phase	5. Absolutely critical	1	1.47%	100.00%
G. Post Project Phase Total		**2**	**2.94%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.22: Technical tasks - Overall result

2.6 Technical tasks	Data Count of Rating	% Total	% Accum.
1. Not important at all	1	1.5%	1.5%
2. Moderately important	2	2.9%	4.4%
3. Important	15	22.1%	26.5%
4. Very important	30	44.1%	70.6%
5. Absolutely critical	20	29.4%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.23: Technical tasks - Results per stakeholder

2.6 Technical tasks	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
1. Not important at all	5. Project Coordinator	1	1.47%	7.69%
1. Not important at all Total		**1**	**1.47%**	**1.47%**
2. Moderately important	7. Project Administrator	1	1.47%	25.00%
2. Moderately important	8. Quality Controller	1	1.47%	33.33%
2. Moderately important Total		**2**	**2.94%**	**4.41%**
3. Important	2. Portfolio Manager	1	1.47%	100.00%
3. Important	3. Programme Manager	1	1.47%	12.50%
3. Important	4. Project Manager	4	5.88%	36.36%
3. Important	5. Project Coordinator	3	4.41%	30.77%
3. Important	6. Construction Manager	1	1.47%	100.00%
3. Important	7. Project Administrator	1	1.47%	50.00%
3. Important	8. Quality Controller	1	1.47%	66.67%
3. Important	9. Quality Assurance Officer	1	1.47%	25.00%
3. Important	10. Construction Safety Office	2	2.94%	33.33%
3. Important Total		**15**	**22.06%**	**26.47%**
4. Very important	1. System Engineer	1	1.47%	33.33%
4. Very important	3. Programme Manager	4	5.88%	62.50%
4. Very important	4. Project Manager	4	5.88%	72.73%
4. Very important	5. Project Coordinator	6	8.82%	76.92%
4. Very important	7. Project Administrator	2	2.94%	100.00%
4. Very important	8. Quality Controller	1	1.47%	100.00%
4. Very important	9. Quality Assurance Officer	3	4.41%	100.00%
4. Very important	10. Construction Safety Office	4	5.88%	100.00%
4. Very important	10. Outage Execution Manage	1	1.47%	100.00%
4. Very important	12. Contract Manager	1	1.47%	100.00%
4. Very important	13. Project Scheduler	1	1.47%	50.00%
4. Very important	17. Materials SME	1	1.47%	100.00%
4. Very important	18. Project Accountant	1	1.47%	100.00%
4. Very important Total		**30**	**44.12%**	**70.59%**
5. Absolutely critical	1. System Engineer	2	2.94%	100.00%
5. Absolutely critical	3. Programme Manager	3	4.41%	100.00%
5. Absolutely critical	4. Project Manager	3	4.41%	100.00%
5. Absolutely critical	5. Project Coordinator	3	4.41%	100.00%
5. Absolutely critical	8. Project Engineer	1	1.47%	100.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	1	1.47%	100.00%
5. Absolutely critical	16. Radiation Protection Advis	1	1.47%	100.00%
5. Absolutely critical	16. Radiation Protection Mana	1	1.47%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	17. Safety Manager	2	2.94%	100.00%
5. Absolutely critical	18. Commercial Manager	1	1.47%	100.00%
5. Absolutely critical Total		**20**	**29.41%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.24: Technical tasks - Results per project phase

2.6 Technical tasks	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
1. Not important at all	E. Execution Phase	1	1.47%	2.00%
1. Not important at all Total		**1**	**1.47%**	**1.47%**
2. Moderately important	C. Concept Phase	1	1.47%	14.29%
2. Moderately important	E. Execution Phase	1	1.47%	4.00%
2. Moderately important Total		**2**	**2.94%**	**4.41%**
3. Important	C. Concept Phase	2	2.94%	42.86%
3. Important	D. Definition Phase	1	1.47%	11.11%
3. Important	E. Execution Phase	12	17.65%	28.00%
3. Important Total		**15**	**22.06%**	**26.47%**
4. Very important	G. Post Project Phase	2	2.94%	100.00%
4. Very important	C. Concept Phase	1	1.47%	57.14%
4. Very important	D. Definition Phase	3	4.41%	44.44%
4. Very important	E. Execution Phase	24	35.29%	76.00%
4. Very important Total		**30**	**44.12%**	**70.59%**
5. Absolutely critical	C. Concept Phase	3	4.41%	100.00%
5. Absolutely critical	D. Definition Phase	5	7.35%	100.00%
5. Absolutely critical	E. Execution Phase	12	17.65%	100.00%
5. Absolutely critical Total		**20**	**29.41%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.25: Client acceptance - Overall result

2.7 Client Acceptance	Data Count of Rating	% Total	% Accum.
3. Important	5	7.4%	7.4%
4. Very important	30	44.1%	51.5%
5. Absolutely critical	33	48.5%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.26: Client acceptance - Result per stakeholder

2.7 Client Acceptance	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
3. Important	5. Project Coordinator	2	2.94%	40.00%
3. Important	10. Construction Safety Office	1	1.47%	60.00%
3. Important	16. Radiation Protection Advis	1	1.47%	80.00%
3. Important	17. Safety Manager	1	1.47%	100.00%
3. Important Total		**5**	**7.35%**	
4. Very important	3. Programme Manager	2	2.94%	6.67%
4. Very important	4. Project Manager	7	10.29%	30.00%
4. Very important	5. Project Coordinator	5	7.35%	46.67%
4. Very important	6. Construction Manager	1	1.47%	50.00%
4. Very important	7. Project Administrator	1	1.47%	53.33%
4. Very important	8. Quality Controller	1	1.47%	56.67%
4. Very important	9. Quality Assurance Officer	2	2.94%	63.33%
4. Very important	10. Construction Safety Office	5	7.35%	80.00%
4. Very important	12. Contract Manager	1	1.47%	83.33%
4. Very important	13. Project Scheduler	1	1.47%	86.67%
4. Very important	16. Radiation Protection Mana	1	1.47%	90.00%
4. Very important	16. Radiation Protection Moni	1	1.47%	93.33%
4. Very important	17. Materials SME	1	1.47%	96.67%
4. Very important	18. Project Accountant	1	1.47%	100.00%
4. Very important Total		**30**	**44.12%**	
5. Absolutely critical	1. System Engineer	3	4.41%	9.09%
5. Absolutely critical	2. Portfolio Manager	1	1.47%	12.12%
5. Absolutely critical	3. Programme Manager	6	8.82%	30.30%
5. Absolutely critical	4. Project Manager	4	5.88%	42.42%
5. Absolutely critical	5. Project Coordinator	6	8.82%	60.61%
5. Absolutely critical	7. Project Administrator	3	4.41%	69.70%
5. Absolutely critical	8. Project Engineer	1	1.47%	72.73%
5. Absolutely critical	8. Quality Controller	2	2.94%	78.79%
5. Absolutely critical	9. Quality Assurance Officer	2	2.94%	84.85%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	87.88%
5. Absolutely critical	11. Design Engineer	1	1.47%	90.91%
5. Absolutely critical	13. Project Scheduler	1	1.47%	93.94%
5. Absolutely critical	17. Safety Manager	1	1.47%	96.97%
5. Absolutely critical	18. Commercial Manager	1	1.47%	100.00%
5. Absolutely critical Total		**33**	**48.53%**	
Grand Total		**68**	**100.00%**	

Table 4.27: Client acceptance - Result per project phase

2.7 Client Acceptance	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
3. Important	E. Execution Phase	5	7.35%	100.00%
3. Important Total		**5**	**7.35%**	
4. Very important	G. Post Project Phase	2	2.94%	6.67%
4. Very important	C. Concept Phase	3	4.41%	16.67%
4. Very important	D. Definition Phase	3	4.41%	26.67%
4. Very important	E. Execution Phase	22	32.35%	100.00%
4. Very important Total		**30**	**44.12%**	
5. Absolutely critical	C. Concept Phase	4	5.88%	12.12%
5. Absolutely critical	D. Definition Phase	6	8.82%	30.30%
5. Absolutely critical	E. Execution Phase	23	33.82%	100.00%
5. Absolutely critical Total		**33**	**48.53%**	
Grand Total		**68**	**100.00%**	

Table 4.28: Monitoring and feedback - Overall result

2.8 Monitoring and feedba	Data Count of Rating	% Total	% Accum.
3. Important	12	17.6%	17.6%
4. Very important	24	35.3%	52.9%
5. Absolutely critical	32	47.1%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.29: Monitoring and feedback - Result per stakeholder

2.8 Monitoring and feedback	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
3. Important	4. Project Manager	2	2.94%	16.67%
3. Important	5. Project Coordinator	3	4.41%	41.67%
3. Important	8. Quality Controller	1	1.47%	50.00%
3. Important	9. Quality Assurance Officer	2	2.94%	66.67%
3. Important	10. Construction Safety Office	3	4.41%	91.67%
3. Important	16. Radiation Protection Mana	1	1.47%	100.00%
3. Important Total		**12**	**17.65%**	
4. Very important	1. System Engineer	2	2.94%	8.33%
4. Very important	3. Programme Manager	5	7.35%	29.17%
4. Very important	4. Project Manager	6	8.82%	54.17%
4. Very important	5. Project Coordinator	3	4.41%	66.67%
4. Very important	7. Project Administrator	1	1.47%	70.83%
4. Very important	8. Project Engineer	1	1.47%	75.00%
4. Very important	9. Quality Assurance Officer	1	1.47%	79.17%
4. Very important	10. Construction Safety Office	2	2.94%	87.50%
4. Very important	16. Radiation Protection Advis	1	1.47%	91.67%
4. Very important	17. Materials SME	1	1.47%	95.83%
4. Very important	18. Project Accountant	1	1.47%	100.00%
4. Very important Total		**24**	**35.29%**	
5. Absolutely critical	1. System Engineer	1	1.47%	3.13%
5. Absolutely critical	2. Portfolio Manager	1	1.47%	6.25%
5. Absolutely critical	3. Programme Manager	3	4.41%	15.63%
5. Absolutely critical	4. Project Manager	3	4.41%	25.00%
5. Absolutely critical	5. Project Coordinator	7	10.29%	46.88%
5. Absolutely critical	6. Construction Manager	1	1.47%	50.00%
5. Absolutely critical	7. Project Administrator	3	4.41%	59.38%
5. Absolutely critical	8. Quality Controller	2	2.94%	65.63%
5. Absolutely critical	9. Quality Assurance Officer	1	1.47%	68.75%
5. Absolutely critical	10. Construction Safety Office	1	1.47%	71.88%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	75.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	78.13%
5. Absolutely critical	12. Contract Manager	1	1.47%	81.25%
5. Absolutely critical	13. Project Scheduler	2	2.94%	87.50%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	90.63%
5. Absolutely critical	17. Safety Manager	2	2.94%	96.88%
5. Absolutely critical	18. Commercial Manager	1	1.47%	100.00%
5. Absolutely critical Total		**32**	**47.06%**	
Grand Total		**68**	**100.00%**	

Table 4.30: Monitoring and feedback - Result per stakeholder

2.8 Monitoring and feedback	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
3. Important	G. Post Project Phase	1	1.47%	8.33%
3. Important	C. Concept Phase	2	2.94%	25.00%
3. Important	E. Execution Phase	9	13.24%	100.00%
3. Important Total		**12**	**17.65%**	
4. Very important	G. Post Project Phase	1	1.47%	4.17%
4. Very important	C. Concept Phase	1	1.47%	8.33%
4. Very important	D. Definition Phase	4	5.88%	25.00%
4. Very important	E. Execution Phase	18	26.47%	100.00%
4. Very important Total		**24**	**35.29%**	
5. Absolutely critical	C. Concept Phase	4	5.88%	12.50%
5. Absolutely critical	D. Definition Phase	5	7.35%	28.13%
5. Absolutely critical	E. Execution Phase	23	33.82%	100.00%
5. Absolutely critical Total		**32**	**47.06%**	
Grand Total		**68**	**100.00%**	

Table 4.31: Communication - Overall result

2.9 Communication	Data Count of Rating	% Total	% Accum.
3. Important	9	13.2%	13.2%
4. Very important	20	29.4%	42.6%
5. Absolutely critical	39	57.4%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.32: Communication – Result per stakeholder

2.9 Communication	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
3. Important	3. Programme Manager	1	1.47%	12.50%
3. Important	4. Project Manager	2	2.94%	18.18%
3. Important	5. Project Coordinator	2	2.94%	15.38%
3. Important	9. Quality Assurance Officer	1	1.47%	25.00%
3. Important	10. Construction Safety Office	2	2.94%	33.33%
3. Important	16. Radiation Protection Mana	1	1.47%	100.00%
3. Important Total		**9**	**13.24%**	**13.24%**
4. Very important	1. System Engineer	1	1.47%	33.33%
4. Very important	3. Programme Manager	3	4.41%	50.00%
4. Very important	4. Project Manager	2	2.94%	36.36%
4. Very important	5. Project Coordinator	4	5.88%	46.15%
4. Very important	7. Project Administrator	2	2.94%	50.00%
4. Very important	9. Quality Assurance Officer	2	2.94%	75.00%
4. Very important	10. Construction Safety Office	3	4.41%	83.33%
4. Very important	16. Radiation Protection Advis	1	1.47%	100.00%
4. Very important	17. Materials SME	1	1.47%	100.00%
4. Very important	18. Project Accountant	1	1.47%	100.00%
4. Very important Total		**20**	**29.41%**	**42.65%**
5. Absolutely critical	1. System Engineer	2	2.94%	100.00%
5. Absolutely critical	2. Portfolio Manager	1	1.47%	100.00%
5. Absolutely critical	3. Programme Manager	4	5.88%	100.00%
5. Absolutely critical	4. Project Manager	7	10.29%	100.00%
5. Absolutely critical	5. Project Coordinator	7	10.29%	100.00%
5. Absolutely critical	6. Construction Manager	1	1.47%	100.00%
5. Absolutely critical	7. Project Administrator	2	2.94%	100.00%
5. Absolutely critical	8. Project Engineer	1	1.47%	100.00%
5. Absolutely critical	8. Quality Controller	3	4.41%	100.00%
5. Absolutely critical	9. Quality Assurance Officer	1	1.47%	100.00%
5. Absolutely critical	10. Construction Safety Office	1	1.47%	100.00%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	100.00%
5. Absolutely critical	11. Design Engineer	1	1.47%	100.00%
5. Absolutely critical	12. Contract Manager	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	2	2.94%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	17. Safety Manager	2	2.94%	100.00%
5. Absolutely critical	18. Commercial Manager	1	1.47%	100.00%
5. Absolutely critical Total		**39**	**57.35%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.33: Communication - Result per stakeholder

2.9 Communication	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
3. Important	G. Post Project Phase	1	1.47%	11.11%
3. Important	C. Concept Phase	1	1.47%	22.22%
3. Important	E. Execution Phase	7	10.29%	100.00%
3. Important Total		**9**	**13.24%**	
4. Very important	G. Post Project Phase	1	1.47%	5.00%
4. Very important	C. Concept Phase	2	2.94%	15.00%
4. Very important	D. Definition Phase	2	2.94%	25.00%
4. Very important	E. Execution Phase	15	22.06%	100.00%
4. Very important Total		**20**	**29.41%**	
5. Absolutely critical	C. Concept Phase	4	5.88%	10.26%
5. Absolutely critical	D. Definition Phase	7	10.29%	28.21%
5. Absolutely critical	E. Execution Phase	28	41.18%	100.00%
5. Absolutely critical Total		**39**	**57.35%**	
Grand Total		**68**	**100.00%**	

Table 4.34: Troubleshooting - Overall result

2.10 Troubleshooting	Data Count of Rating	% Total	% Accum.
1. Not important at all	1	1.5%	1.5%
2. Moderately important	2	2.9%	4.4%
3. Important	12	17.6%	22.1%
4. Very important	34	50.0%	72.1%
5. Absolutely critical	19	27.9%	100.0%
Grand Total	**68**	**100.00%**	

Table 4.35: Troubleshooting - Results per stakeholder

2.10 Troubleshooting	1.4 PLCM stakeholder	Data Count of Rating	% Total	% Accum.
1. Not important at all	8. Quality Controller	1	1.47%	33.33%
1. Not important at all Total		**1**	**1.47%**	**1.47%**
2. Moderately important	2. Portfolio Manager	1	1.47%	100.00%
2. Moderately important	7. Project Administrator	1	1.47%	25.00%
2. Moderately important Total		**2**	**2.94%**	**4.41%**
3. Important	3. Programme Manager	1	1.47%	12.50%
3. Important	4. Project Manager	2	2.94%	18.18%
3. Important	5. Project Coordinator	3	4.41%	23.08%
3. Important	7. Project Administrator	1	1.47%	50.00%
3. Important	9. Quality Assurance Officer	2	2.94%	50.00%
3. Important	10. Construction Safety Office	1	1.47%	16.67%
3. Important	16. Radiation Protection Advis	1	1.47%	100.00%
3. Important	18. Project Accountant	1	1.47%	100.00%
3. Important Total		**12**	**17.65%**	**22.06%**
4. Very important	1. System Engineer	1	1.47%	33.33%
4. Very important	3. Programme Manager	4	5.88%	62.50%
4. Very important	4. Project Manager	6	8.82%	72.73%
4. Very important	5. Project Coordinator	8	11.76%	84.62%
4. Very important	6. Construction Manager	1	1.47%	100.00%
4. Very important	7. Project Administrator	2	2.94%	100.00%
4. Very important	8. Quality Controller	1	1.47%	66.67%
4. Very important	9. Quality Assurance Officer	1	1.47%	75.00%
4. Very important	10. Construction Safety Office	3	4.41%	66.67%
4. Very important	11. Design Engineer	1	1.47%	100.00%
4. Very important	12. Contract Manager	1	1.47%	100.00%
4. Very important	13. Project Scheduler	1	1.47%	50.00%
4. Very important	16. Radiation Protection Mana	1	1.47%	100.00%
4. Very important	17. Safety Manager	2	2.94%	100.00%
4. Very important	18. Commercial Manager	1	1.47%	100.00%
4. Very important Total		**34**	**50.00%**	**72.06%**
5. Absolutely critical	1. System Engineer	2	2.94%	100.00%
5. Absolutely critical	3. Programme Manager	3	4.41%	100.00%
5. Absolutely critical	4. Project Manager	3	4.41%	100.00%
5. Absolutely critical	5. Project Coordinator	2	2.94%	100.00%
5. Absolutely critical	8. Project Engineer	1	1.47%	100.00%
5. Absolutely critical	8. Quality Controller	1	1.47%	100.00%
5. Absolutely critical	9. Quality Assurance Officer	1	1.47%	100.00%
5. Absolutely critical	10. Construction Safety Office	2	2.94%	100.00%
5. Absolutely critical	10. Outage Execution Manage	1	1.47%	100.00%
5. Absolutely critical	13. Project Scheduler	1	1.47%	100.00%
5. Absolutely critical	16. Radiation Protection Moni	1	1.47%	100.00%
5. Absolutely critical	17. Materials SME	1	1.47%	100.00%
5. Absolutely critical Total		**19**	**27.94%**	**100.00%**
Grand Total		**68**	**100.00%**	

Table 4.36: Troubleshooting - Results per project phase

2.10 Troubleshooting	1.6 Project Phase2	Data Count of Rating	% Total	% Accum.
1. Not important at all	E. Execution Phase	1	1.47%	100.00%
1. Not important at all Total		**1**	**1.47%**	
2. Moderately important	C. Concept Phase	1	1.47%	50.00%
2. Moderately important	D. Definition Phase	1	1.47%	100.00%
2. Moderately important Total		**2**	**2.94%**	
3. Important	C. Concept Phase	1	1.47%	8.33%
3. Important	E. Execution Phase	9	13.24%	83.33%
3. Important	G. Post Project Phase	2	2.94%	100.00%
3. Important Total		**12**	**17.65%**	
4. Very important	C. Concept Phase	4	5.88%	11.76%
4. Very important	D. Definition Phase	4	5.88%	23.53%
4. Very important	E. Execution Phase	26	38.24%	100.00%
4. Very important Total		**34**	**50.00%**	
5. Absolutely critical	C. Concept Phase	1	1.47%	5.26%
5. Absolutely critical	D. Definition Phase	4	5.88%	26.32%
5. Absolutely critical	E. Execution Phase	14	20.59%	100.00%
5. Absolutely critical Total		**19**	**27.94%**	
Grand Total		**68**	**100.00%**	

Table 4.37: Ranking of CSFs of the PIP (based on stakeholder status for the absolutely critical CSFs)

5. Absolutely critical	2.1 Project Mission	2.2. Top Management Support	2.3 Schedule and Plans	2.4 Client Consultation	2.5 Personnel	2.6 Technical tasks	2.7 Client Acceptance	2.8 Monitoring and feedback	2.9 Communication	2.10 Troubleshooting	
1. System Engineer	3	2	1	1	1	2	3	1	2	2	18
2. Portfolio Manager	0	1	1	1	0	0	1	1	1	0	6
3. Programme Manager	4	4	3	5	4	3	6	3	4	3	39
4. Project Manager	7	5	6	6	1	3	4	3	7	3	45
5. Project Coordinator	4	10	9	4	3	3	6	7	7	2	55
6. Construction Manage	0	0	0	0	0	0	0	1	1	0	2
7. Project Administrato	1	2	1	1	1	0	3	3	2	0	14
8. Project Engineer	1	1	0	0	0	1	1	0	1	1	6
8. Quality Controller	2	2	2	1	2	0	2	2	3	1	17
9. Quality Assurance Of	3	4	4	3	1	0	2	1	1	1	20
10. Construction Safety	1	4	1	2	0	0	0	1	1	2	12
10. Outage Execution M	0	1	1	1	0	0	1	1	1	1	7
11. Design Engineer	1	1	1	1	0	1	1	1	1	0	8
12. Contract Manager	1	1	1	0	0	0	0	1	1	0	5
13. Project Scheduler	2	1	2	2	1	1	1	2	2	1	15
16. Radiation Protectior	0	0	0	0	0	1	0	0	0	0	1
16. Radiation Protectior	1	0	0	0	0	1	0	0	0	0	2
16. Radiation Protectior	1	1	1	1	0	1	0	1	1	1	8
17. Materials SME	0	0	0	0	0	0	0	0	0	1	1
17. Safety Manager	1	1	2	0	0	2	1	2	2	0	11
18. Commercial Manage	1	0	1	1	0	1	1	1	1	0	7
18. Project Accountant	0	0	0	0	0	0	0	0	0	0	0
	34	**41**	**37**	**30**	**14**	**20**	**33**	**32**	**39**	**19**	**299**
1. System Engineer	8.8%	4.9%	2.7%	3.3%	7.1%	10.0%	9.1%	3.1%	5.1%	10.5%	
2. Portfolio Manager	0.0%	2.4%	2.7%	3.3%	0.0%	0.0%	3.0%	3.1%	2.6%	0.0%	
3. Programme Manager	11.8%	9.8%	8.1%	16.7%	28.6%	15.0%	18.2%	9.4%	10.3%	15.8%	
4. Project Manager	20.6%	12.2%	16.2%	20.0%	7.1%	15.0%	12.1%	9.4%	17.9%	15.8%	
5. Project Coordinator	11.8%	24.4%	24.3%	13.3%	21.4%	15.0%	18.2%	21.9%	17.9%	10.5%	
6. Construction Manage	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.1%	2.6%	0.0%	
7. Project Administrato	2.9%	4.9%	2.7%	3.3%	7.1%	0.0%	9.1%	9.4%	5.1%	0.0%	
8. Project Engineer	2.9%	2.4%	0.0%	0.0%	0.0%	5.0%	3.0%	0.0%	2.6%	5.3%	
8. Quality Controller	5.9%	4.9%	5.4%	3.3%	14.3%	0.0%	6.1%	6.3%	7.7%	5.3%	
9. Quality Assurance Of	8.8%	9.8%	10.8%	10.0%	7.1%	0.0%	6.1%	3.1%	2.6%	5.3%	
10. Construction Safety	2.9%	9.8%	2.7%	6.7%	0.0%	0.0%	0.0%	3.1%	2.6%	10.5%	
10. Outage Execution M	0.0%	2.4%	2.7%	3.3%	0.0%	0.0%	3.0%	3.1%	2.6%	5.3%	
11. Design Engineer	2.9%	2.4%	2.7%	3.3%	0.0%	5.0%	3.0%	3.1%	2.6%	0.0%	
12. Contract Manager	2.9%	2.4%	2.7%	0.0%	0.0%	0.0%	0.0%	3.1%	2.6%	0.0%	
13. Project Scheduler	5.9%	2.4%	5.4%	6.7%	7.1%	5.0%	3.0%	6.3%	5.1%	5.3%	
16. Radiation Protectior	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	
16. Radiation Protectior	2.9%	0.0%	0.0%	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	
16. Radiation Protectior	2.9%	2.4%	2.7%	3.3%	0.0%	5.0%	0.0%	3.1%	2.6%	5.3%	
17. Materials SME	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%	
17. Safety Manager	2.9%	2.4%	5.4%	0.0%	0.0%	10.0%	3.0%	6.3%	5.1%	0.0%	
18. Commercial Manage	2.9%	0.0%	2.7%	3.3%	0.0%	5.0%	3.0%	3.1%	2.6%	0.0%	
18. Project Accountant	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
% Accumulative	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
1. System Engineer	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	9.1%	3.1%	100.0%	100.0%	
2. Portfolio Manager		100.0%		100.0%			12.1%	6.3%	100.0%		
3. Programme Manager	76.5%	100.0%		100.0%	100.0%	100.0%	30.3%	15.6%	100.0%	100.0%	
4. Project Manager	100.0%	100.0%		100.0%	100.0%	100.0%	42.4%	25.0%	100.0%	100.0%	
5. Project Coordinator	61.8%	100.0%		100.0%	100.0%	100.0%	60.6%	46.9%	100.0%	100.0%	
6. Construction Manage								50.0%	100.0%		
7. Project Administrato	64.7%	100.0%		100.0%	100.0%		69.7%	59.4%	100.0%		
8. Project Engineer	2.9%	100.0%			100.0%	100.0%	72.7%		100.0%	100.0%	
8. Quality Controller	26.5%	100.0%		100.0%	100.0%		78.8%	65.6%	100.0%	100.0%	
9. Quality Assurance Of	41.2%	100.0%		100.0%	100.0%		84.8%	68.8%	100.0%	100.0%	
10. Construction Safety	79.4%	100.0%		100.0%				71.9%	100.0%	100.0%	
10. Outage Execution M		100.0%		100.0%	100.0%		87.9%	75.0%	100.0%	100.0%	
11. Design Engineer	5.9%	100.0%		100.0%	100.0%	100.0%	90.9%	78.1%	100.0%		
12. Contract Manager	8.8%	100.0%						81.3%	100.0%		
13. Project Scheduler	32.4%	100.0%		100.0%	100.0%	100.0%	93.9%	87.5%	100.0%	100.0%	
16. Radiation Protectior					100.0%	100.0%					
16. Radiation Protectior	11.8%					100.0%					
16. Radiation Protectior	14.7%	100.0%		100.0%	100.0%	100.0%		90.6%	100.0%	100.0%	
17. Materials SME					100.0%					100.0%	
17. Safety Manager	17.6%	100.0%			100.0%	100.0%	97.0%	96.9%	100.0%		
18. Commercial Manage	20.6%			100.0%		100.0%	100.0%	100.0%	100.0%		
18. Project Accountant					100.0%						

Table 4.42 Additional CSFs per stakeholder in the Concept Phase

NPLCM Status	Department	CAT - A	CAT - B	CAT - C	CAT - D	CAT - E	CAT - F	CAT - G
		Safety (Nuclear , Industrial Radiological, Security	Cross functional team and collaboration / Alignment+ Integration	Quality Management (Plant Systems, Processes and Procedures	Regulatory (NNR) + Legal	Funding + Contracts Management	Stakeholder Management	Risk Management
System Engineer 2	Plant Engineering							
Portfolio Manager	Nuclear PMO			X				X (IRM)
Programme Mana	Project Development							
Project Manager	Standard Project Execution						X	
Project Administrator	Standard Project Execution		X					Contingence Plan
Quality Assurance Officer	Quality Management			X			Customer	
Total		**0**	**1**	**2**	**0**	**0**	**2**	**2**
%		**0**	**14.29**	**28.57**	**0**	**0**	**28.57**	**28.57**

Table 4.43 Additional CSFs per stakeholder in the Definition Phase

PLCM Status	Department	CAT - A	CAT - B	CAT - C	CAT - D	CAT - E	CAT - G	CAT - G
		Safety (Nuclear , Industrial Radiological, Security	Cross functional team and collaboration / Alignment+ Integration	Quality Management (Plant Systems, Processes and Procedures	Regulatory (NNR) + Legal	Funding + Contracts Management	Stakeholder Management	Risk Management
Programme Manager (3)	Project Development		X	PSP - Plant health				X
	Nuclear PMO	X	XX				X	
	Standard Project Execution		XX				X	
Project Manager (3)	Standard Project Execution				X			
		X						
			X					
Project Administrator	Standard Project Execution			Documentation readiness implementation approval				
Design Engineer	Nuclear Engineering				XX	X		
Commercial Manager	Commercial Management					Vendor management		
Total		**2**	**6**	**3**	**3**	**2**	**2**	**1**
%		**10.53**	**31.58**	**15.79**	**15.79**	**10.53**	**10.53**	**5.26**

Table 4.45 Additional CSFs per stakeholder in the Execution Phase

NPLCM Status	Department	CAT - A	CAT - B	CAT - C	CAT - D	CAT - E	CAT - G	CAT - F
		Safety (Nuclear, Industrial Radiological, Security	Cross functional team and collaboration / Alignment + Integration	Quality Management (Plant Systems, Processes and Procedures	Regulatory (NNR) + Legal	Funding + Contracts Management	Stakeholder Management	Risk Management
System Engineer	Nuclear Engineering				X	XX		
Programme Manager	Complex Projects	X	XXX					
	Complex Projects			Plant Systems, Processes and Procedures	XXX		X	
	Complex Projects		XXX					X
	Complex Projects		XX					
Project Manager	Standard Projects				XX	X	X	
	Standard Projects				XX		XX Public engagement	
	Complex Projects			Lessons Learnt - OE		XX	X	X Risk based thinking
	Contracts Management							
	Maintenance	XX		XX Plant Systems, Processes and Procedures - Handover				
	Maintenance	XX			X			
	NPMO		X	Lessons Learnt - OE				
Project Coordinator	Standard Projects		X				X (Collaboration	
	Standard Projects	XX						
	Outage		XXX					
	Monitoring and Support	X		X				
	Complex Projects	X		XX		X	X	
	Construction							
	Construction							
	Construction	X						
	Construction			XX Plant Systems, Processes and Procedures - OTS				

	Construction	XX		Plant Systems, Processes and Procedures				
	Construction							
	Construction						X	
	Quality Management							
Construction Manager	Construction		X	Plant Systems, Processes and Procedures				XX IRM Risk anticipation
Project Administrator	Contracts Management					XX		
Project Engineer	Nuclear Engineering		Interface management		X	X		
Quality Controller	Construction			X				
	Quality Management		X					
	Quality Management		X					
Quality Assurance Officer	Standard Project	XX	Lessons Learnt (OE)	Plant Systems, Processes and Procedures				
	Quality Management	XX	X					
Construction Safety Officer	Standard Project	X		X				
	Nuclear Services OH&S	Incident and investigation management						
	Construction	XXXX						
		XXXX						
		XXXX						
		XX						
Outage Execution Manager	Outage							
Contract Manager	Contracts Management	XX				X		XX
Project Scheduler	Standard Project					XX		
	Complex Projects					X		X
Radiation Protection Advisor	Radiation Protection							
Radiation Protection Manager	Radiation Protection							
Radiation Protection Monitor	Radiation Protection	RP Controls						
Materials SME	Nuclear Engineering				XX	Vendor management		
Safety Manager	Nuclear Services OH&S							

	Construction Management				X			
Project Accountant	Finance		X					
Total		**36**	**20**	**15**	**13**	**14**	**8**	**7**
%		**31.89**	**17.70**	**13.27**	**11.50**	**12.39**	**7.08**	**6.19**

Table 4.45 Additional CSFs per stakeholder in the Post Project Phase

PLCM Status	**Department**	**CAT - A**	**CAT - B**	**CAT - C**	**CAT - D**	**CAT - E**	**CAT - F**	**CAT - G**
		Safety (Nuclear , Industrial Radiological, Security	**Cross functional team and collaboration / Alignment+ Integration Management**	**Quality Management (Plant Systems, Processes and Procedures**	**Regulatory (NNR) + Legal**	**Funding + Contracts Management**	**Stakeholder Management**	**Risk Management**
Project Administrator	Standard Project Execution			XX (Documentation)				
Quality Assurance Officer	Quality Management	X		X	X			
Total		**1**	**0**	**2**	**1**	**0**	**0**	**0**
%		**25**	**0**	**50**	**25**	**0**	**0**	**0**