



Department of Construction Economics and Management

Project Management Master's Thesis: CON5032Z

Research Report

**Factors Causing Delay of Modification Projects at Koeberg
Power Station**

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ABSTRACT

Project delays are common in construction projects, and at Koeberg Nuclear Power Station, modification and outage projects are not exempted from these delays. Subsequently, these project delays have a detrimental effect on the Eskom organization in terms of its mandate to supply electricity to promote and boost the South African economy. Therefore, timely project delivery within the Eskom business is of paramount importance in ensuring the utility honours its mandate.

The aim of this research study is to identify factors and that influence untimely delivery of plant system modification projects which at times affect the timely delivery of outage projects at Koeberg Power Station. The research study focuses on the following objectives: (i) identification of factors contributing to untimely delivery of plant system modification projects at Koeberg Power Station, (ii) analysis of identified factors to determine the main determinants of untimely delivery of plant system modification projects, (iii) assessing whether a gap or correlation exists between the factors identified through the study and the factors the project management fraternity believe to have a significant contribution to the untimely delivery of projects, and (iv) to recommend mitigating measures that Koeberg Power Station may consider in addressing the consequences of identified project delay factors on modification projects.

Through the use of interactive management research methodology, a total of 92 identified project delay factors were reduced to 21 principal project delay factors that form part of the interpretive structural model. The results of the research study show that the main determinant of modification project delays at Koeberg Power Station is the “proficiency of a project manager”. Proficiency of a project manager relates to the ability of a project manager to accomplish the required project tasks based on his or her skills, competency, and experience within the project management field. Inadequate proficiency of a project manager was found to be the major cause of modification delays at Koeberg Power Station. Proficiency of a project manager could not be directly matched with other project delay factors identified from the reviewed literature, but it could be matched with the “poor professional management” identified by Fugar and Agyakwah-Baah (2010). In addition, the matching of “proficiency of a project manager” project delay factor could also be established through other project delay factors identified by this study. These include poor leadership, competency, and skill of a project manager in communication, planning, coordination, risk management, and scope management. The study found that, a total of 9 out of 21 project delay factors identified are unique to Koeberg Power Station.

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- Outage department project leaders/managers at Koeberg Power Station;
- Operating department project leaders at Koeberg Power Station;
- Plant Engineering department system engineers at Koeberg Power Station; and
- Work Control department manager/coordinator at Koeberg Power Station.

DECLARATION

I, ***Sikholiwe Ntoyanto***, hereby declare that:

- the work in this research study is my own original work;
- all sources used or referred to have been documented and recognised;
- this research paper has not previously been submitted in full or partial fulfilment of the requirements of an equivalent or higher qualification at another recognised educational institution.

Signed

TABLE OF CONTENTS

ABSTRACT	i
ACKNOWLEDGEMENTS	ii
DECLARATION	iii
LIST OF TABLES	vi
LIST OF FIGURES	vi
LIST OF APPENDICES	vi
ABBREVIATIONS	vii
Chapter 1 – INTRODUCTION	1
1.1 Background to the study	1
1.1.1 Maintenance shutdown (outage) projects at Koeberg Power Station	3
1.1.2 Plant system modification projects at Koeberg Power Station	4
1.1.3 Challenges facing Koeberg Power Station projects	5
1.2 Research focus	6
1.3 Problem statement	6
1.4 Research question	6
1.5 Research aim	7
1.6 Research objective	7
1.7 Report Structure	7
Chapter 2 – LITERATURE REVIEW	10
2.1 Comparison of Koeberg Power Station modification projects and general engineering construction projects	10
2.2 Project delay overview	13
2.3 Factors causing project delays	15
2.4 Relationship review of delay factors from literature	26
2.5 Effect of project management elements on project delays	30
2.5.1 Effect of risk management and project planning on project delay	31
2.5.2 Effect of quality management on project delays	32
2.5.3 Effect of procurement management on project delay	34
Chapter 3 – RESEARCH METHODOLOGY	36
3.1 Reflection on prominent methods used to identify project delay factors	36
3.2 Types of research	41
3.3 Research design	43
3.3.1 Interactive management in identifying modification project delay factors	44
3.3.2 Interactive management processes	46
3.3.2.1 Idea writing and nominal group techniques	47
3.3.2.2 Interpretive structural modelling	48
3.4 Ethics clearance	51
Chapter 4 – DATA COLLECTION AND ANALYSIS	52
4.1 Data collection	52
4.1.1 Selection of participants based on designation per department	52
4.1.1.1 Decision making to initiate modification projects	53
4.1.1.2 Affected stakeholders by modification projects	53
4.1.1.3 Who adopts and implements modification projects	54
4.1.1.4 Who is interested in modification projects?	55
4.1.2 Research study sample	55
4.2 Data analysis	56

TABLE OF CONTENTS

4.2.1 Questionnaire and interview responses	56
4.2.1.1 Participants grouped by departments.....	57
4.2.1.2 Participants grouped by experience in number of years	57
4.2.1.3 Participants grouped by designation	58
4.2.1.4 Project phases.....	59
4.2.1.5 Idea writing results.....	60
4.2.1.6 Nominal group technique results.....	65
4.2.2 Interpretive structural modelling workshop.....	74
4.2.3 Modification project delay factors' model analysis	79
4.2.3.1 Proficiency of a project manager as a project delay factor	81
4.2.3.2 Loop 1 project delay factors	82
4.2.3.3 Top management decision as a project delay factor.....	87
4.2.3.4 Loop 2 project delay factors	87
4.2.3.5 Loop 3 project delay factors	88
4.3 Comparison of research findings and literature review	89
Chapter 5 – CONCLUSION AND RECOMMENDATIONS	94
5.1 Review of research objective and conclusion	94
5.2 Research limitations	96
5.3 Recommendations.....	96
5.3.1 Proficiency of a project manager.....	97
5.3.2 Loop 1 project delay factors	99
5.4 Propositions for possible further research.....	101
REFERENCES	103

LIST OF TABLES

Table 2-1: Project delay influential factors versus project management field elements	17
Table 2-2: Most important delay factors for construction projects in Pakistan	18
Table 2-3: Factors which caused delays in 2010 South African stadiums	19
Table 2-4: Factors which caused delay in Egyptian construction projects.....	20
Table 2-5: Beneficiaries of project delays	23
Table 2-6: Problems encountered and lessons learnt.....	25
Table 2-7: Project delay factors' matrix	27
Table 4-1: Generated elements of project delay factors' matrix.....	61
Table 4-2: Merged project delay factors.....	66
Table 4-3: Significant project delay factors	71
Table 4-4: Comparison of research findings delay factors with literature review.....	90

LIST OF FIGURES

Figure 3-1 Fundamental steps to construct an effective ISM.....	46
Figure 3-2: Conceptual view of ISM (Sorach_Inc, 1999: 3)	50
Figure 4-1: Project phases and stage gates.....	55
Figure 4-2: Number of participants per department	57
Figure 4-3: Experience of participants.....	58
Figure 4-4: Participants group by designation.....	59
Figure 4-5: Project phase	59
Figure 4-6: Identified delay factors with number of appearance equal or greater than three	65
Figure 4-7: Constructing a relationship model using Concept Star (Sorach_Inc, 2014: 30).....	76
Figure 4-8: List of elements with assigned numbers.....	77
Figure 4-9: Context phrase.....	77
Figure 4-10: Relation phrase	78
Figure 4-11: Example of posed questions during the workshop session.....	78
Figure 4-12: Vote results	79
Figure 4-13: Model for factors causing modification project delay	80

LIST OF APPENDICES

Appendix 1 Idea Generation Questionnaire for Identifying Factors causing Modification Project Delays	108
Appendix 2 Information Sheet and Consent Form	110
Appendix 3 Ethics Approval.....	112

ABBREVIATIONS

BOT- Build-Operate-Transfer project

CRA - Concept Release Approval

DB - Design Build contract

DRA - Definition Release Approval

ERA - Execution Release Approval

HOA - Handover Approval

FRA - Closure Approval

IM - Interactive Management

ISM - Interpretive Structural Modelling

KPI - Key Performance Indicators

KSA - Kingdom of Saudi Arabia

MPDFM - Modification Project Delay Factors' Model

NPP - Nuclear Power Plant

NPM - Nuclear Project Management department

NNR - National Nuclear Regulator

OMD - Outage Management Department

PLCM - Project Life Cycle Model

PMSA - Project Management South Africa

TVO - Teollisuuden Voima

UAE - United Arabic Emirates

CHAPTER 1 – INTRODUCTION

1.1 Background to the study

Nokes and Kelly (2007: 13) defined project as “a unique process, consisting of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost, and resources”. (PMBOK(R)_Guide, 2013) further defines project as “a temporary endeavour undertaken to create a unique product, service, or results”. Both these definitions explicitly indicate the constriction of project fundamental ingredients (cost, time, and resources). It is generally true that there are more to do than time and resources will allow, which is to say there are more projects to be done than can be done (Nokes and Kelly, 2007: 130).

Since projects are temporary in nature, the success of the project should be measured in terms of completing the project within the constraints of scope, time, cost, quality, resources, and risk as approved between the project managers and senior management (PMBOK(R)_Guide, 2013: 35). The performance of a project has been described as the degree of achievement of project objectives with regards to quality, cost, and time (Chitkara, 2005 cited by, (Jeptepkeny, 2015: 1). A project is considered successful if it is completed on time, within budget, and to the specified quality standards (Chan and Kumaraswamy, 1997: 55).

Therefore, given the inclusion of time element in project definitions, this paper deduces that timely delivery of projects is one of the success criteria used in industry and also in the project management field. In addition, timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors, and consultants alike (Bowen et al., 2014: 48). However, project failure in terms of cost overrun and time delays is commonplace and is being investigated for several years (Flvbjerg et al, 2003; Hall, 1981; Morris and Hough, 1987 quoted by (Bosch-Rekvelde et al., 2011: 729) and Doloi et al. (2011: 480) posited that delay in construction projects has been a research topic for decades. Even though there are plenty of management techniques to control time and cost overrun in construction projects, most projects are still facing the problem of time and cost overruns (Mulla and Waghmare, 2015: 52). Mulla and Waghmare (2015: 48) further added that successful completion of construction projects within the specified time have become the most valuable and challenging task for managers, architects, engineers, and contractors.

Frimpong et al. (2003: 322) highlighted that 75% of the projects conducted in Ghana between 1970 and 1999 exceeded the original project schedule and cost whereas only 25%

were completed within the budget and on time. A study conducted by Assaf and Al-Hejji (2006: 349) found that around 70% of all public sector construction projects were delayed due to several factors in construction projects in the Kingdom of Saudi Arabia. Van et al. (2015: 92) indicated that 70% of projects experienced time overruns and the average time overrun was between 10% and 30% of the original duration. In Australia, Bromilow found that only one-eighth of building contracts were completed within the scheduled completion dates and that the average time overrun exceeded 40% (Chan and Kumaraswamy, 1997: 55). Investigating the factors that caused a delay in construction projects in United Arab Emirates, Faridi and El-Sayegh (2006), cited by (Doloi et al., 2011: 480) reported that over 50% of construction projects experience delay due to factors such as delay in approval of construction drawings, poor pre-planning, and slow decision making processes.

Eskom is the only major electricity utility in South Africa that supplies electricity for industrial, commercial, and domestic use, and positions Eskom as one of the building blocks and foundations of the South African economy (Eskom, 2016: 3). Few would deny the importance of electricity as an essential input to production and to economic activity in general (Cameron and Rossouw, 2012: 2). Therefore, timely delivery of projects within Eskom is of paramount importance in ensuring the utility continuously delivers on its mandate. However, South Africans are currently being subjected to load shedding which comes as a result of a limited generating capacity and an ever increasing demand for electricity. The lack of electricity supply and interruption of supply is increasingly recognised as a potentially serious constraint on sustained economic growth, given the wide consensus on the important links between electricity and economic development (Fedderke et al., 2006).

To address this challenge, the Eskom organization, with government support has undertaken to implement various projects throughout the Eskom business. These projects include building new power plants and refurbishing existing plant through modification projects to ensure adequate and uninterrupted supply of electricity to the country. Despite the concerted efforts in resolving the energy crisis, these projects continue to experience severe delays which exacerbate the crisis.

The above discussion does not suggest that time delay is the only criterion for measuring project performance. Other project performance criteria exist within various types of projects. For example, the evaluation of a project for development of a large-scale power plant project in East Asia under a multi-contract design-build (DB) system, was based on six criteria: (i) staying on budget, (ii) staying on schedule, (iii) meeting specifications, (iv) conforming to the client's expectations, (v) achieving acceptable quality of work, and (vi) minimizing construction aggravation (Ling and Lau, 2001: 419).

1.1.1 Maintenance shutdown (outage) projects at Koeberg Power Station

The author of this document has nine years of working experience (both as a technician, in maintenance department and as a project leader in outage department) at Eskom, particularly at Koeberg Power Station. Therefore, information presented in this document about Koeberg Power Station is based on the author's knowledge and experience about Koeberg Power Station, unless the information is referenced.

Koeberg Power Station is one of Eskom's generation power plants and it is a nuclear power plant characterized by two identical pressurized water reactor (PWR) units, each producing approximately 930 MW of electricity for the South African national electricity grid. Each of Koeberg's two units is required to be refuelled and maintained approximately every 18 months of operation. The outage management department at Koeberg Power Station is responsible for managing maintenance shutdown (outage) projects. Outage projects comprises between 20 000 and 45 000 work packages which must be carried out or executed within a specified period. These activities include preventive maintenance, corrective maintenance, activities from plant system modification projects and operating routine testing activities to verify the functionality of various plant (hardware or software) systems. More than 15 functional departments with more than 2 000 personnel are employed (permanent and contracting staff) to carry out these work activities during the outage projects.

Despite the increase in electricity demand in South Africa, all Eskom base-load power stations (including Koeberg Power Station) need to be taken out of service for maintenance for the minimum reasonable time to avoid blackouts and load-shedding. The outage department at Koeberg Power Station is required to produce an activity plan for the outage project based on the work scope identified by various functional areas of Koeberg Power Station. The outage plan produced to execute the outage work activities determines the duration of the outage projects and Eskom corporate expectation is that the outage project will be delivered within this agreed period. Based on this information, the Eskom network control centre engages in discussions with other Eskom generation power stations to determine the best suitable time for these power stations to be taken out service for maintenance shutdown (outage) projects. These discussions and planning take into account the available electricity capacity in the national grid.

Therefore, timely delivery of outage projects at Koeberg Power Station is crucial as un-planned unavailability of the Koeberg Power Station units has the following knock-on effects:

- disrupting the maintenance shutdown (outage) projects schedule of other power stations;

- affecting electricity capacity of the national grid;
- possible load-shedding restricting supply to domestic, commercial, and industrial consumers; and
- detrimental consequences to the country's economic activities.

1.1.2 Plant system modification projects at Koeberg Power Station

Projects are done for the purpose of developing systems, either to create new ones or to improve existing ones (Nicholas and Steyn, 2012: 86). Koeberg Power Station follows a similar approach for plant system modification projects. Various plant system modification projects are identified and implemented by the Nuclear Project Management department at Koeberg Power Station for the purpose of improving the plant system's performance. The criteria used in selecting plant system projects to be implemented takes into consideration plant and personnel conventional safety, nuclear safety, compliance to regulatory requirements, plant reliability and efficiency, which in turn ensure continuous availability of electricity supply to the South African national grid.

Pla et al. (2012: 76) suggested that nuclear safety in Europe is one of the European Union's primary concerns, and therefore the European Union decided to take a prominent role in international efforts to help the new independent states and countries of central and eastern Europe to ensure the safety of their nuclear reactors since the early 90s. During the construction of the Olkiluoto 3 nuclear power plant (NPP), safety and quality were at the top of all official priority lists, as the case concerned the building of a NPP (Ruuskaa et al., 2010: 652). Koeberg Nuclear Power Station takes a similar stance towards nuclear safety and some of the modification projects are implemented to enhance nuclear safety at Koeberg.

Plant system modification projects at Koeberg Power Station are subjected to a project life cycle model (PLCM). PLCM provides the basic framework for managing the project regardless of the specific work (PMBOK(R)_Guide, 2013: 38). Eskom_KAA-501 (2010: 4) also describes PLCM as the order of consecutive stages which a project needs to follow and the model has been deemed to be essential for effective project management by major organizations in South Africa. These stages include a pre-planning phase, concept phase, definition phase, execution phase, close-out phase, and a post-project phase. Each phase in a project life cycle model has a duration which, when combined with other phase durations, make up the total duration of a project.

Most plant system modification projects at Koeberg Power Station are executed or implemented during the outage project as mentioned in section 1.1.1 of this document. Therefore, delays encountered in phases prior the execution or implementation phase of the

project life cycle model affects the execution phase of the project and thus affects the outage project. This knock-on effect sometimes results in a decision to be made by Koeberg Power Station management to postpone the plant modification project initially planned to be implemented during a specific outage project or to absorb the effect of extending the outage project duration. Depending on the purpose of the project that has been delayed or postponed, the following may ensue:

- Continue operating with inefficient plant system.
- Operate with a risk of unit failure or trip which may result in an unavailability of Koeberg Power Station unit to be able to supply electricity to the national grid.
- Extend the duration of outage project which will result in the unavailability of the Koeberg Power Station unit.

1.1.3 Challenges facing Koeberg Power Station projects

From the observation made by the author of this document, plant system modification projects and outage projects are still challenged to be completed within the targeted period, and this results in a loss of income by the client. The researcher has identified this problem in his area of work and also through literature review of previously conducted studies. Delay in the completion of the project results in increased costs, and delays the generation of income from incomplete projects (Mulla and Waghmare, 2015: 49). In fact, some projects become uneconomical due to the time and cost overruns. Delay means loss of income for the owner or client, and additional costs due to longer work time, labour cost increase, and higher fabrication cost for the contractor (Haseeb et al., 2011: 41). Cruywagen (2012: 61) also supports this view and is of opinion that, for the owner and contractor, delays could result in missing possible new opportunities due to unavailability of capital and resources to exploit new opportunities. In addition, time overruns caused by delays will have a knock-on effect that will lead to cost overruns as a result of increased overheads (Cruywagen, 2012: 61). Baloyi and Bekker (2011: 52) also added that, given the large capital amount associated with construction projects, the performance in terms of cost and time are closely monitored and the quantitative results from measuring against original project duration estimate and approved budget, remains a popular yardstick for assessing overall project performance. Delays as well as disruptions are sources of potential risks that are currently being studied to find ways to manage the technical, social, economic, legal, financial, resource, construction and commercial aspects (Kikwasi, 2012: 52).

Conflicting views exist among the Koeberg personnel with respect to the reasons why some projects are not delivered on time. Some team members believe that the planning strategy is

a major contributing factor to project delays. On the other hand, team members are of view that the lack of accountability and commitment to follow and adhere to established time schedules by team members is the cause for the experienced project delays. Therefore, the resulting debacle for projects to not be delivered on time constitutes a need to conduct a research study which seeks to identify the key reasons why projects are not delivered on time at Koeberg Power Station.

1.2 Research focus

Section 1.1 of this document presented maintenance shutdown (outage) projects and plant system modification projects at Koeberg Power Station. There is an inextricable link between the two types of projects as the planning and execution of one type affects the other. For example, execution or implementation of most plant system modification projects needs to be incorporated into the outage project plan and as such, the delay of a plant system modification project may result on the delay of the maintenance shutdown (outage) project. However, it is important to note that outage projects do not influence plant system modification projects, and as such, the relationship between the two project types may be viewed to be of one-directional relationship type. With this interrelationship between the two types of projects at Koeberg Power Station, the study will focus on factors resulting in delays of plant system modification projects and some attention will also be given to the outage projects as they are affected by plant system modification projects.

1.3 Problem statement

The problem statement to be addressed in this study is:

Various factors may contribute to the untimely delivery of plant system modification projects at Koeberg, which consequently affects the availability and reliability of electricity supply by Eskom generation business unit to South Africa.

1.4 Research question

Research questions to be addressed by this study are:

- a) Which factors affect plant system modification projects and lead to project delivery being delayed?
- b) Which organizational factors contribute to the untimely delivery of projects, which in turn contribute to project failure?

1.5 Research aim

The purpose of this study is to identify factors that influence the untimely delivery of plant system modification projects at Koeberg Power Station. Analysis of these factors were done and Eskom was used as a case.

1.6 Research objective

The following are the objectives of this research study:

- a) To identify factors contributing to the untimely delivery of plant system modification projects at Koeberg Power Station.
- b) To evaluate interrelationships among identified project delay factors to establish which factors drive the others.
- c) To analyse identified factors and determine the main determinants of untimely delivery of plant system modification projects.
- d) To assess whether a gap or correlation exists between the factors identified through the study and the factors the project management fraternity believe to have a great contribution on the untimely delivery of projects.
- e) To recommend mitigating measures that Koeberg Power Station may consider in addressing the consequences of identified project delay factors on modification projects.

1.7 Report Structure

This document is divided into five chapters. Chapter two gives a detailed background to the study in a form of research problem statement, research focus, research aim, research objectives, and research question. The researcher uses the case of Eskom, specifically the Koeberg Power Station. The study focused on modification projects within Koeberg Power Station; however, Chapter one details and describes how modification projects are being integrated into the outage project at Koeberg Power Station. The difference between modification projects and outage projects is also presented in Chapter one. Chapter two presents the literature review and justifies why modification projects in a nuclear power plant are viewed as a construction project. Consequently, a literature review is conducted on nuclear power plant construction projects and other general construction projects. The review was conducted to evaluate previous work completed on the subject of project delays in order to give basis to the argument of the finding of this research. Literature review also helps with understanding how previous work on project delays has been conducted, what the findings

were, and whether there has been a particular trend identified by previous researchers on the subject of project delays. Conducting a literature review is a means of demonstrating the depth knowledge of the author about a particular field of study, including vocabulary, theories, key variables and phenomena, and its method and history (Randolph, 2009: 3).

Chapter three presents an overview of the research methodology, different research types explained by other authors in the research methodology field, and the interactive management (IM) research methodology. Interactive management (IM) research methodology has been adopted for the study of identifying factors causing project delays is also used. IM methodology involved questionnaires distributed to participants, individual interviews to clarify participants' responses to the questionnaires and for the purpose of assessing commonalities among identified factors, and a group workshop for interpretive structural modelling (ISM).

Chapter four presents the data collection and analysis. Research findings are discussed in this chapter. Comparison between project delay factors identified through this research study and project delay factors identified by other researchers is also presented to satisfy one of the research objectives. The results of the research study show that the main determinant of modification project delays at Koeberg Power Station is the "proficiency of a project manager". Proficiency of a project manager relates to the ability of a project manager to accomplish the required project tasks based on his or her skills, competency, and experience within the project management field. Inadequate proficiency of a project manager was found to be the major cause of modification delays at Koeberg power station. Furthermore, proficiency of a project manager could not be directly matched with other project delay factors identified from the reviewed literature, but it could be matched with the "poor professional management" identified by Fugar and Agyakwah-Baah (2010). In addition, the matching of "proficiency of a project manager" project delay factor could also be done through other project delay factors identified from the study. These include poor leadership, the project manager's communication competencies and skills, planning, coordination, risk management, and scope management. The study found that, a total of 9 out of 21 project delay factors identified are unique to Koeberg Power Station.

Chapter five presents the recommendations which Koeberg Power Station management may consider in addressing the identified project delay determinants. A model presenting the interrelationship between project delay factors was produced from the research study. The model reveals that some project delay factors lead to other project delay factors. Therefore, driving project delay factors are given a specific attention. It is assumed that if these project delay factors addressed, driven project delay factors will significantly be reduce or mitigated.

A review to determine whether research objectives have been achieved is also presented under this chapter to provide the conclusion of the research study.

CHAPTER 2 – LITERATURE REVIEW

2.1 Comparison of Koeberg Power Station modification projects and general engineering construction projects

During this research study modification projects will be benchmarked and assessed against research on project delays undertaken by various authors on several projects in several disciplines. Most of these projects are in the general engineering construction industry. Therefore, it is necessary to clarify similarities and differences between general construction projects and plant modification projects at Koeberg Power Station. The purpose of this section is to demonstrate the similarities and distinct critical characteristics between general engineering construction projects (hereinafter referred to as construction projects) and modification projects at Koeberg Power Station.

Rashid et al. (2006: 4) suggested that the responsibility of design and construction or implementation of construction projects are sometimes carried out by different independent organizations, namely the designers and contractors. This is referred as a linear or sequential contracting system or a multiple responsibility approach. It is a system where the project development activities that start from the feasibility study, preliminary design, detailed design, documentation to construction and handover, are carried out sequentially.

In contrast, Ling and Lau (2001: 415) suggested that a single design-build (DB) contract is advantageous as there will be one party with a single point of responsibility who has overall control with regard to the design and construction of the entire project. Chan and Kumaraswamy (1997: 55) also added that an engineering construction project is usually divided into three important phases, namely, project conception, project design, and project construction. These phases are defined as follows:

- **Project conception phase:** The recognition of a need that can be satisfied by a physical structure. Feasibility studies and preliminary design are part of this phase.
- **Project design phase:** Translates the primary concept into an expression of a spatial form that will satisfy the owner's requirements in an optimal and economic manner. Detailed design is part of this phase.
- **Project construction phase:** Creates the physical form that satisfies the conception and which permits the realization of the design. Implementation or construction of the project is part of this phase.

It is important to note that the words 'construction' and 'implementation' in the context of delivering a physical or tangible form of the project or product are used interchangeably throughout this document.

Ogunsanmi (2013: 217) also describes the following tendering processes used in engineering construction projects:

- **Open tendering method:** Involves placing an advertisement in a widely read publication to invite prospective contractors to tender. It is strongly criticized for its increased cost of processing.
- **Selective tendering:** Involves inviting 5 to 8 competent contractors to tender for a project. Criteria used in selecting these contractors may include amongst others, verification of their ability to provide the standard of workmanship required, their equipment base, their historical business records, and their financial standing.
- **Negotiation approach:** Is used when a firm or client has previously had a satisfactory association with a contractor, and the client is prepared to award the contract to this contractor on the basis of a favourable price tendered for the project.

Some of the above tendering processes used in general engineering construction projects are also used in Koeberg Power Station modification projects. Modification projects at Koeberg Power Station follow an approach similar to general engineering construction projects where project activities start from feasibility studies, preliminary design, detailed design, manufacturing, implementation or construction, and handover. It is also important to note that some modification projects carried out at Koeberg Power Station are akin to construction industry type projects. For example, a project to renovate the rail tracks of the electrical transformers and transformer storage building, and the manufacturing and installation of tanks used for plant operations at Koeberg Power Stations.

In addition, Ruuskaa et al. (2010) conducted a study on "a new governance approach for multi-firm projects and identified lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant projects". During the study, the management of projects in nuclear power plants (Olkiluoto 3 and Flamanville 3) was compared to general engineering construction projects (Thames Barrier and Channel Tunnel projects). Ruuskaa et al. (2010: 655) reported that, in the Thames Barrier project, the technical specifications were prepared in a detailed manner, but the responsibility of the work was allocated to a contractor without mechanisms to ensure the early commitment of skilled resources. For the Channel Tunnel project, there was no one person 'objectively' representing the project's interests who would have had the aim, need, and charter to discuss and interact with all the parties. Ruuskaa et al. (2010: 655) further claimed that a similar scenario occurred in the Olkiluoto 3 project, where all the responsibility

was allocated to the turnkey contractor Areva. Teollisuuden Voima (TVO), as the principal, did not realize or accept its responsibility as the owner of the project. Instead, TVO assumed that contracts will be a sufficient way to delegate authority to the turnkey contractor. Turnkey contracts involve the delivery of a complete system or product and extend the timescale of the project backwards to pre-bid activities and forwards to beyond the handover stage (Ahola et al., 2007: 88). In the turnkey approach, clients do not provide any designs at all. Instead, they employ contractors to undertake complete design, construction, fitment, and commissioning, from inception to completion of the project (Ling and Lau, 2001: 418). In the Flamanville 3 project, EDF, the owner, acted as an architect-engineer. It is the view of the author of this document that the comparison between the nuclear power plant project and general engineering construction project was viable with regard to the governance and management required for both the nuclear projects and general engineering construction projects.

Chen and Doloi (2007: 391) conducted a research study on build-operate-transfer (BOT) projects in China to identify driving and impeding factors on BOT projects. The following China-specific impeding factors for BOT projects were identified based on extensive literature review and unstructured questionnaires:

- Opaque and weak legal systems.
- Complex approval systems.
- Regulatory constraints upon market entry.
- Low market prices for infrastructure products and services.
- Creditworthiness of local utilities.
- No direct interests in local government and its subordinates.
- Foreign currency administration difficulty.

It is important to note that the above impeding factors were applicable to all the BOT projects, which included general engineering construction related projects and power plant projects (Chen and Doloi, 2007: 391). The applicability of the impeding factors highlights the relevance of these factors to various types of projects. However, Doloi et al. (2011: 480) stated that the findings on high-ranked project delay factors in the United Arab Emirates (UAE) had no significant impact on construction projects in the Kingdom of Saudi Arabia (KSA). This clearly indicates that factors causing construction delay cannot be considered common across different countries.

The difference on technical aspects and objectives of some Koeberg Power Station modification projects and general construction projects is recognized. Modification projects at Koeberg Power Station are mostly aimed at improving the efficiency and effectiveness of the existing nuclear power plant, and also to ensure continuous production of reliable power energy. On the other hand, construction projects are generally vast in scope as it involves the gathering and organizing of a multitude of individuals, firms, and companies to design, manage, and build construction products such as residential accommodation, office buildings, shopping complexes, roads, bridges and others for specific clients or customers (Rashid et al., 2006: 1).

For nuclear power plants, regulatory frameworks exist and these frameworks specify how a nuclear utility should approach the implementation of change to its plant equipment, what process to follow, and what approvals are required in the nuclear industry. Koeberg Power Station is a nuclear utility and is subjected to the South African nuclear regulator, National Nuclear Regulator (NNR). Regulation of nuclear utilities is a world standard, for example Autorité de sûreté nucléaire (ASN) is the French regulator and Radiation and Nuclear Safety Authority (STUK) is the Finnish regulator (Ruuskaa et al., 2010). Ruuskaa et al. (2010: 652) define nuclear regulator as a “regulatory authority, research centre, and expert organization, whose mission is to protect people, society, environment, and future generations from the harmful effects of radiation”. The ultimate quality objective of operations is to keep the radiation exposure of people as low as reasonably achievable and to prevent radiation and nuclear accidents with a very high certainty.

Some of the modification projects at Koeberg Power Station require the regulator’s review, concurrence, and approval to implement such projects. General construction projects are subjected to a different regulatory framework; however, modification projects at Koeberg Power Station are not exempted from construction regulation such as Construction Regulations (OHS Act 85 of 1993, Department of Labour, 2003) on the basis of the work activities imposed by modification projects.

Consequently, the literature on construction projects should be considered relevant to modification projects at Koeberg Power Station, and the knowledge gained from reviewing literature on construction projects may be used to assess problems and challenges faced by modification projects.

2.2 Project delay overview

Irrespective of the project phase or kind of work activity, every project can be measured in three ways at any stage in its life cycle, namely time, cost, and performance. Time refers to a

temporal progress of activities and extent to which schedules and deadlines are being met (Nicholas and Steyn, 2012: 86). Chan and Kumaraswamy (1997: 55) posited that Rwelamila and Hall found that the timely completion of a project is frequently seen as a major criterion of project success. It has been pointed out that, in today's highly competitive and uncertain business environment, the client, who is the major stakeholder, wants speedier delivery of its projects with early commencement of construction work, certainty of performance in terms of cost, quality and time, value-for-money from their investment, minimal exposure to risk, and early confirmation of design and price or cost (Rashid et al., 2006: 2).

Many organizations are facing the herculean task of executing projects that meet or exceed the expectations of its customers; however, globally, numerous projects are unsuccessful and fail to get completed within budget and timelines. A successful project means that the project has accomplished its technical performance, maintained its schedule, and remained within budget (Frimpong et al., 2003: 322). Therefore, if one of the components mentioned above (technical performance, schedule, and budgetary costs) is not achieved, a project is considered a failure. Failure to achieve the targeted time, budgeted cost, and specified quality result in various unexpected negative consequences (Sambasivan and Soon, 2006: 517). Untimely delivery of projects or project delay occurs as result of failure to achieve the scheduled component of a project.

Haseeb et al. (2011: 20) define construction delay as “execute later than intended particular period or later than specific time that all the concerned parties agreed for a construction project”. Lo, Fung, and Tung (2006), quoted by Kikwasi (2012: 53) also define delay as “the slowing down of work without stopping construction entirely and that can lead to time overrun either beyond the contract date or beyond the date that the parties have agreed upon for the delivery of the project”. Many authors on construction management projects are of opinion that one of the most serious challenges facing construction projects today is delays (Cruywagen, 2012: 60). Projects are considered delayed when their stipulated completion duration has not been achieved (Sunjka and Jacob, 2013: 3). Delay as referred to in construction is prolonged construction period and disruptions are events that disturb the construction programme (Kikwasi, 2012: 52).

Construction delays can be grouped or classified into the following three types (Abdullah et al., 2010), (Kikwasi, 2012: 53); (Sunjka and Jacob, 2013: 2); (Gourlay, 2010: 237):

- **Excusable delay:** Delay due to causes beyond the contractor's control such as unforeseen events and not through fault or negligence on the part of the contractor. It can be divided into compensable or non-compensable delays. Compensable delay is a delay caused by the client or designer (architect or engineer) such as design

errors and changes in the client's requirements. On the other hand, non-compensable delay is a delay that is not caused by the client, designer, contractor, subcontractor, supplier, or any other party.

- **Non-excusable delay:** Delay due to contractor weaknesses or delay not caused by the contractor but could have been anticipated by the contractor under normal conditions. Besides that, a non-excusable delay provides no basis for recovery of either the time or the consequence of the delay. The contractor is the sole responsible party and consequently, it is not entitled to either extension of time or compensation; however, the client could be entitled to claim liquidated damages from the contractor.
- **Concurrent delay:** Delay due to the combination of two or more independent causes of delay during the same period. Often, this delay involves excusable and non-excusable delays; therefore, this delay may lead to disputes between contractor and client.

Most studies previously conducted on delays amalgamates the investigation of project delays with cost overruns and this makes sense as these project components (project delays and cost overruns) affect each other. For example, Haseeb et al. (2011: 20) suggested that delays are measured as expensive to all parties concerned in the project and often it will result in disagreement, claims, or even total desertion, and jeopardises the feasibility of the project and slows growth in the construction sector. However, the focus of this literature review is to determine the various factors leading to project delays, and to advise on cost overruns as a consequence of project delays.

2.3 Factors causing project delays

This section focuses on reviewing previous studies conducted to evaluate and determine the causes of delays in various regions or projects. There is a strong need to understand the attributes that cause the delays, understand the impact of these attributes, combine them into factors, and decipher the interdependencies between these factors (Doloi et al., 2011: 480). Based on their knowledge and experience, Frimpong et al. (2003: 322) listed the following influential factors that caused delays in groundwater projects in Ghana:

- Poor technical performance due to improper planning resulted in a number of wells being abandoned and thereby causing project delays and cost overruns.
- Work in these projects depended mainly on equipment, plant, and materials; projects without effective and efficient procurement procedures may be delayed.

- The projects involved numerous series of activities; diligence to the regular use of scheduling techniques and update schedules was needed. A great deal of coordination of these activities was required to avoid delay, especially in public projects.
- Due to the lack of skilful management, less attention was paid to resources allocation i.e. human, financial, and material.

Kasim et al. (2005: 793) also added that the key factor adversely affecting project performance is the improper handling and management of materials on site. This argument coincides with one of the influential delay factors mentioned above, namely, project material. Bell and Stukhart (1986) cited by Kasim et al. (2005: 793) define materials management “as functions which include planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution”. The objective of procurement in materials management is to provide the materials at the right time, at the right place, of the required quality, and within an agreed budget (Kasim et al., 2005: 795). Frimpong et al. (2003: 324) further developed a questionnaire with a set of 26 project delay factors derived from the list of influential factors (discussed above) and literature review conducted during the research study of causes of delay and cost overrun in construction of groundwater projects in Ghana. Using the relative importance weight (RIW) of data analysis, of the 26 project delay factors, the following five were identified to be the most important for the survey questionnaire:

- Difficulty with monthly payments by agencies.
- Poor contract management.
- Material procurement.
- Poor technical performance.
- Escalation of material cost.

Owners or clients, consultants, and contractors of the groundwater projects were the respondents in the survey of the study conducted by Frimpong et al. (2003). In order to identify the most important factors that influence time and cost overruns in the groundwater projects, the items were ranked in various groups, such as owners, contractors, and consultants (Frimpong et al., 2003: 323). Sambasivan and Soon (2006: 518) also categorized factors causing delays during their study of “Causes and effects of delays in Malaysian construction industry” as client-related, contractor-related, consultant-related, material-related, labour-related, contract-related, contract relationship-related, and external factors.

Walker (1995:269) quoted by (Baloyi and Bekker, 2011: 56) surveyed Australian project representatives and found that the most important factors that affect time delays are, the ability of the organisation to manage risk, planning capabilities, and effective resource coordination. Doloï et al. (2011: 480) suggested that reasons for construction project time and cost overruns in India include land acquisition, improper planning and budgeting, and poor coordination and monitoring of projects. Chan and Kumaraswamy (1997: 62) used the relative importance of construction project delay factors in Hong Kong and five principal delay factors were identified:

- Poor risk management.
- Poor supervision.
- Unforeseen site conditions.
- Slow decision making involving variation.
- Necessary variation works.

Poor supervision also made a list of the top 10 project delay factors identified by Fugar and Agyakwah-Baah (2010: 111) as shown in Table 2-7. Mulla and Waghmare (2015: 48) also added that poor planning, implementation, and management are the main reasons for time and cost overruns in construction projects in India. The time and cost overrun and its control is an extremely vast and complex subject which requires in-depth studies and it also requires a sound knowledge of other specialized subjects such as financial management, risk management, legal frameworks for construction, project management, and others (Mulla and Waghmare, 2015: 50). The influential factors mentioned above by Frimpong et al. (2003: 322) for project delays relate to these specialized subjects, referred to as project management field elements. Given the above arguments presented by Walker (1995), Doloï et al. (2011), and Mulla and Waghmare (2015), the author of this document made inferences on the relationship between influential factors observed by Frimpong et al. (2003: 322) and project management field elements, and developed Table 2-1 below which shows the link or association of delay influential factors with the project management field elements.

Table 2-1: Project delay influential factors versus project management field elements

Frimpong's Project Delay Influential Factors	Project Management Field Elements
Improper planning	Risk management and project planning
Poor technical performance	Quality management
Inadequate procurement procedures	Procurement management

§ 2.5.1, § 2.5.2, and § 2.5.3 of this document discuss in detail the effects of risk management, project planning, quality management, procurement management, scheduling management, and human resource management on project delays.

Haseeb et al. (2011: 41) also investigated the effects of delays in the construction industry of Pakistan. Haseeb organized each group of delay factors according to their relevance to the client, consultant, contractor, and external, and rated them on a scale of 1 to 10. The significance rating for each factor was scored on a scale of 1 to 10, with 1 having a low importance and 10 the uppermost importance. Table 2-2 shows the 11 most important delay factors out of 37 delay factors which were included on the survey questionnaire of the research conducted by Haseeb et al. (2011: 41).

Table 2-2: Most important delay factors for construction projects in Pakistan

Delay Factor	Category
Economic feasibility or economical arrangement for the project	Client
Completeness and timelines of project information	Consultant
Priority on construction time	Consultant
Missing of some details in the drawing	Consultant
Lack of acquiring new equipment	Contractor
Suitability to project time	Contractor form
Nationality of labour	Labour
Low productivity of work	Labour
Project location	Project condition
Changes to government regulations and laws	External
Effect of subsurface conditions	External

During a study of critical success factors for build-operate-transfer (BOT) in electric power projects in China, Zhao et al. (2010: 2085) also pointed out that the economic efficiency of the project is very important. This statement indicates that there is some correlation between success factors and delay factors as economic feasibility of the project is one of delay factors listed in Table 2-2. The expected profitability and the expected ability to repay debt determine the financial performance of the project, which will affect the motivation of the private sector and foreign investors (Zhao et al., 2010: 1285). In contrast, when the financial viability of a project is challenged, contractors and suppliers will limit their participation in a project which affects the timely delivery of a project.

Baloyi and Bekker (2011: 52) conducted a study on the causes of cost and time overruns of the 2010 FIFA soccer world cup in South Africa and Table 2-3 below shows ten factors found to have caused time delays during the construction of stadiums. A questionnaire comprising

18 potential factors causing cost overruns and 34 potential factors causing delays, ranked by respondents, was developed (Baloyi and Bekker, 2011: 59). In analysing the results, the relative importance index (RII) formula was used:

$$RII = \sum W / (A \times N), (0 \leq \text{index} \leq 1),$$

where W = weighting given to each factor by the respondents, and ranges from 1 to 5, (where “1” is “never” and “5” is “always”), A is the highest weighting (that is 5 in this case) and N = total number of respondents.

Table 2-3: Factors which caused delays in 2010 South African stadiums

Delay Factor	Category
Incomplete drawings	Client
Design changes	Client
Clients' slow decision-making	Client
Late issue of instructions	Client
Shortage of skilled labour	Contractor
Poor planning and scheduling	Contractor
Labour disputes and strikes	Contractor
Shortage of manpower	Contractor
Change orders by client during construction	Client
Poor information dissemination	Client
Delay in work approval	Client

Ling and Lau (2001: 420) conducted a study on the “management of the development of the large-scale power plant” and suggested that one of the subcontractors failed to work according to the work package and stay on budget and schedule. Cost over-run was more than 20%, and schedule over-run was more than 1 month. The contractor claimed that unsatisfactory performance arose because of extensive change orders by the client, while the client representative claimed that extensive sub-contracting by the contractor affected the sub-project performance. The “extensive change orders by the client” factor was identified as one of the delay factors by Baloyi and Bekker (2011: 52) as shown in Table 2-3 and the above situation on development of the large-scale power plant provides added evidence that extensive change orders by the client can affect project delays. Baloyi and Bekker (2011: 52) also identified “clients’ slow response” as one of the project delay factors as shown in Table 2-3. This can be argued as Ling and Lau (2001: 419) indicated that the contractor appointed as a project manager (to represent the client) for the development of large-scale power plant project in East Asia, was responsible for approval of design-build (DB) contractors’ schematic drawing during the design stage. DB contractors also had to seek the APM’s approval before

they could appoint sub-contractors and sub-vendors to supply critical materials such as turbines, steam generators, and high voltage switchgear. The required approval process would need a thorough verification by the client before authorizing the forwarded requests.

Marzouk and El-Rasas (2012: 50) prepared a detailed questionnaire comprising 43 factors which cause project delays in Egyptian construction projects, and respondents were asked to determine the frequency of occurrence of each cause as follows: Rarely (R) = 1, Sometimes (S) = 2, Often (O) = 3, Always (A)= 4. The degree of severity of identified factors was also rated by the respondents using the following levels: Low (L) = 1, Moderate (M) = 2, High (H) = 3, Extreme (E) = 4. Importance Index (IMP.I) was then calculate and the following 10 factors (shown in Table 2-4) were identified to be the top 10 factors causing delays in Egyptian construction projects. Frequency Index (F.I), Severity Index (S.I), and Importance Index (IMP.I) were calculated using the following equations:

$$Frequency\ Index\ (F.I)(\%) = \sum_{i=1}^4 \frac{a_{if} \times n_{if}}{4 \times N} \times 100$$

$$Severity\ Index\ (S.I)(\%) = \sum_{i=1}^4 \frac{a_{is} \times n_{is}}{4 \times N} \times 100$$

$$Importance\ Index\ (IMP.I)(\%) = \frac{F.I}{S.I}$$

where a_{if} and a_{is} are numbers of respondents who choose a certain frequency and severity degree respectively, n_{if} and n_{is} are degrees of frequency and severity respectively (1 or 2 or 3 or 4), N is total number of respondents.

Table 2-4: Factors which caused delay in Egyptian construction projects

Delay Factor	Category
Finance and payments of completed work by owner	Owner related
Variation orders, changes of scope by owner during construction	Owner related
Effects of subsurface conditions (e.g. soil, high water table, etc.)	Project Related
Low productivity level of labour	Labour and equipment
Ineffective planning and scheduling of project	Contractor Related
Difficulties in project financing by contractor	Contractor Related
Type of project bidding and award (negotiation, lowest bidder)	Owner related
Shortage of construction material in market	Material related
Late in approving design documents by the owner	Owner related
Unqualified workforce	Labour and equipment

Mulla and Waghmare (2015: 50) suggested that the time and cost overruns of projects are mainly due to:

- Inaccurate estimate of time and cost.
- Faulty design.
- Land acquisition problems.
- Poor bidding.
- Irregular flow of finance.
- Delay in payment of work.
- Deficiencies in management.
- Delay in making decision by client, architect.
- Lack of coordination between different parties involved.
- Change in work scope.

During the construction of Olkiluoto 3 nuclear power plant in Finland, Ruuskaa et al. (2010: 654) suggested that the Olkiluoto 3 concrete work was halted twice due to severe problems. The concrete supplier, Forssan Betoni was selected from four candidates, despite the small size of the company being considered a risk factor. In addition, special requirements of nuclear power plant building were not emphasized in the call for tenders and there was no training related to safety culture provided to the personnel of the concrete supplier prior to laying the concrete base slab. This relates to the “deficiencies in management” delay factor identified by (Mulla and Waghmare, 2015: 50). “Lack of coordination between different parties involved” delay factor identified by Mulla and Waghmare (2015: 50) can also be associated with the lack of collaboration during the construction of Olkiluoto 3 nuclear power plant. Several challenges concerning the collaboration between the project parties occurred and these problems caused friction between project parties (mainly TVO and Areva), which led to an “us versus them” atmosphere and the conflict became public in the media with Areva and TVO debating over contractual reparations (Ruuskaa et al., 2010: 655). Another example which relates to coordination was that, during the development of a large-scale power plant project in East Asia, Ling and Lau (2001: 419) suggested that some of the sub-projects within the large-scale power plant project were successful as they required minimum coordination and interfacing with other contractors. This was due to the fact that the client representative selected a turnkey procurement method, which is suitable for the complex projects which required a high level of skills in undertaking the specialized design and installation works (Ling and Lau, 2001: 419).

Through the research study of addressing construction delays in the Kingdom of Saudi Arabia, Albogamy et al. (2012: 149) identified a list 63 delay factors from the previous studies and literature review and these delay factors were categorized into for major categories such as client-related factors, contractor-related factors, consultant-related factors, and external factors. Using the importance index formula (pg. 20), the following were identified to be the top 10 factors causing delays in the construction industry of the Kingdom of Saudi Arabia (Albogamy et al., 2012: 153):

- Low performance of the lowest bidder contractor in the government tendering system.
- Delays in sub-contractors work.
- Poor qualification, skills, and experience of the contractor's technical staff.
- Poor planning and schedule of the project by the contractor.
- Delay in progress payment by the owner.
- Shortage of qualified engineers.
- Delay in preparation of construction drawings.
- Cash flow problems faced by contractor.
- Inadequate early planning of the project.
- Non-utilization of professional construction contract management.

Sunjka and Jacob (2013: 8) conducted a study on significant causes and effects of project delays in the Niger Delta region in Nigeria and the questionnaire was constructed on the groupings of 38 causes of delay factors. Results from mean score analyses using 3.5 as a cut-off point for significant factors and the sub-hypotheses' testing showed that the respondents perceived 11 factors (listed below) to have been the most important causes of project delay factors in the Niger Delta region (Sunjka and Jacob, 2013: 8)

- Youth unrest, militancy, and community crises.
- Inadequate planning by the contractors.
- Delay or non-payment of compensation to the communities.
- Selection of inappropriate consultants and contractors by the clients.
- Weather conditions.
- Late identification and resolution of drawings and specification errors and omissions by the consultants.

- Lack of community buy-in.
- Poor contract management by the consultants.
- Inappropriate design by the consultants.
- Unrealistic contract duration by the clients.
- Poor coordination of sub-contractors by the contractors.

Van et al. (2015: 92) discarded the following delay factors in their study analysis based on reliability test:

- Delay of owner in solving the arising during the project implementation.
- Lack of continuous updating of the project implementation process by owner.
- Long waiting time due to owner's authority decentralization in approving payment.

Van et al. (2015: 92) used the 5-point Likert scale ranging from 1 (no impact) to 5 (extreme impact) to measure the impact of delay factors affecting government construction projects in Vietnam. Based on the ranking, the 3 most influential factors out of 31 factors considered on project completion are (Van et al., 2015: 95):

- Information delays and lack of information exchange between the parties (mean = 3.82).
- Incompetent owner (mean = 3.81).
- Incompetent supervision consultant (mean = 3.8).

With the factors that caused delay in projects, Sunjka and Jacob (2013: 9) also investigated beneficiaries of the delays during their study. Table 2-5 summarizes the findings of the beneficiary investigation by the Sunjka and Jacob study.

Table 2-5: Beneficiaries of project delays

Beneficiary	Percentage of Respondent with the opinion	Justification for Respondent's opinion
Contractors	48.2%	When projects are delayed, contractors ask for upward review of their contract sum, and they could thus make more profit as a result of the revised contract price.
Consultants	28.9%	When projects are delayed, supervising consultants request for extension of their contract duration with the clients and this gives them the opportunity to make more income.
Communities	20.5%	When projects are delayed, workers indigenous to the host community continue to stay on employment until such projects are completed.

Beneficiary	Percentage of Respondent with the opinion	Justification for Respondent's opinion
Client	9.6%	Sponsors, clients could make claims from the contractors for delays caused by them

In contrast, Van et al. (2015: 92) suggested that contractors perceive delay as an additional responsibility due to the construction period becoming longer, increasing overhead costs and expenses for the longer period of the project, and the total working capital of the contractor becoming trapped in one project which renders them unable to participate in other projects. The owners perceive delay as a loss of yield and revenue due to lack of production facilities and lease space or a dependence on present facilities (Van et al., 2015: 92). In addition, the delays during construction of the Olkiluoto 3 nuclear power plant evolved into a serious confrontation between Teollisuuden Voima (TVO) and Areva (Ruuskaa et al., 2010: 652). Areva decided to run an international arbitration procedure in December 2008 due to delays, accusing TVO of taking too much time to study documents. Areva has claimed compensation of €1.4 billion. On the contrary, TVO has claimed €2.4 billion from Areva as penalties for the delay. Moreover, Areva publicly announced that TVO will have to change its procedures to be able to maintain agreed schedules.

Ling and Lau (2001) conducted a case study on the management of the development of a large-scale power plant project in East Asia based on design-build (DB) arrangement. During this study, the data was collected by interviews and unstructured discussions with 15 project participants, five being clients, five project managers, and five contractors. It is also important to note that the power plant project was divided into 16 work packages or sub-projects in which each sub-project was contracted to a specific contractor. A single contractor was appointed by the client to represent the client as a project manager to manage all other contractors. Its role included performing feasibility studies, preparing the client's requirements, basic designs, requests for proposal (RFP), formulating contract strategy, and advising the client on the appointment of contractors (Ling and Lau, 2001: 416). In addition to the appointed project manager, a client's project group and client's operation and maintenance (O&M) groups were also involved in the project to represent the client. Ling and Lau (2001: 421) identified the following five problems encountered in a power plant project and the lessons learnt, and these are summarized in Table 2-6.

Table 2-6: Problems encountered and lessons learnt

Problems	Lessons Learnt
Work could not progress smoothly due to multiple contracts in which one contractor was dependent on the other contractor. This problem resulted in project delays in some of the subprojects.	Single-point contact and single-point responsibility was needed to coordinate information exchange among contractors.
Inaccurate project information supplied from one contractor to the other was also one of the problems that resulted to some sub-project delays.	If the client has information which may be useful to the contractors, the client should include this information to form part of the contract.
Excessive change orders by the client caused delays in some of the sub-projects.	Due to different entities representing the client, different views with regard to client's requirements among these entities existed. The client who is made up of several entities should appoint a client's representative who is vested with power and authority to make final decisions and sign off drawings.
Ineffective communication among the project participants resulted in delays of some sub-projects.	Communication among contractors led to a huge burden of issues that needed to be addressed by the project manager contractor. Project participants should make commitments to comply with the agreed format of communication and involve the project manager on informal communication issues to avoid unnecessary conflict.
Misalignment of client expectations. This problem was not identified to have caused delays in power plant project.	The client had previously embarked in projects with some of the contractors which were involved in the power plant project. The client felt that these contractors did not provide the superior design, material, and workmanship they had previously provided in previous projects. These contractors were alleged to have settled with providing the minimum requirements stipulated in the contract. However, the client did not specify its expectation in the contract.

Ling and Lau (2001: 423) associated the problems listed in Table 2-6 to what extent large and complex projects can be affected by the use and implementation of a multi-contract design-build (DB) system. However, it should be noted that only some of the problems mentioned above resulted in project delays. For example, inaccurate project information supplied from one contractor to another was one of the problems identified and this is similar to the delay factors “information delays and lack of information exchange between the parties” and “poor information dissemination” identified by Van et al. (2015: 95) and Baloyi and Bekker (2011: 59) respectively. Excessive change orders by a client mentioned in Table 2-6 is also one of the delay factors identified by Baloyi and Bekker (2011: 52) and Mulla and Waghmare (2015: 50).

2.4 Relationship review of delay factors from literature

From the delay factors identified by various authors in various projects and regions as discussed in § 2.3, the author of this document holds two views regarding the factors identified by these authors. One view is that there is a common element among some delay factors identified through the conducted studies. This view is on the basis that some delay factors made the top list of delay factors in various research studies as discussed above. For example, “economical ability or arrangement for a project and payment of completed projects” delay factor was identified as one of the top ten by Haseeb et al. (2011: 41), Marzouk and El-Rasas (2012: 50), Frimpong et al. (2003: 324), Mulla and Waghmare (2015: 153) and Sunjka and Jacob (2013: 8). Another example of the delay factors which are common among most researchers findings are “planning capabilities and effective resource coordination”. These factors were listed as one of the top 10 by Walker (1995:269) quoted by (Baloyi and Bekker, 2011: 56), Marzouk and El-Rasas (2012: 50), Mulla and Waghmare (2015: 50), Albogamy et al. (2012: 153), and Sunjka and Jacob (2013: 8).

Another view of this document’s author regarding the project delay factors is the uniqueness of some delay factors to projects in which previous research studies were conducted. These factors are unique to the situation and setup of projects and have not been found to be common across the top list of delay factors on different research studies. It can be argued that perhaps the research respondents or participants in a particular study may have felt the factors which are not appearing in their top list, but appear in one of the research studies may have been resolved at the time the research was conducted. Or it might be the case that the factor(s) had no relevance to their projects due to various reasons, such location of the project, organizational situation, or state in terms of maturity towards the aspect which may result into a factor. The scenario of delay factors being unique to projects relates to the general definition of a project. A project is a unique process, consisting of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost, and resources (Nokes and Kelly, 2007: 13). The word ‘unique’ appears in the definition of the project by Nokes and Kelly (2007: 13) and this explains that some elements of a project such as project delay factors are distinct to the situation and setup of a project. For example, the “labour dispute and strikes” delay factor identified by Baloyi and Bekker (2011: 52) during the study of factors causing project delays in the construction of stadiums in South Africa may not have been viewed as a delay factor in other projects.

Table 2-7 shows a summarized matrix of the top list of project delay factors identified by Kasim et al. (2005), Frimpong et al. (2003), by Walker (1995), Chan and Kumaraswamy (1997) , Haseeb et al. (2011), Baloyi and Bekker (2011), Marzouk and El-Rasas (2012),

Mulla and Waghmare (2015), and Albogamy et al. (2012). Mark 'x', in black indicates the top list of delay factors identified by a particular author, and mark 'x', in red indicates identification of the same factor by other authors on their top list. Using the both marks, it is possible to determine the frequency of appearance of factors in various studies conducted by authors listed in the matrix. The last column of the matrix shows how often a factor appeared amongst the top delay factors list of the authors.

Table 2-7: Project delay factors' matrix

Project Delay Factors	Authors											No of Appearances	
	Kasim	Frimpong	Walker	Chan	Haseeb	Baloyi	Marzouk	Mulla	Albogamy	Sunjka	Van		Ling
Kasim et al. (2005)													
Improper handling and management of material on site	X												
Frimpong et al, (2003)													
Monthly payment difficulties from agencies		X			X	X	X	X					5
Poor contract management		X					X	X	X			X	5
Material procurement		X											
Poor technical performances		X											
Escalation of material cost		X											
Walker (1995)													
The ability of the organization to manage risk			X	X									2
Planning capabilities			X		X	X	X		X	X			6
Effective resource coordination			X				X		X				3
Chan and Kumaraswamy (1997)													
Poor risk management			X	X									2
Poor supervision				X						X		X	3
Unforeseen site conditions				X									
Slow decision making involving variation				X		X	X						3
Necessary variation works				X		X	X	X			X		5
Haseeb et al, (2011)													
Economical ability or economical arrangement for the project		X			X	X	X	X					5
Completeness and timelines of project information					X								
Priority on construction time					X								
Missing of some details in the drawing					X	X		X					3
Lack of acquiring new equipment					X								
Suitability to project time			X		X	X	X		X	X			6
Nationality of labour					X								

Table 2-7: Project delay factors' matrix

Project Delay Factors	Authors											No of Appearances		
	Kasim	Frimpong	Walker	Chan	Haseeb	Baloyi	Marzouk	Mulla	Albogamy	Sunjka	Van		Ling	Fugar
Low productivity of work					X									
Project location					X									
Changes to government regulations and laws					X									
Effect of sub-surface conditions					X									
Baloyi and Bekker (2011: 52)														
Incomplete drawings					X	X		X						3
Design changes						X								
Clients' slow decision making				X		X	X							3
Late issue of instructions						X								
Shortage of skilled labour						X		X						2
Poor planning and scheduling			X		X	X	X	X	X					6
Labour disputes and strikes						X								
Shortage of manpower						X								
Change orders by client during construction				X		X	X	X				X		5
Poor information dissemination						X					X	X		3
Delay in work approval						X								
Marzouk and El-Rasas (2012: 50)														
Finance and payments of completed work by owner	X				X	X	X	X						5
Variation orders/changes of scope by owner during construction			X		X	X	X					X		5
Effects of subsurface conditions (e.g. soil, high water table, etc.)						X								
Low productivity level of labour						X								
Ineffective planning and scheduling of project			X		X	X	X	X	X					6
Difficulties in financing project by contractor						X								
Type of project bidding and award (negotiation, lowest bidder)						X	X	X						3
Shortage of construction material in market						X								
Late in approving design documents by owner						X								
Unqualified workforce						X								
Mulla and Waghmare (2015)														
Inaccurate estimate of time and cost							X						X	2
Faulty design							X		X					2
Land acquisition problems							X							
Poor bidding						X	X	X						3

Table 2-7: Project delay factors' matrix

Project Delay Factors	Authors											No of Appearances	
	Kasim	Frimpong	Walker	Chan	Haseeb	Baloyi	Marzouk	Mulla	Albogamy	Sunjka	Van Ling		Fugar
Irregular flow of finance								X					
Delay in payment of work	X		X				X	X					4
Deficiencies in management	X							X	X	X		X	5
Delay in making decision by client, architect				X		X		X					3
Lack of coordination between different parties involved			X	X				X		X			4
Change in work scope				X		X	X	X				X	5
Albogamy et al. (2012: 149)													
Low performance of the lowest bidder contractor in the government tendering system								X	X	X			3
Delays in subcontractors work									X				
Poor qualification, skills, and experience of the contractor's technical staff									X				
Poor planning and schedule of the project by the contractor			X		X	X	X		X	X			6
Delay in progress payment by the owner	X				X		X	X	X				5
Shortage of qualified engineers						X			X				2
Delay in preparation shop drawings									X				
Cash flow problems faced by contractor					X	X			X				3
Inadequate early planning of the project									X				
Non-utilization of professional construction contractual management	X							X	X	X		X	5
Sunjka and Jacob (2013: 8)													
Youth unrest, militancy and communal crises									X				
Inadequate planning by the contractors			X		X	X	X		X	X			6
Delay or non-payment of compensation to the communities									X				
Wrong choice of consultants and contractors by the clients									X				
Weather condition									X				
Late identification and resolution of drawings and specification errors and omissions by the consultants									X				
Lack of community buy-in									X				
Poor contract management by the consultants	X							X	X	X		X	5
Inappropriate design by the consultants								X	X				
Unrealistic contract duration by the clients									X				
Poor coordination of sub-contractors by the contractors			X					X	X				3

Table 2-7: Project delay factors' matrix

Project Delay Factors	Authors											No of Appearances	
	Kasim	Frimpong	Walker	Chan	Haseeb	Baloyi	Marzouk	Mulla	Albogamy	Sunjka	Van		Ling
Van et al. (2015: 92)													
Information delays, lack of information exchange between the parties					X					X	X		3
Incompetent owner										X			
Incompetent supervision				X						X		X	3
By Ling and Lau (2001: 421)													
Multiple contracts in which one contractor was dependent on the other contractor											X		
Inaccurate project information supplied from one contractor to the other					X					X	X		3
Excessive change orders by the client			X		X	X	X				X		5
Ineffective communication among the project participants											X		
By Fugar and Agyakwah-Baah (2010)													
Delay in honouring certificates												X	
Underestimation of the cost of project							X					X	
Underestimation of complexity of project												X	
Difficulty in accessing bank credit												X	
Poor supervision			X							X		X	3
Underestimation of time for completion of projects by contractors						X						X	2
Shortage of materials												X	
Poor professional management												X	
Fluctuation of prices, rising cost of materials												X	
Poor site management	X						X	X	X			X	5

2.5 Effect of project management elements on project delays

In § 2.3, the following project management elements have been identified and linked with project delays influential factors identified by (Frimpong et al., 2003) as shown in Table 2-1.

- Risk management and project planning.
- Quality management.
- Procurement management.

Evaluation of effects of these elements on project delay is reviewed in this section.

2.5.1 Effect of risk management and project planning on project delay

In non-projects, repetitive operations tend to be familiar and stable, whereas in projects, where resources, schedules, work tasks and others have to be managed, unexpected events are often unfamiliar and in a constant state of change (Nicholas and Steyn, 2012: 87). Project uncertainty is a great challenge for most of the projects that may challenge set targets (Thamhain, 2013: 20). Managing of construction projects involve a great deal of managing risk (Kikwasi, 2012: 53). Analytical models indicate that project delays result from excessive iteration for rework related to uncertainty, and excessive communication for coordination (Mitchell and Nault, 2007: 375). All projects contain an element of uncertainty and unforeseen obstacles can cause missed deadlines, cost overruns, and poor project performance (Nicholas and Steyn, 2012). Various studies have identified sources and types of construction risks that need to be managed as part of project management process and there are also risks and factors that affect the construction project delivery time (Kikwasi, 2012: 52). Planning for delays is not about being negative, but being realistic about the construction process. The knowledge of the risk that is posed by delays in a specific environment and type of project is of paramount importance in delay mitigation that will save time in the end (Cruywagen, 2012). Early resolution of uncertainty, when design requirements are known and stable, mitigates the risk of project delay (Mitchell and Nault, 2007: 375). Nicholas and Steyn (2012) suggested that managers must try to anticipate the problems, plan for them, and adjust activities and shift resources to mitigate or overcome them.

Project risk management includes the process of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project (PMBOK(R)_Guide, 2013). The practice of risk management needs to expand beyond the common, yet overly simplistic approach of identifying the most obvious and expected risks during project planning, then categorise these as low, medium, and high risk, reviewing them, and update the risk register once a year (Schroeder and Hatton, 2012: 410).

In order to reduce delays, skilled and experienced project managers, technical staff, and workers should be sourced to assist in improving work performance (Haseeb et al., 2011). The capacity of the project team to predict possible delays will lower the risk when delays do occur and will limit the negative effect as they can be taken into consideration in the planning process for the project (Cruywagen, 2012).

The need for planning in project development and delivery is crucial because of the complex nature of resources, processes, activities, and parties that are involved (Idoro, 2012: 83). Chalabi and Camp stressed that adequate construction planning at very early stages of the

project is important to limit delays and cost overruns (Chan and Kumaraswamy, 1997: 55). Many researchers consider project planning as one of the components of project delivery process and use project performance as the basis of evaluating its effectiveness (Idoro, 2012: 83). PMBOK^(R)_Guide (2013: 49) identified the following project management processes which are grouped into five categories known as project management process groups:

- **Initiating Process Group:** Those processes performed to define a new or a new phase of existing project by obtaining authorisation to start the project or phase.
- **Planning Process Group:** Those processes required to establish the scope of the project, refine the objectives, and define the course of action required to attain the objectives that the project was undertaken to achieve.
- **Executing Process Group:** Those processes required to complete the work defined in the project management plan to satisfy the project specifications.
- **Monitoring and Controlling Process Group:** Those processes required to track, review, and regulate the process and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes.
- **Closing Process Group:** Those processes performed to finalize all activities across all process groups to formally close the project or phase.

A process is a set of interrelated actions and activities performed to create a predetermined product, service, or results (PMBOK(R)_Guide, 2013). The key purpose of initiating process group is to align the stakeholders' expectations with the purpose of the project, reveal the scope and objectives, and demonstrate how their participation in the project and its associated phases can ensure that their expectations are achieved (PMBOK(R)_Guide, 2013).

2.5.2 Effect of quality management on project delays

During the construction of Flamanville 3 nuclear power plant, Ruuskaa et al. (2010: 654) suggested that the French nuclear regulator (ASN) stop concrete pouring activities because of concerns regarding the quality management system of the French electricity company (EDF). In order to restart the work, EDF submitted to the ASN an action plan to improve the efficiency of the quality management system. The quality management issue in the Flamanville project caused a delay on the progress of the project. Ruuskaa et al. (2010: 656) further added that the Olkiluoto 3 nuclear power project lacked monitoring policies for ensuring that the various organizations have implemented the required safety and quality standards. Further, the practices related to documentation transfer and the way of

processing them, were unsystematic. Thus, these quality problems challenged the duration of Olkiluoto project.

Aiyetan et al (2008), quoted by Kikwasi (2012: 5) pointed out that there are three most significant factors that adversely affect construction project delivery time. These are:

- Quality of management during construction.
- Quality of management during design.
- Design coordination.

Bowen et al. (2014) argue that, although it is claimed that time, cost, and quality are incorporated in the management of construction projects, research has shown that in fact a time-cost bias exists. Bowen et al. (2014) further added that the client's objectives can be achieved through a management effort that recognises the interdependence of time, cost, and quality.

Total quality management is a system approach to quality management that focuses on the system to produce a quality product, and considers the wider aspect of quality by integrating all of the quality management components into a quality management system (Burke, 2007). Vincent and Joel (1995), quoted by (Bowen et al., 2014) define total quality management (TQM) as "the integration of all functions and processes within an organisation in order to achieve continuous improvement of the quality of goods and services". Saeed and Hasan (2012:12) also define TQM as "a philosophy with a system science point of view that focuses on continuous improvement within the organization so as to provide superior value to customers".

TQM, when well applied, provides substantial benefits by achieving customer satisfaction, improving employee quality awareness and consciousness, reducing quality costs, decreasing wastage, avoiding project delays, improving organizational performance and closer relationships with sub-contractors and suppliers and offers firms a competitive advantage (Kheni and Ackon, 2015:26). Saeed and Hasan (2012:11) added that TQM has positive effects on teamwork satisfaction, quality of construction project implementation, client satisfaction, and construction project performance. (Bowen et al., 2014) posited that in order to achieve successful project quality management, three separate drivers to quality management must be managed, namely:

- Integration of the project team so as to have a single objective and a common culture.
- A customer focus for the team thereby facilitating the provision of products and services that will meet the client needs.

- A process of continuous improvement in the management of the construction project.

2.5.3 Effect of procurement management on project delay

The term 'procurement' encompasses a wide range of activities that includes purchasing of equipment, materials, labour, and services required for construction and implementation of a project (Barrie and Paulson 1992 cited by budget (Kasim et al., 2005: 795). Project procurement has been described as an organized method or process or procedure for clients to obtain or acquire construction products (Rashid et al., 2006: 1). The procurement management process involves soliciting people who can do the work, evaluating their proposals, and reaching an agreement (Nicholas and Steyn, 2012). A process of soliciting people who can do the work is done through tendering. Tendering is the administrative procedure of sending out drawings and bill of quantities or specifications to contractors with the intention to submit a price for the construction of the project (Ogunsanmi, 2013: 217). Rashid et al. (2006: 7) identified the following four procurement systems that have varying effects on project performance based of their respective processes:

- **Traditional Procurement System:** Due to its linear or sequential approach, the traditional procurement system has been identified as the slowest project delivery approach. However, this approach is more preferable because it provides clear accountability and better design and construction control by the client.
- **Design and Build and Turnkey Procurement System:** Often referred to as a "fast-tracking" or "build-it-fast" project delivery system where design and construction are integrated. It also allows the process of detail design and construction to run almost in parallel and concurrently to each other, thus reducing the overall project development period considerably.
- **Management Contracting and Professional Construction Management Procurement System:** This system allows for more efficient and effective coordination of works, materials, manpower and plant, thus making construction time shorter compared to other procurement systems. This is especially so, given the fact that the same management contractor is able to manage and contribute towards the development of the design. It allows the management contractor to improve constructability.

Eriksson and Westerberg (2010: 199) posited that design-bid-build (DBB) involve a complete specification prior to contractor procurement, resulting in a divorce between design and construction, and this separation results in long project duration and decreased joint

problem-solving compared to design-build (DB) contracts. The importance of selection of a procurement method or system has been found to have important influence on time performance of construction projects (Ali et al., 2012: 71). Ogunsanmi (2013: 215) also suggested that the use of these procurement methods or systems can significantly affect the performance of most projects and several studies have also indicated that the selection of a particular procurement system has significant effects on construction project performance. Laedre et al. (2006: 689) contends that, in order to enhance project performance, an increased understanding of how different procurement procedures affect aspects of project performance is vital. Ali et al. (2012) suggested that the procurement methods used in refurbishment projects should have an element of integration between the design and the construction processes.

During the research study on “management of the development of a large-scale power plant project in East Asia”, Ling and Lau (2001: 422) suggested that the excessive change in orders caused a delay in one of the sub-projects in the power plant project. One of the reasons the problem arose was because of the use of design-build (DB) arrangement that was made for the power plant project. Ling and Lau (2001: 420) suggested that the lesson learned is that in deciding on the procurement form, it is important to consider the degree of the client’s involvement in the design. In DB projects, clients should merely define their requirements clearly, and allow the contractor to execute the design and construction without unnecessary interference. If clients want to be deeply involved, develop and construct or traditional design-bid-build (DBB) would be more suitable procurement forms.

CHAPTER 3 – RESEARCH METHODOLOGY

This chapter explore the concept of research methodology by reviewing various literature sources relating to the subject. Various research methodologies are briefly discussed and evaluation is made on how these methods relate to the research study of modification project delays. However, detailed attention is given to the adopted research methodology (Interactive Management) and § 3.3 gives a full discussion of this research methodology.

Research is a habit of questioning what you do, and a systematic examination of clinical observations to find and explain answers for what you perceive, with a view to institute appropriate changes for a more effective professional service (Kumar, 2011: 3). According to Kerlinger (1986: 10) cited by (Kumar, 2011: 28), scientific research is a systematic, controlled empirical and critical investigation of propositions about the presumed relationships about various phenomena. Welman et al. (2005: 2) also defined research as a process that involves obtaining scientific knowledge by means of various objective methods and procedures. The term 'scientific' is not restricted to knowledge in certain fields of study only; many fields of study besides physics, chemistry, and surgery may lay claim to being scientific (Welman et al., 2005: 2). Research involves systematic, controlled, and valid and rigorous exploration and description of what is not known and the establishing of association and causation that permit the accurate prediction of outcomes under a given set of conditions (Kumar, 2011: 41).

3.1 Reflection on prominent methods used to identify project delay factors

§ 2.3 of this document deals with the identification of project delays through various studies previously conducted by various authors in different projects. This section will examine the methods used by these authors in the process of identifying project delays and review the strengths and weakness of concerned methods. Welman et al. (2005: 52) posited that the research data is collected from objects of enquiry to conduct research to investigate the hypothesis or research question in order to solve the problem concerned. From the reviewed project delay literature studies, the objects used to identify factors causing project delays were clients, contractors, and consultants who took part in these projects (Baloyi and Bekker, 2011: 58), (Ling and Lau, 2001: 413), (Albogamy et al., 2012: 149), (Frimpong et al., 2003: 322), (Sunjka and Jacob, 2013: 3), (Marzouk and El-Rasas, 2012: 50).

As discussed in § 2.3 of this document Frimpong et al. (2003), Haseeb et al. (2011), Baloyi and Bekker (2011), Marzouk and El-Rasas (2012), Mulla and Waghmare (2015), Albogamy et al. (2012), Sunjka and Jacob (2013), and Van et al. (2015) conducted their research studies relating to identification of project delay factors on different projects. The authors

mentioned above made use of questionnaire methods to collect the data needed for analysis during their research studies. According to Baloyi and Bekker (2011: 59), the main purpose of the question during the study of identifying project delay and cost overrun in 2010 FIFA world cup stadiums was to assess the perception of respondents regarding the factors that caused project delays and cost overruns. A questionnaire is a set list of questions, the answers to which are recorded by the respondents (Kumar, 2011: 138). Welman et al. (2005: 174) suggested that the questions in a questionnaire can be made to be open-ended in which the respondents have to formulate their own responses. On the other hand, the questions in the questionnaire can be represented as multiple-choice (closed) questions in which the respondents have to select the most suitable response. Sunjka and Jacob (2013: 8) indicated that open-ended questions were used during their study of significant causes and effect of project delays in the Niger Delta region, Nigeria. Baloyi and Bekker (2011: 59) argued that the research method of extended questionnaire or interviews has been a proven application of identifying project delays. However, Welman et al. (2005: 175) highlighted the following advantages and disadvantages of both open-ended and close-ended questionnaires:

Advantage of open-ended question

- The respondent's answer is not influenced unduly by the interviewer or the questionnaire and the verbatim replies from respondents can provide a rich source of varied material which might have been untapped by categories on a pre-coded list.

Disadvantage of open-ended question

- Require ability to express oneself.
- Require a higher level of education on the part of respondents than with multiple choice items.
- The respondent may be unwilling to exert the special effort required by open ended questions.
- Responses obtained are more difficult to score.
- More time is needed for scoring than multiple choices.
- More difficult to compare different respondent responses than with multiple choice.
- Possibility of obtaining inappropriate responses is greater.

Advantages of closed or pre-coded questions

- Do not rely on the ability of respondents to express themselves.

Disadvantage of closed or pre-coded questions

- Inappropriate response may be obtained from the responses when the respondents are unfamiliar with the answers or do not have an opinion, and may respond in a lackadaisical manner.
- Some respondents may feel irritated because multiple choice items restrict them to particular responses that may not provide a unique situation. As a result, they may prefer the freedom to express themselves in a way that is allowed in open questions.

Furthermore, Kumar (2011: 141) identified the following advantages and disadvantages of the questionnaire without grouping them as open-ended or closed questions:

Advantages of Questionnaires

- **Questionnaires are less expensive:** No need to conduct interviews with respondents, which saves time and human and financial resources. The use of a questionnaire, therefore, is comparatively convenient and inexpensive.
- **Questionnaires offers greater anonymity:** In situations where sensitive questions are asked it helps to increase the likelihood of obtaining accurate information as there is no face-to-face interaction.

Disadvantages of Questionnaire

- Application is limited to a study population that can read and write. It cannot be used on a population that is illiterate, very young, very old, or handicapped.
- Questionnaires are notorious for their low response rates, that is, people fail to return them. The response rate may sometimes be as low as 20 per cent.
- There is a self-selecting bias. Those who return their questionnaire may have attitudes, attributes, or motivations that are different from those who do not. Hence, if the response rate is very low, the findings may not be representative of the total study population.
- Opportunity to clarify issues is lacking. If, for any reason, respondents do not understand some questions, there is almost no opportunity for them to have the meaning clarified unless they get in touch with the researcher (which does not happen often). If different respondents interpret questions differently, this will affect the quality of the information provided.

- The questionnaire may lack proper representation of the object of enquiry as respondents may consult each other before responding the questions, and also the response to specific questions may be influenced by the response in other questions.

Although a questionnaire has several disadvantages, it is important to note that not all data collection using this method has these disadvantages (Kumar, 2011: 141). Ling and Lau (2001) conducted a study on the management of the development of a large-scale power plant project in East Asia based on design-build arrangement. From their study, problems encountered during the project were presented and some of these problems resulted to project delays and discussed in § 2.3. Mulla and Waghmare (2015) conducted a study of factors causing time and cost overruns in the construction projects and their remedial measures. Ruuskaa et al. (2010) conducted a study on a new governance approach for multi-firm projects: “Lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant”. Ling and Lau (2001), Ruuskaa et al. (2010), and Mulla and Waghmare (2015) used a case study approach during their research study. In a case study, the focus of attention is the case in its idiosyncratic complexity, not on the whole population of cases. Therefore, the case study usually uses purposive, judgemental, or information-oriented sampling techniques (Kumar, 2011: 123). This has been observed on the study cases of the authors mentioned above and the interview sessions were one of the methods used for data collection. However, Palys (2008: 697) suggested that the biggest questions all researchers need to ask themselves are what they want to accomplish and what they want to know. Thereafter, the appropriate sampling strategy will follow from the answers obtained from these questions. Kumar (2011: 142) 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.

- 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.
- The researcher may introduce his or her bias by the framing of questions and the interpretation of responses.

The methods used by different researchers to identify factors causing project delays have their advantages, disadvantages, and limitations as described above. However, the author of this document is of the view that the methods used by authors who conducted their research studies of identifying project delay factors lack the ability to identify interdependence among the project delay factors. Some authors considered the evaluation of the significance of the factor based on the opinions of the research participants, and the platform to challenge their opinions by providing different perspectives was not provided by closed questionnaire methods. This argument is also supported by Van et al. (2015: 93) as he alleged that most of the previous studies conducted on project delays only focused on ranking the causes of delay according to separate perspectives of different parties, and then as a whole. This method or approach used to determine the significance of delay factors is not quantifiable, but rather based on the feelings and views of the individual participant when responding to the questionnaire. By being not quantifiable, it means there is a lack of rigid measurable reasons or even justifiable reasons for a participant to assign a specific significance to a delay factor. A participant is only dependent on his or her feelings, intuition, and viewpoint when assigning the significance to a delay factor. This exudes an element of subjectiveness as the participant may have his or her single viewpoint without anyone challenge. While we observe a phenomenon, the intercepted pictures, manipulated by our mental activities, are converted into various images and the distinct intercepting positions and different manipulations lead to diverse perceptions (Tuan, 2003: 64). Tuan (2003: 64) further argued

that perhaps these perceptions possess similar attributes; nevertheless, they are not exactly identical. A process of clarifying the perception may bring about consensus.

Tuan (2003: 69) posited that “participation” is an indispensable concept to cope with complexity and a mechanism is needed in which relevant stakeholders are able to “rationally interact” with each other and, by doing so, produce comprehensible results. The author of this document recognizes the importance of interdependency among the project delay factors. Interdependency means one factor leading to or causing another factor. For example, a relationship may exist between improper planning and scope growth, and these two factors may be considered as project delay factors. Evaluation of relationship may help to reveal the effect of one factor to another factor and in this way, the significance among the delay factors can be determined. Once the effect of one factor to the other is identified, a solution may easily be applied and focused on the delay factors that cause other delay factor(s). This chapter will introduce the methods and techniques which further elaborates on the identification of delay factors to include relationships among them. Capra (1996) cited by (Jackson, 2003: 3) posited that the more we study the major problems of our time, the more we come to realise that they cannot be understood in isolation. They are systemic problems, which mean that they are interconnected and interdependent.

3.2 Types of research

Different research types identified by Kumar (2011) are presented under this section of the document. However, it should be noted that the research methodology used for the study of modification project delays is interactive management discussed in detail in § 3.3. Kumar (2011: 29) postulated that types of research can be looked at from three different perspectives, namely the applications of findings of the research study, objectives of the study, and mode of enquiry used in conducting the study. Each perspective has different categories that are listed and explained below.

Application Perspective Research Type

- **Pure research** involves developing and testing theories and hypotheses that are intellectually challenging to the researcher, but may or may not have practical application at the present time or in the future.
- **Applied research** ensures that the research techniques, procedures, and methods that form the body of research methodology are applied to the collection of information about various aspects of a situation, issue, problem, or phenomenon so that the information gathered can be used in other ways such as for policy

formulation, administration, and to bring about a better understanding of a phenomenon. Most research studies in social sciences are applied research.

Objective Perspective Research Type

- **Descriptive Research** attempts to systematically describe a situation, problem, phenomenon, service, or programme, or provides information about. For instance, the living conditions of a community, or describes attitudes towards an issue.
- **Correlational Research** is used to discover or establish the existence of a relationship, association, or interdependence between two or more aspects of a situation.
- **Explanatory research** attempts to clarify why and how there is a relationship between two aspects of a situation or phenomenon.
- **Exploratory research** is when a study is undertaken with the objective either to explore an area where little is known or to investigate the possibilities of undertaking a particular research study. Examples of exploratory study include, but are not limited to, feasibility study or pilot study.

Mode of Enquiry Perspective Research Type

- In a **Quantitative or Structured research** approach, everything that forms the research process, i.e. objectives, design, sample, and the questions that you plan to ask of respondents, is predetermined. The structured approach is more appropriate to determine the extent of a problem, issue, or phenomenon.
- **Qualitative or Unstructured research** approach, by contrast, allows flexibility in all these aspects of the process, and is predominantly used to explore its nature, in other words, variation or diversity per se in a phenomenon, issue, problem, or attitude towards an issue.

Stainback and Stainback (1984) cited by (Welman et al., 2005: 9) allege that both quantitative and qualitative researchers aim at reliable and valid results. Validity and verifiability are the concepts that imply that whatever the conclusion, the basis of the findings is correct and can be verified (Kumar, 2011: 29). However, there are aspects of quantitative research that are qualitative in nature and this depends upon how a piece of information has been collected and analysed (Kumar, 2011: 19). Qualitative researchers are less often interested in asking about central tendency (e.g. “what do most people in this population think about an issue?”), and much more interested in case study analysis—why particular people (groups) feel in a particular ways, the processes by which these attitudes are constructed, and the role they play in dynamic processes within the organization or group

(Palys, 2008: 697). On the hand, Kumar (2011: 104) is of opinion that, the qualitative–quantitative–qualitative approach to research is comprehensive and worth consideration. This involves starting with qualitative methods to determine the spread of diversity, using quantitative methods to quantify the spread and then going back to qualitative to explain the observed patterns (Kumar, 2011: 104).

Based on the description of research types given above, the identification of factors causing untimely delivery of modification projects can be considered under different research perspectives. These include application research perspective, under which the applied research type appears to be appropriate and the mode of enquiry perspective with qualitative an approach taking part of the study. Interactive Management methodology will involve the use of “open-ended questionnaires” in which participants are required to list factors they believe to be the cause of modification project delays. The researcher’s view is that this part of the interactive management methodology correspond well with the approach of qualitative methods to determine the spread of diversity as described by Kumar (2011) above.

The information gathered from the “factors causing delay of modification projects” research study will be made available to Koeberg Power Station management to make strategic decisions and possible organizational process changes to deal with the issue of modification project delays. If Koeberg Power Station management decide to use information gathered from the research study in making process changes, that would demonstrate a completion of applied research type. Correlation research type elements are anticipated to be seen during the study of modification project delays, when an effort to evaluate interdependency among modification delay factors is completed. However, it is important to note that a study to determine factors that delay modification projects is not a correlation research type, although the correlation of some aspects of the study will be examined.

3.3 Research design

A research design is a plan according to which we involve research participants (subjects) and collect information from them (Welman et al., 2005: 52). Kumar (2011: 95) also added by defining the research design as “a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems”. The main function of a research design is to explain how one will find answers to research questions and it should include the study design and the logistical arrangements that is proposed to be undertaken, the measurement procedures, the sampling strategy, the frame of analysis, and the timeframe (Kumar, 2011: 41). The research study for identification of factors causing modification project delays at Koeberg Power Station is a single case study focusing on a Koeberg Power

Station case. Conclusion with regard to the research study will be made based on the data collected from Koeberg Power Station participants.

3.3.1 Interactive management in identifying modification project delay factors

Interactive management (hereinafter referred as IM) is the research methodology adopted by the researcher, and which will be used for the study of identifying factors causing delays of plant modification projects at Koeberg Power Station. The development of IM is based on the recognition that for coping with complex situations there is a need for a group of people, knowledgeable of the situation, to tackle together the main aspects of concern, to develop a thorough understanding of the situation under analysis and to elaborate on the basis for effective action; all these are founded in a spirit of collaboration, commitment, and within the framework of a serious and organized effort (Warfield and Cardenas, 2002: 1). Tuan (2003: 68) posited that varieties amongst a group of people are greater than that of an individual because generally, each person captures only a portion of a problematical situation. However, through group collaboration, conjoining various angles to promote versatile solutions can generate larger varieties and that can expand the breadth and depth of our horizon spectrum. In some way, they increase the variety in a designing system, which is vital to unravel a “messy situation”.

Warfield and Cardenas (2002: 1) further define IM “as a system of management invented explicitly to be applied intermittently in organizations to enable those organizations to cope with issues or situations whose scope is beyond that of the normal type of problem that organizations can readily solve”. IM is one of system thinking approaches. Systems thinking eschews simple solutions to complex problems and embraces holism and creativity to handle complexity, change and diversity (Jackson, 2003: xx). Jackson (2003: xx) suggested that the notions of holism and creativity are initially a little more difficult to grasp than the fads and panaceas prepared in easily digestible form for managers to consume. Furthermore, Warfield (1999: 5) suggested that today, it appears that there is only one sound alternative in managing complexity, and that is interactive management, whose advocates claim that it satisfies all the following defining requirements for complexity resolving systems:

- **Full disclosure:** Its explanation is widely available in the literature.
- **Replicability of activity:** The explanation is in significant depth, so that replication is possible.
- **Specializing in resolving complexity:** It is intended only for resolving complexity in organizations.

- **Sizeable record of value-adding application:** It has been applied in many organizations and has added significant value.
- **Founded in science:** It is founded in science.

Initiation, development, and execution of modification projects in a nuclear power plant are subjected to various processes and requirements before they can be confirmed successfully completed. These requirements and processes could influence one or more of the project success factors. Timely delivery of projects is one of the project success factors, and as such the identification of factors causing project delays is viewed, in the context of this research, as a complex issue or situation.

Beer (1979), cited by Tuan (2003: 64), postulates that complexity can be denoted by variety, which is defined as the number of possible states of anything of which one needs to measure the complexity. During interpretive structural modelling technique, which is part of interactive management process, the participants will be asked to answer the questions presented by the computer, and the final answers to those questions are based on a democratic rule where the majority leads. It is also during this process where participants will be asked to give rationales for their individual decisions in order for the others to be exposed to different points of view and information, and then to have a better basis for a final decision regarding the questions under consideration. It is in this “exchange” of points of view where most of the learning during the IM activity takes place among the participants (Warfield and Cardenas, 2002: 92).

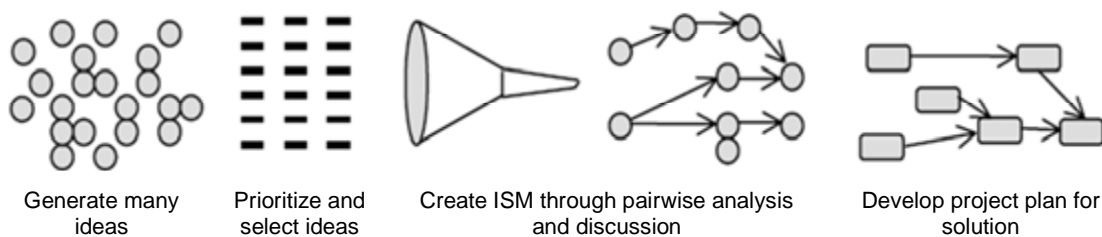
Although Baloyi and Bekker (2011: 59) suggested that the research method of extending questionnaires or interviews has been a proven application of identifying project delays, the further step in the context of modification projects in a nuclear power plant will be considered. This step involves establishing the interrelationships or links among the identified delay factors using the interactive management methodology and this approach, as described in the above paragraph, is part of holism. Holism considers systems to be more than the sum of their parts, and of course interested in the parts and particularly the networks of relationships between the parts, but primarily in terms of how they give rise to and be sustained in existence (Jackson, 2003: 4). In the research study for “identifying factors causing modification project delays”, the combination of modification projects and project related processes in a nuclear power plant which have influence in modification projects, will be considered as a system. A system is a complex whole, the functioning of which depends on its parts and the interactions between those parts (Jackson, 2003: 3). Jackson (2003: vii) further posited that complexity stems from the nature of problems that rarely present themselves individually, but come related to other problems in a richly interconnected

problem situation that are appropriately described as “messes”. As a result, once examined, problems seem to get bigger and to involve more issues and stakeholders. IM is a system thinking approach which will be used to examine the complexity of modification project delay factors. The intent is to advance the identification of project delay factors and investigate how these factors influence each other through the assessment of their interrelationships.

Previous studies on the subject of identifying factors causing project delays have focused on reducing the subject to just the trimming of a large number factors to a manageable number deemed significant to cause project delays. This approach is similar to an approach of individually optimising specific elements of the system or organization, referred by Jackson (2003: xiv) as sub-optimization. Jackson (2003: xiv) suggested that these simple solutions to problems fail simply because they concentrate on parts of the organization rather than the whole. In doing so, they miss the crucial interactions between the parts and they fail to recognize that optimizing the performance of one part may have consequences elsewhere that are damaging for the whole (Jackson, 2003: xiv).

3.3.2 Interactive management processes

Warfield and Cardenas (2002: 85) posited that it cannot be denied that sub-areas such as banking, electrical engineering, writing legislation, developing computer software, or designing power plants possess some unique aspects. However, the uniqueness in processes within these fields is much less than might be imagined and the processes can be shared across vast territories. Interactive management (IM) methodology will be applied in the identification of project delay factors through the use of the idea writing technique, nominal group technique, and interpretive structural modelling technique. These techniques entail processes that exhibit common features that can be used across the techniques, and this demonstrates the less uniqueness of processes in various techniques which is sometime time the case in different fields. Figure 3-1 shows the process or steps of interactive management which will be followed to identify factors causing modification project delays.



Source: Sorach Inc, 1999:3

Figure 3-1 Fundamental steps to construct an effective ISM

The above figure depicts the idea writing technique as generate many ideas, the nominal group technique as prioritize and select ideas, and the interpretive structural modelling technique as create ISM through pairwise analysis and discussion. However, it should be noted that the last step (develop project plan for solution) will be omitted in this research study as the research scope is only limited to the first three steps.

3.3.2.1 Idea writing and nominal group techniques

The idea writing technique and the nominal group technique are both discussed under this section as one technique, is an extension of another technique; namely the nominal group technique, which is a continuation of idea writing technique. (Warfield and Cardenas (2002: 87) describes nominal group technique as a process of generating ideas, clarifying ideas, doing a preliminary partitioning of the set of generated and classified ideas, based on a criterion of relative saliency, and helping to build a spirit of participation and teamwork or group morale. On the other hand, idea writing is described as an efficient idea generation process for eliciting many ideas relevant to a stated issue from one or more small groups (Warfield and Cardenas, 2002: 85). The idea writing technique is characterized by the following four attributes which make it suitable for certain cases over the nominal group technique:

- It can be more easily learned by facilitators.
- It requires less time, perhaps only about 20% as much time as the nominal group technique.
- Many groups can carry out idea writing simultaneously.
- It is less demanding on physical facilities and space availability for wall displays.

Both the idea writing and nominal group technique processes are initiated by carefully formulating a triggering question (Warfield and Cardenas, 2002). The triggering question that we seek to address in this research study has been described in Chapter 1 of this document. The triggering question to be addressed during the process of identifying modification project delay factors is; which factors influence plant system modification projects and lead to the delay of project delivery? This question will be addressed through the processes of the idea writing and nominal group techniques. Open ended questions will form part of the process in which participants will be asked to indicate in their opinion on factors causing untimely delivery of modification projects. § 3.1 of this document exhaustively discussed advantages and disadvantages of open ended questions in detail.

IM methodology involves examination and investigation of the stated problem through participation of personnel who are invested with knowledge in a particular field. This inherently addresses the following two disadvantages of open-ended questions mentioned in § 3.1:

- Requirement of the ability to express oneself.
- Requirement of high level of education on the part of respondents than with multiple choice items.

In addition, the type of sampling to be used to collect data for identifying factors causing untimely delivery of project in a nuclear power plant is a purposive sample method. Welman et al. (2005: 69) describes purposive sample as one of non-probability sampling in which researchers rely on the participants' experience, ingenuity, and previous research findings to deliberately obtain units of analysis in such a manner that the sample obtained may be regarded as being representative of the relevant population. As part of the interactive management methodology the researcher will rely on the participants' experience with modification projects for gathering data. Therefore, elected personnel from specific departments will be used as research participants for the study and that constitutes a purposive sample.

3.3.2.2 Interpretive structural modelling

Interpretive structural modelling (hereafter referred as ISM) is a management decision making tool that links ideas to facilitate thorough understanding of complex situations by helping the human brain to organize information and ideas in a clear manner to facilitate a better understanding of the various aspects of the problem (Sorach_Inc, 1999: 2). Sorach_Inc (2014: 1) cited that in 1973, J. Warfield proposed ISM as an effective method to understand complex situations and finding solutions to difficult problems. Since then, ISM has been used worldwide by many prestigious organizations, including NASA. Tuan (2003: 70) suggested that at inception, Warfield (1976) devised ISM as a tool for solving systems engineering problems. In the on-going elaboration, ISM is refined and elevated to interactive management and can enable a group of people collectively to build a model that manifests the interrelation of systems or components. ISM process provides the means to enable groups to structure information with computer assistance, while simultaneously clarifying the component ideas to produce a model (Warfield and Cardenas, 2002: 91). However, Sorach_Inc (1999: 9) argue that an individual can construct a model using ISM for a limited number of ideas (less than 8) by manually structuring ideas with just a paper and pencil. The technique consists of writing each idea on an individual card, then manually applying the

principles of pairwise comparison and transitive logic to arrange the cards into the outline of the ISM, without showing the linking relationship arrows. When the outline is completed, it is copied onto paper and the relationship arrows are drawn.

ISM untangles a complex issue by allowing the user to focus on only two ideas at a time and these ideas and their relationships are analysed within the framework of the issue being studied (Sorach_Inc, 1999: 2). Warfield and Cardenas (2002: 91) pointed out the following attributes and procedure with respect to the use of ISM:

- The technique is useful when a complex issue is under study, and there are interactions among the diverse elements of the issue.
- A focused group discussion on the issue is needed on the way to the development of one or more relationship maps.
- Elements of the issue will be available from prior work, frequently as a consequence of use of the nominal group technique and the entire element set that has been developed from the nominal group technique activity will be entered into a computer.
- The machine will present inquiries visually to the group, which discusses them and makes judgments about relationships of the elements.
- Following the completion of the computer-questioning and group discussion of the questions, the computer computes information needed to construct and display a map of the relationship among the elements.

ISM uses pairwise analyses of ideas to transform a complex issue, involving a lot of ideas, thus synthesizing a model which makes the situation understandable in a form of a structured relationship model that is easier to understand as shown in Figure 3-2 (Sorach_Inc, 1999: 3). Figure 3-2 shows a situation in which the interrelationship of ideas is not clear before the ideas are processed by using the ISM tool. However, there is little understanding that an interrelationship among the ideas exist. Once ideas are processed through use of the ISM tool, a better understanding and clear relationship among the ideas is established.

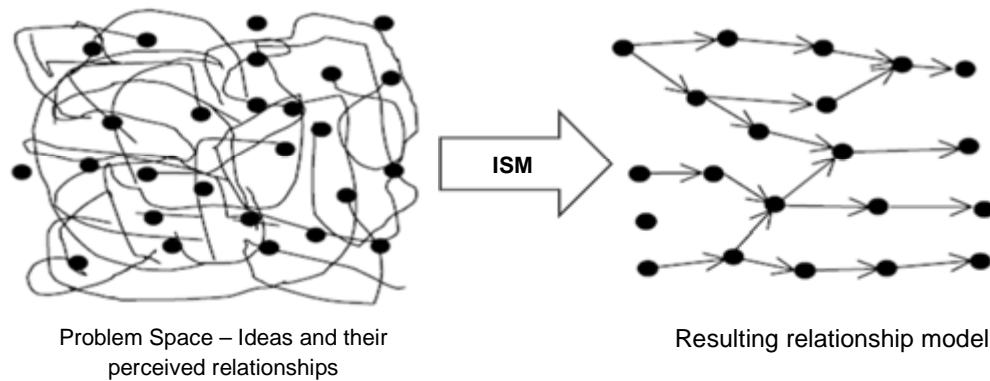


Figure 3-2: Conceptual view of ISM (Sorach_Inc, 1999: 3)

For the purpose of identifying interrelationships and interdependency among the project delay factors on modification project, Concept Star application software will be used to facilitate the interpretive structural modelling process.

Advantages of interpretive structural modelling

Sorach_Inc (1999: 6) suggested that ISM offers many advantages over other methods used for analysis and decision making:

- The ISM method addresses many communication problems associated with problem solving in a group environment, such as lack of common language and importance of buy-in of solutions.
- In a group situation, the pairwise analysis of ideas encourages contributions from people who understand the issues being discussed, but may not understand all issues related to the problem.
- Most available management tools are dichotic processes; they break a problem down into smaller parts. ISM is a synthetic process. It builds a higher-level concept from a collection of seemingly disjointed ideas.
- Constructing an ISM forces people to make decisions. The final solution decided is actually the result of many smaller decisions that are made in the process of constructing the model.
- Hundreds of ideas can be dealt with methodically with the help of an ISM computer tool. ISM is easy to learn and use. It is based on the concepts of pairwise comparison and transitive logic, which most people already use in everyday life.

3.4 Ethics clearance

This research study involves human participants for the collection of data. According to the UCT ethics code, research clearance is required for conducting research work which involves the collection of data or about living people. The researcher approached senior management at Koeberg Power Station before starting with the research. A verbal agreement was granted for the researcher to conduct the research study as it was clear that the research would not infringe on Eskom intellectual property and contravene with any Eskom ethics code. In addition, the researcher is an Eskom employee and he is familiar with the ethics code required to protect Eskom information.

The researcher also submitted the ethics clearance application to the faculty of Engineering & Built Environment for approval. The application constituted a research proposal, interview questionnaire (refer to Appendix 1), application for ethics clearance form, and the information sheet and consent form (refer to Appendix 2). Ethic approval is shown in Appendix 3.

CHAPTER 4 – DATA COLLECTION AND ANALYSIS

4.1 Data collection

The interpretive structural modelling (ISM) technique, which is part of the interactive management (IM) methodology, is useful when a complex issue is under study, and there are interactions among the diverse elements of the issue. A focused group discussion on the issue is needed to develop one or more relationship maps during ISM workshop session. (Warfield and Cardenas, 2002: 91). For this, a group of focused participants needs to be assembled from identified groups of populations who are knowledgeable about subject being investigated. As indicated in § 3.3.2.1 of this document, this is referred to as the purposive sample method. Purposive sample is one of non-probability sampling in which the research relies on the experience and ingenuity of participants, and previous research findings to deliberately obtain units of analysis in such a manner that the sample they obtain may be regarded as being representative of the relevant population (Welman et al., 2005: 69). Embedded in this is the idea that who the person is and where that person is located within a group is important, unlike other forms of research where people are viewed as essentially interchangeable (Palys, 2008: 697). Therefore, specific individuals within the Koeberg Power Station organization were approached by the researcher and a request was made to these individuals to participate in the research study of identifying factors causing modification project delays.

4.1.1 Selection of participants based on designation per department

As discussed in § 4.2 of this document, the IM methodology requires participants who are knowledgeable about the issue being studied. Therefore, the criterion which seeks to answer the following questions was considered to identify the participants towards the research study:

- Who makes the decision for modification projects to be initiated?
- Who is affected or interested in the modification projects?
- Who can influence its adoption or implementation
- Who is interested in modification projects?

The above questions are similar to the questions that need to be considered when developing a communication plan for a project. Nokes and Kelly (2007: 256) define communication plan as “the process of determining the information and communication needs of stakeholders: who they are, what is their level of interest and influence in the

project". The above criteria were developed for the purpose of this research study project taking cognisance of the key stakeholders for modification projects. A stakeholder is an individual, group, or organization who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project (PMBOK(R)_Guide, 2013: 30). The research participants and their role in modification projects as stakeholders are discussed below. The researcher is of the view that these participants are knowledgeable in terms of modification projects and applicable processes that influence the success or failure of modification projects. Therefore, with the research study focus being identification of project delay factors, it was believed that chosen participants will have a meaningful contribution in helping to identify the project delay factors.

4.1.1.1 Decision making to initiate modification projects

System engineers in the Plant Engineering Department (PED) are responsible for technical performance, the health, and the capabilities of systems at Koeberg Power Station, and are required to be recognized as experts of the systems' performance. They should be continuously aware of the condition of plant systems and are responsible for resolving engineering problems related to the condition or performance of their systems, propose changes to design bases of their systems, and prepare and update the life-of-plant plans (LOPPs) of their systems (Eskom-KGU002, 2014). Based on the system technical knowledge system engineers have at Koeberg Power Station, they are able to decide and justify the need to initiate modification projects. Therefore, given the above argument, system engineers have been identified to be important stakeholders for modification projects and as such a consideration was made to include them as participants in this research study. However, it is important to note that the proposed modification projects need to go through various senior management committees for approval before resources may be committed towards identified projects.

4.1.1.2 Affected stakeholders by modification projects

As discussed in § 2.1.2 of this document, most plant system modification projects at Koeberg Power Station are executed or implemented during the outage project. The Outage Management Department (OMD) is responsible for the planning and managing all outage projects at Koeberg Nuclear Power Station (Eskom_KGA-040, 2015). To fulfil this role, OMD consists of project managers and project leaders within its organizational structure who perform the planning and management of outage project activities. Project managers and project leaders from both Outage Management Department and Nuclear Project Management (NPM) Department are responsible to ensure that modification projects which

are planned to be executed during a specific outage are integrated with other outage activities to ensure timely delivery of both the modification project and other outage activities. The modification project execution plan developed by the NPM department is incorporated into the outage project master plan developed by the OMD. Therefore, the project managers and project leaders from the Outage Management Department are affected by the implementation of modification projects.

It is important to note that not all modification projects implementation take place during outage projects; some modification projects do not necessarily require the nuclear power plant to be completely shut down before they can be implemented. Only a certain portion of the power plant needs to be shut down for certain modification projects to be implemented. Therefore, OMD is not responsible for the planning of these modification projects. Work Control Group leads the implementation of these modification projects with other online plant maintenance activities which are required to be performed to ensure continuous production of electricity to the national grid. Hence, a selected team from the Work Control Group was also included as participants to the identification of project delay research study.

In addition, the Operating Department is responsible for the safe operation of the plant to ensure continuous production and supply of electricity to the national grid. Modification projects are initiated either to improve efficiency of the plant, upgrade safety features of the plant, and sometime to comply with certain regulatory requirements. The Operating Department is affected by the implementation of modification projects as these projects may introduce a change in the manner in which the plant is operated. As a result, the modification project process requires the Operating Department to review the technical effect of modification projects to the operation of the plant. Therefore, the selected team from the Operating Department are considered to be crucial stakeholders for modification projects and as such are viewed as participants with vested knowledge to help the research study with identifying factors causing modification project delays.

4.1.1.3 Who adopts and implements modification projects

The Nuclear Project Management (NPM) department is responsible for the planning and execution of modification projects at Koeberg Power Station. Project managers and project leaders in the NPM department are responsible to ensure that all project activities are completed timely within various project phases shown in the project life cycle model (PLCM) of Figure 4-1. PMBOK^(R)_Guide (2013) PLCM is defined as a collection of sequential or overlapping project phases. The name and number of these phases are determined by organisation or nature of the project, and its area of application (PMBOK^(R)_Guide, 2013).

Therefore, the PLCM shown in Figure 4-1 is specific to modification projects at Koeberg Power Station.



Figure 4-1: Project phases and stage gates

Items indicated with the diamonds (CRA, DRA, ERA, IRA, HOA, and FRA) are the stage gates at which approval is required before proceeding to the next phase. PLCM normally follows a stage gate approach, where project phases in the life cycle of a project are divided into number of stages. Each stage gate should meet certain requirements for project activities to proceed to the next phase (Cooper, 1990: 44). Project managers and project leaders were considered to take part on the research study of identifying factors causing modification project delays.

4.1.1.4 Who is interested in modification projects?

The Koeberg management team, comprising senior members from various departments, have a vested interest in the success of modification projects. Department managers from the Outage Management Department, the Nuclear Project Management Department, and the Plant Engineering Department were also considered to participate in the research study of identifying factors causing project delays.

4.1.2 Research study sample

Warfield and Cardenas (2002: 92) consider the following participants to be adequate for achieving a successful interpretive structural modelling workshop:

- between 6 and 12 participants;
- experienced group leader;
- a computer operator; and
- possibly other staff available to document key comments by the participants.

The required number of participants reflects a similar number setup for a committee organized to review certain issue(s), evaluate available options, and make a collective decisions based on majority rule of committee members. A questionnaire (Appendix 1) was prepared and sent to the participants as a starting point to the research study. The number of participants for collecting or generating ideas through the questionnaire was deliberately increased above the recommended maximum number of 12 participants recommended by Warfield and Cardenas (2002) to 18 participants. The objective for the extension of the number of participants was to assess whether a perception of a multitude of common factors causing modification project delays existed among a bigger population. The idea was not to have all eighteen participants present for the workshop, but rather to expand the idea generation and get more ideas with regard to factors causing modification project delays at Koeberg Power Station.

4.2 Data analysis

This section is divided into two subsections, namely the questionnaire and interview responses, and the interpretive structural modelling workshop. Both these sub-sections are part of interactive management with one action preparing the other and one complementing the other action. Questionnaire and interview responses form part of nominal group Technique described in § 3.3.2.1 of this document. The nominal group technique has several properties and is a process of generating ideas, clarifying ideas, doing a preliminary partitioning of the set of generated and classified ideas based on a criterion of relative saliency, and helping to build a spirit of participation and teamwork or group morale (Warfield and Cardenas, 2002: 87). An interpretive structural modelling workshop is part of interpretive structural modelling described in § 3.3.2.2 of this document.

4.2.1 Questionnaire and interview responses

The questionnaire was structured to provide participants with the opportunity to indicate at least five significant factors which they believed are leading to delays of modification projects. However, to achieve the plan of getting this information from specific participants or stakeholders and measure their designation and experience within Koeberg Power Station, it was important to request the participants to also respond to the following questions in the questionnaire (refer appendix 1):

- The participant's departmental affiliation;
- The participant's experience in terms of number of years in the current job.
- The participant's current position.

- Whether the department makes use of a time parameter to measure project success.
- The participant to indicate at what phase of a project is the time parameter considered significant in his or her department.

4.2.1.1 Participants grouped by departments

Figure 4-2 shows the number of participants who responded to the questionnaire per department according to the hierarchical organizational structure of Koeberg Power Station. NPM represent Nuclear Project Management, OMD represent Outage Management Department, WC represent Work Control, PE represent Plant Engineering, OPS represent Operating Department. Personnel who have a high degree of exposure and involvement to modification projects are personnel from the Nuclear Project Management Department and Outage Management Department. Therefore, the picture of the number of participants per department shown in Figure 4-2 provides a good balance of participants to give significant and reflective information on the challenges encountered to the timely delivery of modification projects.

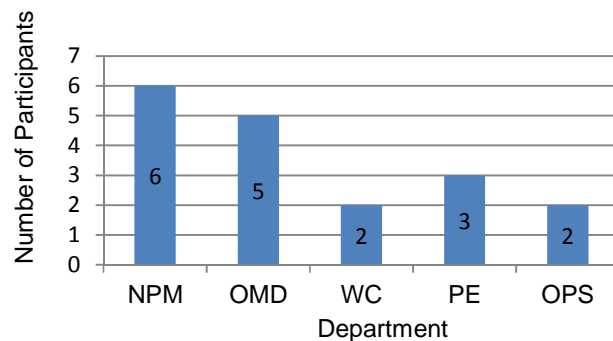


Figure 4-2: Number of participants per department

It is important to note that Figure 4-2 only groups the participants per department, and does not indicate their designation, experience, etc.

4.2.1.2 Participants grouped by experience in number of years

Participants were requested to indicate the number of years' experience in their respective departments, the reason being to gauge their level of exposure to modification projects. The assumption was made that a considerable number of years' experience is an indication of exposure to modification projects and that would enable a participant to provide a profound

insight on factors causing modification project delays. However, it is recognized that there is a possibility for participants to have less number of years' experience than the others, but possess a valuable amount of experience in the field of project management. Or it may be the case that the participants have years' of experience in project management not necessarily at Koeberg Power Station, but in other organizations where he or she was provided with the opportunity to practise project management principles. Figure 4-3 shows the number of years' experience of participants in their respective departments. Most participants have more than five years of experience, about 30% of participants have two to five years of experience, and only one participant have less than two years. About 61% of participants have more than 5 years of experience in their respective departments. Therefore, this provided a degree of confidence towards the factual and accuracy aspect of responses on factors which are believed to be causing project delays identified by the participants.

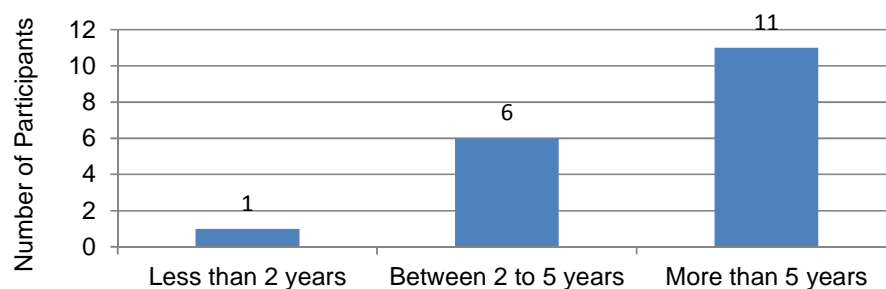


Figure 4-3: Experience of participants

4.2.1.3 Participants grouped by designation

Participants were also requested to indicate their level of seniority within the hierarchy of the Koeberg Power Station organizational structure. This was done to measure the level of exposure to decision making relating to modification projects by the participants. Various decisions with regard to modification projects are made at various levels of the organization. It is believed that the decision making may influence or be influenced by certain organizational factors which could contribute to modification project delays. A sense of knowledge at various organizational levels was deemed important for the research study, and as such participants at various levels were selected for identification of factors causing project delays. Figure 4-4 shows the number of participants and their respective designations within the organizational structure. A large number of participants were project leaders or coordinators followed by project managers.

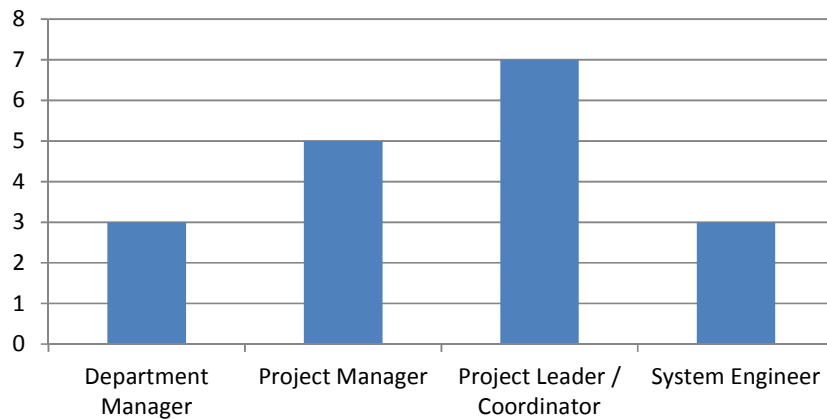


Figure 4-4: Participants group by designation

4.2.1.4 Project phases

Modification projects go through various phases of the project life cycle model. It was important to establish and comprehend the phases in which the participants get to be involved with modification project. The project is subjected to disparate factors at different phases of the project life cycle model. Some of these factors may contribute to project delays. Therefore, project delay may be experienced in any phase of the project life cycle. To solicit from what perspective and position the participants present those factors causing modification project delays, participants were requested to indicate the project phase in which the time parameter is considered significant in their respective departments. Most participants indicated that the time parameter is considered significant in their departments at all phases of the life cycle model as shown in Figure 4-5.

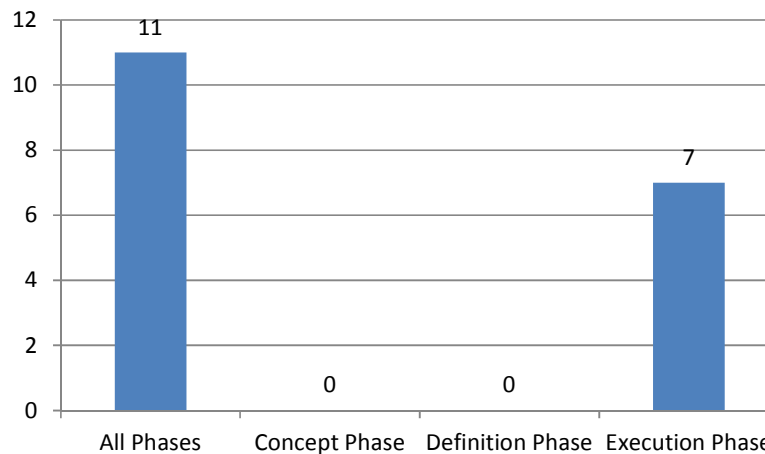


Figure 4-5: Project phase

4.2.1.5 Idea writing results

Tuan (2003: 71) described the process of interactive management as follows; the first step that is generally employed is the nominal group technique (NGT), which generates a list of issues, problems, or solutions to be ranked. There is no limitation on the number of elements proposed. Subsequently, the group clarifies the meaning of each element and then eliminates the unnecessary duplication of elements.

Idea writing is an efficient process for eliciting many ideas relevant to a stated issue from one or more small groups in fractions of an hour, in other words, an idea-generating process. It is especially useful for issue formulation, including problem definition, and for identification of objectives and options (Warfield and Cardenas, 2002: 85).

A questionnaire (shown in Appendix 1) was sent to the participants to indicate from their experience at least five significant factors which they believed are leading to delays of modification projects at Koeberg Power Station. Participants were also requested to provide a brief description of each factor they have identified. This process was part of idea generating described in § 3.3.2.1 of this document.

A total of 92 elements were generated from the questionnaire as shown in Table 4-1. Commonalities among generated elements were assessed in consultation with the participants through the process of element clarifications and this process is further discussed in § 5.2.1.6 of this document. Due to time or participants' availability limitations, the process of clarification was conducted with the participants on an individual basis. An average time of 15 to 30 minutes was spent interviewing each participant with the intent to get clarity of the stated elements, and also to assess whether the participant had the same view as other participants. During the idea generation and the clarification activities, the facilitator must prevent the group from entering into an evaluative tone as the ideas are expressed and clarified. The ideas are not to be judged at that stage (Warfield and Cardenas, 2002: 143). The researcher followed the same principle by not evaluating or judging the stated elements, but rather to seek clarity from the participants to indicate whether they identified elements as common or not.

Table 4-1 shows participants' responses on factors which they believed to be significant in causing untimely delivery of modification projects. The last column "No of appearance" of the table indicates the number of times a particular modification project delay factor was stated by the participants. Where there is a blank space or no number written in the "No of appearance" column, it means that the stipulated modification project delay factor has only been identified once. The "x" indicator on the table or matrix signifies the appearance of the delay factors. The black "x" indicators represent elements identified by a particular

participant, whereas the red “x” indicators represent the same element or delay factor identified by other participants.

It should also be noted that the list shown in Table 4-1 was kept confidential by the researcher and it was not shared with the participants during the process of element clarification. This was done to ensure that participants are not influenced by seeing factors identified by other and change their mind prematurely. However, adequate information regarding other identified factors was shared with the participants during the element clarification process and an opportunity was presented to the participant to indicate his or her position without influencing his or her view about the identified delay factor.

Table 4-1: Generated elements of project delay factors’ matrix

Project Delay Factors	Research Participants																	No of Appearance	
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17		Participant 18
Participant 1																			
Design changes	X												X						2
Bureaucratic commercial and investment processes	X			X	X														3
Delayed regulatory approvals	X					X				X									3
Delayed delivery of materials/spares	X	X				X				X	X								5
Proficiency of a project manager	X		X		X						X			X	X				6
Participant 2																			
Delayed delivery of materials/spares	X	X				X				X	X								5
Poor planning		X	X	X													X	X	6
Poor co-ordination		X	X															X	3
Scope creep		X		X	X		X										X		5
Resource constraints		X			X	X		X			X	X						X	7
Participant 3																			
Inaccuracy of execution duration on the plan			X				X	X						X	X				5
End-user requirements not fully detailed			X																
Poor planning		X	X	X													X	X	6
Poor co-ordination		X	X															X	3
PM not fully understand how modification project fit in outage project	X		X		X						X			X	X				5
Participant 4																			
Scope creep		X		X	X		X										X		5
Delayed delivery of materials				X															
Top management decision				X		X			X	X									4

Table 4-1: Generated elements of project delay factors' matrix

Project Delay Factors	Research Participants																	No of Appearance	
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17		Participant 18
Bureaucratic commercial and investment processes	X			X															2
Poor planning		X	X	X												X	X	X	6
Participant 5																			
Insufficient risk management in terms of risk analysis, response and control					X													X	2
Inadequate governance					X														
Resource constraints		X			X	X	X			X	X						X		7
PM does not fully understand how modification project fit in outage project	X		X		X					X				X	X				6
Scope creep		X		X	X		X									X			5
Bureaucratic commercial and investment processes	X			X	X														3
Participant 6																			
Lack of funding						X	X				X						X		4
Resource constraints		X			X	X	X			X	X						X		7
Delayed regulatory approvals	X				X				X										3
Delayed delivery of materials, spares	X	X			X				X	X									5
Outage project goals				X	X			X	X										4
Participant 7																			
Lack of decision makers	X					X													2
Inaccuracy of execution duration on the plan			X			X	X						X	X					4
No recording of actual activity duration time						X													
Rework		X		X	X	X										X			5
Culture						X				X									2
Poor communication						X													
Participant 8																			
Unrealistic timelines from the client, requestor			X			X	X						X	X					5
Resource constraints		X			X	X	X		X		X	X					X		7
Non adherence to processes and procedures							X												
Lack of commitment							X												
Lack of funding						X	X			X							X		4
Participant 9																			
Processes								X											
Budgetary approval								X											

Table 4-1: Generated elements of project delay factors' matrix

Project Delay Factors	Research Participants																	No of Appearance		
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17		Participant 18	
Cost cutting versus delivery of product									X											1
Priority of modifications									X											1
Outage goals				X		X			X	X										4
Participant 10																				
Delayed regulatory approvals	X					X				X										3
Delayed delivery of materials, spares	X	X				X				X	X									5
Outage project goals				X		X			X	X										4
Poor project management										X										1
Modified plant cannot be handed over, project closure cannot be done										X										1
Project team reporting structure does not work at times										X										1
Participant 11																				
Not following the execution plan											X					X				2
PM does not fully understand how modification project fit in outage project	X		X		X					X				X	X					6
Resource constraints		X			X	X		X			X	X						X		7
Lessons not learnt											X									1
Delayed delivery of materials, spares	X	X				X				X	X									5
Participant 12																				
Project cost underestimation												X	X							2
Lack of funding						X		X				X						X		4
Delayed delivery of materials, spares	X	X				X				X	X									4
Resource constraints		X			X	X		X			X	X						X		7
Lengthy project management process with multiple departments involved												X								1
Participant 13																				
Force majeure, unforeseen events													X							1
Design changes	X												X							2
Project cost underestimation												X	X							2
Sub-contracting													X							1
Foreign expenditure													X							1
Participant 14																				
ERA approvals														X						1
Contract placements														X						1
Inaccuracy of execution duration on the plan			X				X	X						X						4

Table 4-1: Generated elements of project delay factors' matrix

Project Delay Factors	Research Participants																	No of Appearance	
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17		Participant 18
Staff competency	X		X		X						X			X	X				6
Lack of motivation from staff														X					
Participant 15																			
Procrastination of project milestone, targets															X				
Not following the execution plan											X				X				2
Insufficient risk management in terms of risk analysis, response, and control					X										X				2
Lack of urgency in getting the necessary actions, tasks completed															X				
PM does not fully understand how modification project fit in outage project	X		X		X						X			X	X				6
Participant 16																			
Poor planning		X	X	X												X	X	X	6
Poor scope management, definition		X		X	X		X									X			5
Poor leadership															X				
Competing priorities															X				
Poor communication							X									X			2
Participant 17																			
Poor planning		X	X	X												X	X	X	6
Financial constraints						X		X			X						X		4
Unavailability of resources or lack thereof		X			X	X		X			X	X					X		7
Poor identification of scope																X			
Inadequate training or lack thereof																X			
Participant 18																			
Poor, inadequate planning		X	X	X												X	X	X	6
Schedule that is not optimised																		X	
Poor risk identification and lack of contingency plans					X													X	2
Poor coordination during execution		X	X															X	3

Figure 4-6 shows a summary of identified modification project delay factors which made appearance of three times and greater in the list of 92 identified delay factors. For example “resource constraints” was identified by seven participants to be a significant factor which leads to untimely delivery of projects. Research methodology used by previous researchers in identifying project delays would conclude that this factor has a high frequency, and as such it would be considered significant. In contrast, interactive management approach takes

cognisance of the fact that this factor has been identified to be common among the targeted sample, but further assessments are done to understand whether this factor was the most significant or not. In this way, interactive management helps to establish whether other factors, which might not be in the list shown in Figure 4-6 cause or lead to the factor(s), i.e. “resource constraints” with high frequency. This is done by following the process of assessing the interrelationship among project delay factors using interpretive structural modelling, which will be discussed in § 4.2.2 of this document. The interpretive structural modelling process avoids the risk of using conventional voting to generate an incorrect result. It helps the participants to expand the spectrum of their horizons and scrutinize systems in a more rigorous way (Tuan, 2003: 72).

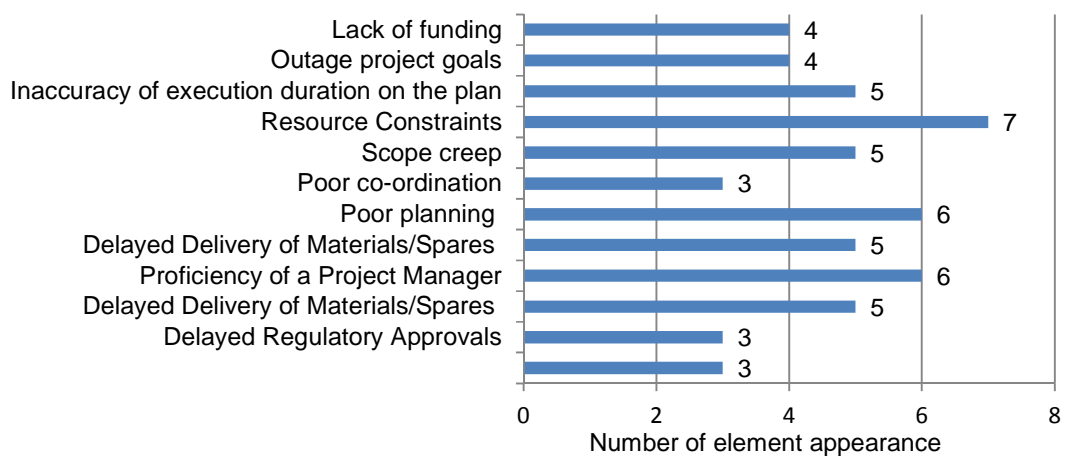


Figure 4-6: Identified delay factors with number of appearance equal or greater than three

4.2.1.6 Nominal group technique results

Through consultation with the participants and the process of identifying commonalities among 92 identified modification project delay factors, the list of 92 modification delay factors was reduced by merging, splitting, and deleting of certain factors. The total number of 37 project delay factors was concluded through this process as shown in Table 4-2. Table 4-2 also shows the description of each project delay factor. As previously explained, participants were also asked to give description of each identified project delay factor. This also helped in the process of merging identical factors. Some participants could not precisely and accurately indicate the project delay factor(s) as they arise in their minds. Therefore, an opportunity provided to the participants to describe each delay factor helped the participants to elaborate on the identified project delay factors. For example, some participants had similar ideas regarding factors causing modification project delays, but these factors were presented in different terms on the questionnaire feedback. Explanation of the context on the

description helped the participants to find common ground, and thus merging similar ideas. In contrast Tuan (2003: 64) argue that as we observe a phenomenon, the intercepted pictures manipulated by our mental activities are converted into various images. The distinct intercepting positions and different manipulations lead to diverse perceptions. Perhaps they possess similar attributes; nevertheless, they are not exactly identical. On the contrary, it can be argued that the interpretation of the pictures in the minds of participants resulted in varied perception and hence they stated different elements on the questionnaires. However, the description they provided challenged this perception and led to one or similar element(s) being forwarded as causing modification project delays.

Table 4-2: Merged project delay factors

Project Delay Factors	Description
Design Changes	Continuously changing user requirements in the design phase with limited resources, and design field changes are a few examples of the delay reasons from the design space.
Poor leadership	Leadership has high demands, lack of control, and lack of support to predict strain outcomes. More and more experienced staff are leaving Koeberg or changing departments. This is leading to a skills drain in those particular areas, leaving inexperienced staff to do the work.
End-user requirements not fully detailed	PM does not understand the full requirements, support needed from functional line departments, groups. When the need for a specific support is realised, it is usually late and when this is communicated, the line group has to rearrange (resources and sequence of maintenance scope) all the planned work for the day. This contributes to both delays on the modification project work and planned maintenance work.
Top management decision	Senior management decisions for strategic planning affect the current projects in terms of allocating funds, resources, and leads to suspension of modification projects.
Lack of motivation from staff	The organization has brought so many changes into the business. The following are some of the areas that have brought low staff morale: <ul style="list-style-type: none"> • Lack of transformation in the business unit, driven by favouritism than competency and fairness. • Valuable work being given to contractors and permanent employees driven to do clerical/ administrative work (Preparing work packages, taking out PTW's, filing documents, updating databases, etc.). • Taking away of benefits such as the bonus, overtime work, limiting the further study bursary recipients and allocation, car allowances, etc. • Lack of promotional opportunities, development, and exposure. • Lack of recognition for good work. • Supervisors and managers that take credit for work done by their subordinates. Instead, tainting the image of such proficient workers.

Table 4-2: Merged project delay factors

Project Delay Factors	Description
Poor co-ordination	At times, the plan is perfect and all spares available, but lack of competent project team to drive the plan results in delays. Project team sometimes exaggerate the urgency of their project work, which means functional line group personnel leave their day-to-day plant work to attend to project work. Afterwards, the functional line group realises that the urgency was misrepresented. This causes mistrust, when there really is an issue, functional line groups are not willing assist with urgency.
Delayed delivery of materials, spares	Suppliers sometimes indicate shorter delivery times when bidding but once the manufacturing process starts, lead times are frequently adjusted. Not ordering the spares in time, or the supplier not supplying the spare on time due to long lead time are some of the causes for delayed delivery of spares.
Non-adherence to processes and procedures	Most projects fail or are delayed by simply not adhering to proper processes and procedures. Some of the processes and procedures are not well governed and therefore the end-users are not always abreast of all the changes.
Insufficient risk management in terms of risk analysis, response and control	Inadequate risk identification in terms of their probability, severity, and impact. In the event of the risk occurring, response to the risk is not planned, and as such, there is no action plan, no responsible party is identified. This results in scrambling and running around at the last minute when time is of the essence and irrational decisions are made and actions taken. Delivery inevitably suffers.
Lessons not learnt	Outage projects and modification projects take place regularly. There are so many lessons we can take out during the reviews. These lessons came from many sources and are tracked until the administration bit is completed, in other words, the actions are closed out for the sake of providing evidence for auditory purposes of proper management. However, there are so many actions and too little learning because over the years the same mistakes are repeated and we start the learning cycle all over again.
Poor scope management, definition	Addition of work that is not properly understood and agreed to by the project sponsor and key stakeholders extend the execution period of the project. Inadequate approach used to perform feasibility studies. Walkdowns to verify plant-drawing agreement are done.
Cross-functional structure is not effective	Koeberg Operating Unit makes use of cross-functional structure for modification projects. The project team does not report directly to the project manager. At times, there is conflict as the project team (design engineers, system engineering, maintenance personnel, etc.) have to prioritise their group, department functions.
Budgetary approval	Budget approval and approval for cost overrun takes long and is difficult to expedite.
Scope creep	Unforeseen problems during the feasibility study or implementation causes scope creep and leading to further time delays.

Table 4-2: Merged project delay factors

Project Delay Factors	Description
Resource, manpower constraints	Project leaders leaving the organisation result in a lack of seamless continuity when executing projects. Inexperience / new personnel expected to manage modification projects without proper training given to them. Design and Subject Matter Expert manpower are scarce. This has led to delays in completing designs, which affect implementation dates.
Bureaucratic Commercial and Investment Processes	The process of obtaining funds to implement the project and the process of sourcing services from the suppliers are normally very long due to the bureaucratic nature of the environment which is intended or based on good governance. These two processes combined normally take up to almost a year when all relevant committees are available with no moratoriums on committees. Investment committee approvals normally delay the modification projects. This is due to investment documents that are below par. At times, committee meetings are cancelled or postponed.
Inaccuracy of execution duration on the plan	After the modification project is handed to the Nuclear Project Management (NPM) construction team for implementation, the full interface requirements, i.e. various plant states or configuration, is not known at the time. This results insufficient detail available for planning, and allocation of resources from line functions. Project Managers can be put in a situation where they are given a window by the Outage Department which does not align with the schedule required to complete the work and be requested to find ways of reducing it without taking much consideration to: contractor's experience, plant availability and requirements, weather conditions, the 'nuclear' environment.
Rework	This is the major cause of project delays, and is caused by amongst others, inadequate skills, poor workmanship, and unmotivated work force.
Procrastination of project milestone, targets	PM, team believe that sufficient time is available for the completion of a project or project task.
PM does not fully understand how the modification project fits into outage project	To fit modification projects into the outage schedule typically requires plant configurations to be out of normal. This has other ramifications, mainly other additional work is needed from line function department to be in a position, i.e. make the plant ready to allow the modification project to proceed and progress. Sometimes project managers have limited knowledge of the plant and adequate resource arrangements and planning do not take place. To execute a plan, one has to be knowledgeable about the intricacies of developing a plan and strategies that can be employed to execute the plan.
Lack of funding	This results in some modifications being deferred until funding is available. Due to the multi-year price determination 3 (MYPD3) requirements, we witnessed drastic budget cuts in most critical operations of the organisations and most of the projects were left crippled and therefore there was no room to increase the resources requirements.
Ineffective decision making	Roles and responsibilities not clear. Items take long to be resolved due to lack of decision making

Table 4-2: Merged project delay factors

Project Delay Factors	Description
Cost cutting versus delivery of product	On some turnkey projects the contractors leave prior to the testing phase in order to lower cost, and permanent staff are used to 'set to work'. This does sometimes incur delays as experience may not be at the preferred levels yet.
Lengthy project management process with multiple departments involved	Long chain in the project management process lengthens the project life span and delays implementation. Too many independent departments are involved in the project (System Engineering, Design Engineering, Nuclear Project Management departments, etc.) and often implementation has to be carried out by a contractor.
Delayed regulatory approvals	The period from submittal of designs to approval normally takes about 6 months. There are often substantial delays due to the competing priorities, resource constraints from the regulator, and sometimes longer review periods for the designs depending on the complexity of a particular project.
Unrealistic timelines from the client, requestor	Most of the projects fail because of the unrealistic time that the client or requestor affords the project team. The PM is given less chance to challenge the vision of the client. In order for a project to succeed when the time is constrained, additional resources must be assigned to the project and the budget must be increased. But most of the crucial aspects are constraints within the organisation.
Lack of discipline in executing the plan	An outage execution plan is drawn up and reviewed prior to an outage project execution phase as an outage preparation milestone and modification projects are part of this plan. More often the plan changes and there is a backlog of work which has to be managed. This results in work being done on a first-come-first-served basis or from an indication from the outage organisation on important or critical work. A key issue in this regard is the review of maintenance windows which only considers the issues that result in maintenance windows being late rather than a breakdown of a series of delays which caused the maintenance windows to be late.
Poor communication	Lack of or poor communication amongst team members, groups, and departments leads to project delays. Modification projects are always viewed in silos and information flow is restricted.
Project cost underestimation	Project cost estimates are sometimes inaccurate, causing discrepancies in projected versus actual costs. This is often attributed to lack of accurate information during the initial phase of the project which is caused by the fact that, at that stage, the solution is not yet known. Variances between the postulated and actual designs also contribute to this. Costing inaccuracies can lead to delays in placing contracts as the funds allocated may not be sufficient.
Sub-contracting by main contractor	When the main constructor sub-contracts with another supplier on different terms of NEC or other contracting contracts which are different to those that the client and the main contractor have agreed on. This causes delays as the condition of arbitration may take long for resolution during a dispute.
Outage project strategy, goals	Due to the outage project strategy or philosophy (short outages for refuelling and long outages for plant modifications), modification projects which are due for implementation may be postponed if their duration will challenge the outage project duration.

Table 4-2: Merged project delay factors

Project Delay Factors	Description
Poor planning	Inadequate project definition and planning and lack of attention to detail results in time delays.
Staff competency	More and more experienced staff are leaving Koeberg or changing departments. This is leading to a skills drain in those particular areas, leaving inexperienced staff to do the work.
Proficiency of a project manager	The proficiency and competency levels of the PM play a larger role in the success or failure of the project. Sometimes maintenance personnel are not trained to take over the project, SAP/BOMs are not updated and spares not ordered for maintenance, stakeholders are not involved during planning and construction as a result they do not accept the modifications during commissioning.
Culture	The longer the projects take, the more overtime is worked.
Inconsistent processes	Some processes, namely, approval, design, placing of contracts, spares procurement, are not synchronised.
Foreign expenditure	Economic parameters vary constantly. These variances affect the availability of foreign currency and commodities

The list of modification project delay factors shown in Table 4-2 is a product of the reduced list of elements depicted in Table 4-1, which was extracted from the questionnaire responses by the participants. It was considered by prioritization and voting to further establish whether certain project delay factors on the list of 37 factors (Table 4-2) were considered to be the most significant delay. Each participant was requested to vote for only three factors from the list of 37 factors, which he or she believed to be most significant in causing modification project delays. Selection criteria for significant elements from the voting list (Table 4-2) were explained to the participants and are as follows:

- Element(s) which receive one or more votes are considered significant.
- Elements(s) which receive no votes are considered not to be significant.
- Element(s) which receive no vote will be excluded from the list.

To ensure confidentiality of the source of the identified modification project delay factors, the factors were mixed so that the participants could not tell the source generated the elements by the sequence on the list. Mixing the element was also done to avoid bias by the participants when selecting which element to vote for among the list of identified elements. Therefore, this approach created an environment where due diligence was provided by the participants to advance beyond what they initially noted on the questionnaire as significant factors, and contemplate whether other factors were more significant than what they initially indicated.

Table 4-3: Significant project delay factors

Project Delay Factors		Description	No. of Votes
1	Poor leadership	Leadership has high demands, lack of control, and lack of support to predict strain outcomes. More and more experienced staff are leaving Koeberg or changing departments. This is leading to a skills drain in those particular areas, leaving inexperienced staff to do the work.	2
2	Top management decision	Senior management decisions for strategic planning impact on the current projects in terms of allocating funds, resources and leads to park the modification projects for a period of time.	1
3	Poor co-ordination	At times the plan is perfect and all spares available, but lack of competent project team to drive the plan results in delays. Project team sometime exaggerated the urgency of their project work, which means functional line groups personnel leave their day to day plant work to attend to project work. Afterwards the functional line group realises that the urgency was misrepresented. This causes mistrust, and when there really is an issue, functional line groups are not willing assist with urgency.	2
4	Delayed delivery of materials/spares	Suppliers sometimes indicate shorter delivery times when bidding but once the manufacturing process starts there gets to be lots of changes in the lead times. Not ordering the spares in time, or the supplier not supplying the spare on time due to long lead time are some of the causes for delayed delivery of spares.	2
5	Insufficient risk management in terms of risk analysis, response and control	Inadequate risk identification in terms of their probability, severity, and impact. In the event of the risk occurring, response to the risk are not planned for, and as such there are no action plan, no responsible party is identified, etc. – this results in scrambling and running around at the last minute when time is off the essence and reactive decisions being made and actions taken and this impact time.	3
6	Lessons not learnt	Outage projects and modification projects take place regularly. There are so many lessons we can take out during the reviews. These lessons came from many sources and are tracked until the administration bit is completed, in other words, the actions are closed out for the sake of providing evidence for auditory purposes of proper management. However, there are so many actions and too little learning because over the years the same mistakes are repeated and we start the learning cycle all over again.	1
7	Poor scope management/definition	Addition of work that is not properly understood and agreed to by the project sponsor and key stakeholders extend the execution period of the project. Inadequate approach used to perform feasibility studies. Walkdowns not being performed to verify plant configurations versus drawings.	1
8	Scope creep	Unforeseen problems during the feasibility study or implementation causes scope creep and further leading to the time delays.	1

Table 4-3: Significant project delay factors

Project Delay Factors		Description	No. of Votes
9	Bureaucratic commercial and investment processes	The process of getting funds to implement the project and the process of sourcing services from the suppliers are normally very long due to the bureaucratic nature of the environment which is intended or based on good governance. These two processes combined normally take up to almost a year when all relevant committees are available with no moratoriums on committees. Investment committee approvals normally delay the modification projects. This is due to investment documents that are below par; at times the committee meetings are cancelled or postponed.	3
10	Inaccuracy of execution duration on the plan	After the modification project is handed to the Nuclear Project Management (NPM) construction team for implementation, the full interface requirements, i.e. various plant states or configuration, is not known at the time. This results insufficient details for planning, namely durations, and allocation of resources from lines. Project managers can be put in a situation where they are given a window by the Outage Department which does not align with schedule required to complete the work and be requested to find ways of reducing it without much consideration of: contractor's experience, plant availability and requirements, weather conditions, the 'nuclear' environment.	1
11	Cross-functional structure is not effective	Koeberg Operating Unit makes use of cross-functional structure for modification projects. The project team does not report directly to the project manager. At times, there is conflict as the project team (design engineers, system engineering, maintenance personnel, etc.) have to prioritise their group, department functions.	2
12	PM does not fully understand how modification project fits into the outage project	To fit modification projects into the outage schedule typically requires plant configurations to be out of normal. This has other ramifications, mainly other additional work is needed from line function department to be in a position, i.e. make the plant ready to allow the modification project to proceed and progress. Sometimes project managers have limited knowledge of the plant and adequate resource arrangements and planning do not take place. To execute a plan, one has to be knowledgeable about the intricacies of developing a plan and strategies that can be employed to execute the plan.	3
13	Lengthy project management process with multiple departments involved	The protracted project management process lengthens the project life span and delays implementation. Too many independent departments are involved in the project (System Engineering, Design Engineering, Nuclear Project Management, etc.) and often implementation has to be carried out by a contractor.	1
14	Delayed regulatory approvals	The period from submittal of designs to approval normally takes about 6 months. There are often substantial delays due to the competing priorities, resource constraints from the regulator, and sometimes longer review periods for the designs depending on the complexity of a particular project.	1

Table 4-3: Significant project delay factors

Project Delay Factors		Description	No. of Votes
15	Resource constraints	Project leaders leaving the organisation result in a lack of seamless continuity when executing projects. Inexperienced new personnel are expected to manage modification projects without proper training. Design and subject matter expert manpower is scarce. This has led to delays in completing designs, which affect implementation dates.	2
16	Lack of discipline in executing the plan	An outage execution plan is drawn up and reviewed prior to an outage project execution phase as an outage preparation milestone and modification projects are part of this plan. More often the plan changes and there is a backlog of work which has to be managed. This results in work being done on a first-come-first-served basis or from an indication from the outage organisation on important or critical work. A key issue in this regard is the review of maintenance windows which only considers the issues that result in maintenance windows being late rather than a breakdown of a series of delays which caused the maintenance windows to be late.	2
17	Poor communication	Lack of or poor communication amongst team members, groups, and departments leads to project delays. Modification projects are always viewed in silos and information flow is restricted.	2
18	Project cost underestimation	Project costing estimates are sometimes inaccurate, causing discrepancies in projected versus actual costs. This is often attributed to lack of accurate information during the initial phase of the project which is caused by the fact that, at that stage, the solution is not yet known. Variances between the postulated and actual designs also contribute to this. Costing inaccuracies can lead to delays in placing contracts as the funds allocated may not be sufficient.	2
19	Outage project strategy, goals	Due to the outage project strategy or philosophy (short outages for refuelling and long outages for plant modifications), modification projects which are due for implementation may be postponed if their duration will challenge the outage project duration.	1
20	Poor planning	Inadequate project definition and planning and lack of attention to detail results in time delays.	4
21	Proficiency of a project manager	The proficiency and competency levels of the PM play a larger role in the success or failure of the project. Sometimes maintenance personnel are not trained to take over the project, SAP / BOMs are not updated and spares not ordered for maintenance, stakeholders are not involved during planning and construction as a result they do not accept the modifications during commissioning.	5

The resulting list from voting by participants is shown in Figure 4-3. Following a portion of interactive management procedure, a total of 21 project delay factors were derived as significant in causing modification project delays at Koeberg Power Station. Consequently,

these factors were redirected and used during interpretive structural modelling workshop discussed in § 4.2.2 of this document to assess the interrelationships among 21 identified significant delay factors.

4.2.2 Interpretive structural modelling workshop

The interactive management facilitator should have an already-prepared set of flip chart displays available for use in briefing the participants on the anticipated activities, their purpose, their sequence, the expected products, and the significance of those products in terms of the situation (Warfield and Cardenas, 2002: 142). A brief presentation regarding the purpose, objectives, and intended outcomes of the workshop session was made for the participants prior the start of the workshop.

A total number of 6 participants satisfying the required stakeholders' profile described in § 5.1.2 attended the interpretive structural modelling workshop. The attendees comprised one system engineer, two project managers from Nuclear Project Management Department, two project managers from the Outage Department and one project leader from the Operations Department. Other participants who contributed towards generating ideas for project delay factors could not attend the workshop due to other priorities and commitments. However, the information and knowledge they shared through the questionnaire responses was used to conduct the workshop session. A turnout of 6 participants is deemed to be sufficient as this number is equivalent to a committee established for a certain purpose. The following are the advantages of the committee:

- Pooling of knowledge and experience results in a more realistic and objective appraisal of the problem from all angles.
- Improved communication is achieved with the committee setup and helps with unwritten policies and objectives to be explained effectively through deliberations of committees.
- Participation in committee meetings promotes mutual understanding, teamwork, and cooperation among the committee members.
- Participation in the decision making process not only improves quality of decisions, it creates a sense of belonging.
- Committee promotes democratic management and help to avoid the risk of concentration of too much authority in the individual and the danger of abuse of power.

- Various group interests may be given a representation and such representation may be necessary to secure the commitment and cooperation of people.

In addition, Janes (1988) cited by Tuan (2003: 76) suggested that the participants in an interpretive structural modelling workshop should be limited to a maximum of approximately eight people. If the group size increases much above this number, the quality of debate deteriorates and each member could pose counter-arguments opposing each other. As a consequence, the number of possible communications between different individuals in a group of n people is $n(n - 1)$.

It is important to stress the fact that during the workshop session the group should enter in an open dialogue, and therefore their primary attitude focused on learning and understanding each other's ideas (Warfield and Cardenas, 2002: 143). A similar approach was encouraged by the researcher during the workshop session of establishing interrelationship among the modification project delay factors identified by the participants. The participants also displayed the same attribute when they were engaged in the discussion to construct the model.

As discussed in § 3.3.2.2 of this document, Concept Star is the relationship modelling software tool used in the study of identifying factors causing modification project delays. Relationship modelling is a method for creating a road map of complex situations where there are many issues or options to consider and is often used to provide fundamental understanding of complex situations, as well as to put together a course of action for solving a problem (Sorach_Inc, 2014: 1). Below are a few examples of how Concept Star has been used (Sorach_Inc, 2014: 2):

- Organizational mission statement and goal setting.
- Personal visioning and goal setting.
- Formulating corporate strategy.
- Selection of technologies for investment.
- Scenario planning.
- Development of organizational structure.
- Creating a common understanding of the situation involving technical staff and marketing through joint exploration.
- Feature prioritization for a complex product.
- Defining new strategic planning process.

- Creating marketing plan.
- Designing user interface logic.
- Designing a training course.

Significant project delay factors shown in Table 4-3 were loaded into Concept Star software as elements of analysis. Within the Concept Star software application, three application tools available for analysis, namely:

- interpretive structural modelling;
- linear interpretive model; and
- interrelationship digraph.

Interpretive structural modelling tool was used for constructing modification project delay model. The trigger question, the context phrase, and the relation phrase were loaded into the software:

- **Trigger question:** Which factors influence plant system modification projects and lead to untimely project delivery?
- **Context phrase:** Does
- **Relation phrase:** Significantly aggravate

The context and relation are important control phrases, with context helping to guide the discussion and decision making during construction of the relationship model, and relation helping to determine the meaning and structure of the relationship model. Both phrases are displayed during the voting activity and used by participants to analyse the relationship between pairs of ideas and remind participants of the situation and what they are hoping to accomplish (Sorach_Inc, 2014: 8). The process of generating a model for factors causing modification project delays at Koeberg Power Station followed a similar approach shown in Figure 4-7.

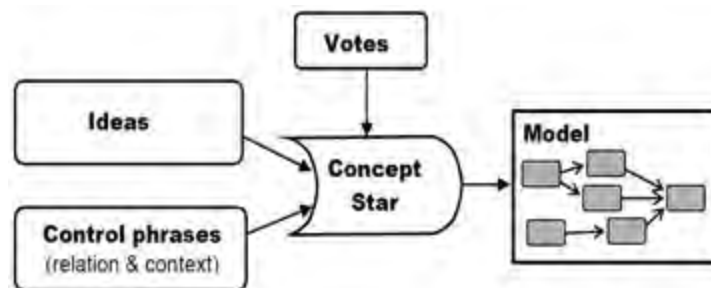


Figure 4-7: Constructing a relationship model using Concept Star (Sorach_Inc, 2014: 30)

During the workshop session, participants were given an opportunity to view project delay factors (herewith referred as elements) loaded on the software. An Excel spreadsheet (soft copy) with the same elements (shown in Table 4-3) was also made available to help the participants to refer to the description of elements where uncertainty of understanding of a particular element was experienced. Figure 4-8 shows a Concept Star dialog box where the elements were added and loaded into the software.

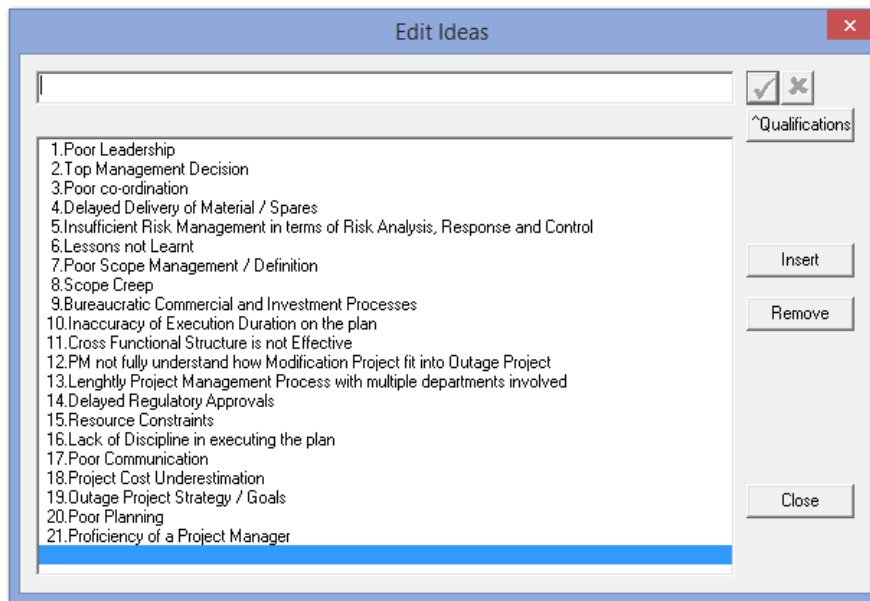


Figure 4-8: List of elements with assigned numbers

The context phrase “Does” was loaded into Concept Star as shown in Figure 4-9.

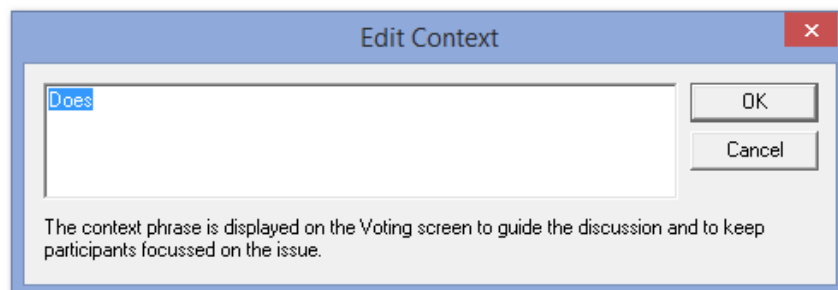


Figure 4-9: Context phrase

The relation phrase “Significantly aggravate” was also loaded on Concept Star software as shown in Figure 4-10.

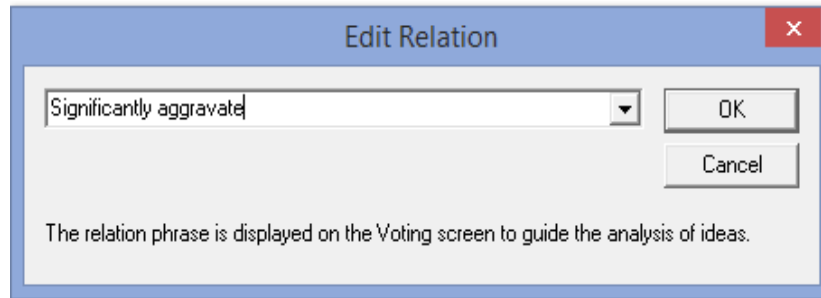


Figure 4-10: Relation phrase

Interpretive structural modelling uses pairwise analyses of ideas to transform a complex issue, involving a lot of ideas, into a structured relationship model that is easier to understand (Sorach_Inc, 1999: 3). Therefore, during the workshop participants were given an opportunity to assess the relation between two elements at a time. A computer dialog box was displayed to the participants each time a question to assess relationship is posed. For example, “does proficiency of a project manager significantly aggravate poor leadership” was posed to the participants as shown in Figure 4-11. Participants were provided with an opportunity to elaborate, discuss, and debate their views regarding relationship of the two elements under evaluation. Consequently, participants were requested to vote in cases where opposing views were presented. In most cases the relationships among the elements were obvious to the participant and the participants could agree to vote either “Yes” or “No” to the imposed question.

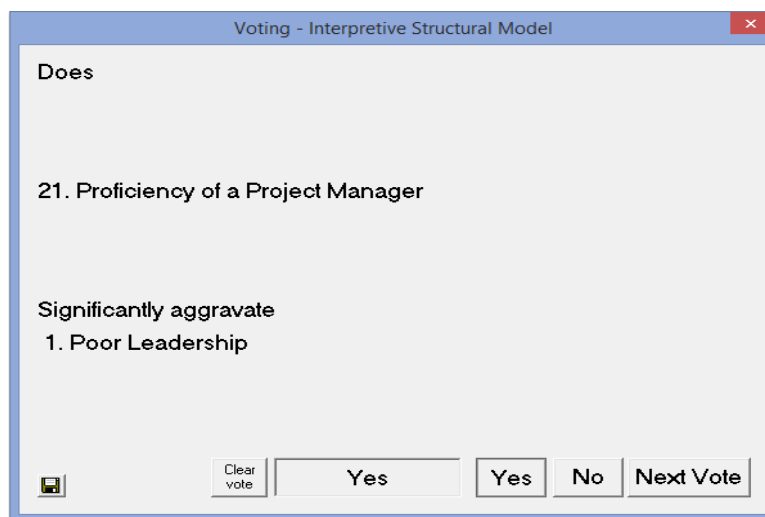


Figure 4-11: Example of posed questions during the workshop session

It is important to note that each element is assigned a specific number by the software. The software (Concept Star) uses these numbers to record the votes made by the participants as they are going through the process of evaluating the relationships among the elements and

judges whether a relationship exists or not. Figure 4-12 shows the votes among the elements indicated by numbers as conducted by the participants during the workshop session. Tuan (2003: 71) suggests that once the problem is posed, the process of structuring starts with a team replying to a series of questions aimed at establishing the contextual relationship between two elements at a time. If the answer is “Yes” to the posed question, then “1” is entered into the cell of the reachability matrix of the elements. Otherwise, “0” is entered signifying that a contextual relationship between the two named elements does not exist. The underpinning algorithm of interpretive structural modelling is to establish relationships between elements related to the problem through the manipulation of binary matrices. The contextual relationships of the generated elements are required to be transitive in nature. For example, if element A is heavier than element B and element B is heavier than element C, then, it can be inferred that A is heavier than C (Tuan, 2003: 78). A similar approach as explained by Tuan was used when assessing interrelationships among factors causing project modification delay at Koeberg Power Station. Consequently, a total of 54 votes concluded the workshop session and produced a model shown in Figure 4-12.

Votes:

1) 1→2 Yes	18) 1→8 Yes	36) 1→15 Yes
2) 2→1 No	19) 8→1 Yes	37) 15→1 Yes
3) 1→3 Yes	20) 1→9 Yes	38) 1→16 Yes
4) 3→1 No	21) 9→1 Yes	39) 16→1 Yes
5) 2→3 No	22) 1→10 Yes	40) 1→17 Yes
6) 3→2 No	23) 10→1 Yes	41) 17→1 Yes
7) 1→4 Yes	24) 1→11 Yes	42) 1→18 Yes
8) 4→1 No	25) 11→1 Yes	43) 18→1 Yes
9) 2→4 Yes	26) 1→12 Yes	44) 1→19 Yes
10) 4→2 No	27) 12→1 No	45) 19→1 No
11) 3→4 Yes	28) 2→12 No	46) 2→19 Yes
12) 1→5 Yes	29) 12→2 No	47) 19→2 No
13) 5→1 Yes	30) 3→12 Yes	48) 3→19 Yes
14) 1→6 Yes	31) 12→3 Yes	49) 4→19 Yes
15) 6→1 Yes	32) 1→13 Yes	50) 19→4 Yes
16) 1→7 Yes	33) 13→1 Yes	51) 1→20 Yes
17) 7→1 Yes	34) 1→14 Yes	52) 20→1 Yes
	35) 14→1 Yes	53) 1→21 No
		54) 21→1 Yes

Figure 4-12: Vote results

4.2.3 Modification project delay factors’ model analysis

Upon completion of the voting by participants, the software generated and produced a modification project delay factors’ model (hereafter referred as MPDF model) shown in Figure 4-13. A brief logic discussion of MPDFM delay factors (herein referred to as elements) and

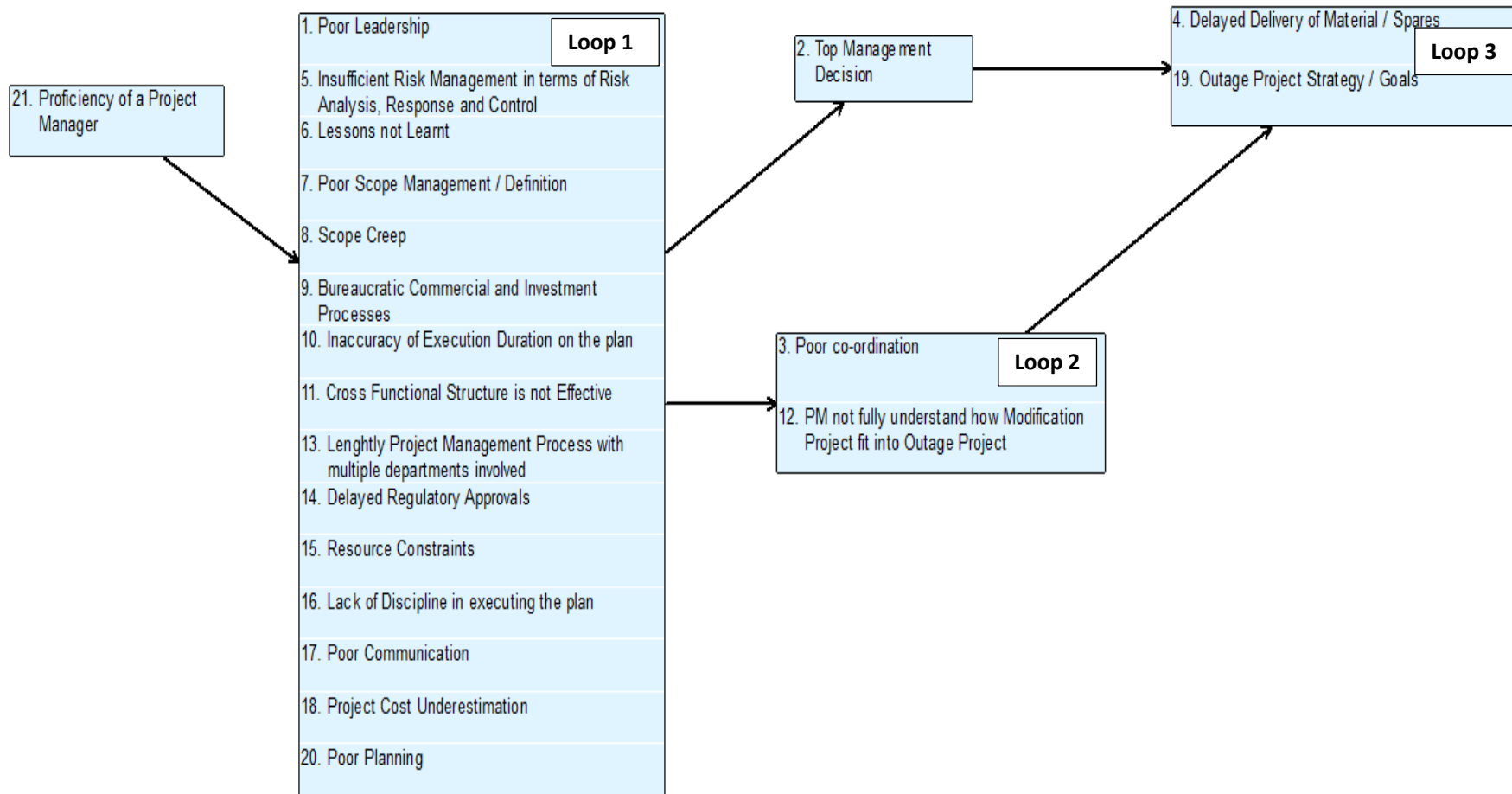


Figure 4-13: Model for factors causing modification project delay

elaboration on each identified element's description (given in Table 4-3) and their implications towards modification project delays are presented below. It should be noted that the elements are presented under sub-section in accordance with how they appear in Figure 4-13 (i.e. Loop 1 factors are presented under one sub-section). MPDF model represents the interconnection of identified project delay factors. Therefore, grouping of project delay factors does not limit the reference and discussion thereof into specific sub-section presented below.

4.2.3.1 Proficiency of a project manager as a project delay factor

MPDF model indicates that element 21 "Proficiency of a Project Manager" is the main determinant of modification project delays as it is influencing other identified modification project delay elements. This is indicated by an arrow extending from element 21 to a group of elements under loop 1, which in turn influences other elements positioned on the right hand side of Figure 4-13. According to MPDF model, element 21 aggravates all elements under loop 1. During the voting session when interrelationships between elements were assessed, participants voted "Yes" for vote number 54 (refer to Figure 4-12) and voted "No" for vote number 53. This voting choice by the participants demonstrates that participants believe that element 21 (Proficiency of a Project Manager) aggravates or causes element 1 (Poor Leadership), but element 1 (Poor Leadership) does not aggravate or cause element 21 (Proficiency of a Project Manager).

Furthermore, element 21 is linked to all elements under loop 1 through element 1, which has an intertwined relationship with the other fourteen elements grouped under loop 1 of the MPDF model. The intertwined relationship of element 1 and other loop 1 elements is discussed in detail in § 4.3.2.1 of this document.

During the workshop session, the software (Concept Star) posed questions on numerous occasions assessing relationship between element 1 (Poor Leadership) and other elements. Numerous occasions of the posed questions is represented by the number of votes concerning element 1 in Figure 4-12. While the participants were going through the voting activity relating to element 1, it seemed that element 1 was the main determinant or driver of all other elements which were loaded to the software. The participants' minds were challenged when the complete model ended as the one shown in Figure 4-13, with element 21 (Proficiency of a Project Manager) being the main driver of all other elements shown in the MPDF model.

It should be noted that proficiency of a project manager relates to the ability of a project manager to accomplish the required project tasks based on his or her skills, competency, and experience within the project management field. Figure 4-13 illustrates through collective evaluation by participants that a lack of project managers' proficiency at Koeberg Power

Station is the main determinant for modification project delays. Price (2005 48) also posited that poor project manager competency accounts for 60% of project failures.

Table 4-3 succinctly provides a description of element 21. From this description it is evident that the project managers at Koeberg Power Station pay little attention to the identification of key stakeholders and ensuring their involvement in modification projects. A stakeholder is an individual, group, or organization who may affect, be affected by, or who perceived itself to be affected by the decision, activity, or outcome of a project (PMBOK(R)_Guide, 2013: 30).

The lack of key stakeholders' involvement results in improper management of the project tasks, and responsibilities are not clarified and planned upfront. It is the project manager's responsibility to identify all the stakeholders and determine their needs and expectations which needs to be managed, influenced and balanced to ensure project success (Burke, 2007: 55). PMBOK(R)_Guide (2013: 563) further defines the stakeholder management plan as a subsidiary plan of the project management plan that defines the processes, procedures, tools, and techniques to effectively engage stakeholders in project decisions and execution based on the analysis of their needs, interests, and potential impact. Therefore, failure to identify and manage stakeholders in projects would constitute improper project management. However, it should be emphasised that stakeholder management is one component of good project management; there are other project management components which determine the attributes of a proficient project manager and are discussed under § 6.1.1 of this document.

4.2.3.2 Loop 1 project delay factors

The following voting attributes which resulted in the generation loop 1 of MPDF model are observed from Figure 4-12:

- A total of 28 votes assessed the relationship between element 1 and fourteen other loop 1 elements.
- Each element of the fourteen loop 1 elements received a “Yes” response or vote when assessed against element 1.
- No assessments other than element 1 were made of the other fourteen loop 1 elements.
- No assessments made between fourteen loop 1 elements and other elements of the model other than element 1.

From the above observation it can be concluded that the number of votes for loop 1 elements were reduced to 28 votes because of the voting choices made by the participants. Based on the “Yes” vote choice made by participants when assessing the relationship between

element 1 and other loop 1 elements, the software automatically concluded with the “Yes” relationship among other loop 1 elements and loop 1 was generated. This illustrates an argument made by Tuan (2003: 78) where he stated that if element A is heavier than element B and element B is heavier than element C, then, it can be inferred that A is heavier than C. Furthermore, the equation below illustrates an algebraic relationship assessment used by the software (Concept Star) when assessing the interrelationships among the elements of loop 1.

If element A → element B, element A → element C and element A → element D

Therefore; element B → element C → element D.

From the above equation, the following can be deduced: If each element of the four elements had to be assessed against each other, the total number of votes would be:

$$\text{number of elements} \times (\text{number of elements} - 1) = \text{number of votes}$$

$$n \times (n - 1) = \text{number of votes}$$

$$4 \times (4 - 1) = 12 \text{ votes}$$

However, based on the voting choice which the participants make in assessing the relationship among the elements (in this case, element $A \rightarrow B$, $A \rightarrow C$, and $A \rightarrow D$), the total number of votes could be reduced from 12 to 6. There a similar case took place when the software generated loop 1 elements of MPDF model. For instance, if the voting choice when assessing relationship among loop 1 elements was “No”, the software would have generated $15 \times (15 - 1) = 210 \text{ votes}$, instead of the 28 votes shown in Figure 4-12. Therefore, it can be concluded that the vote choice(s) made by participants influence the number of votes the software needs to generate, consequently influencing the time duration of interpretive structural modelling workshop session.

As previously mentioned in § 5.2.3.1,1.1.1.1 element 1 has an intertwined relationship with the other fourteen loop 1 elements because of the vote choices made by participants. Table 4-3 describes poor leadership as lack of control and support from leaders. Argyris (2000: 84) suggests that nearly 95% of the executives involved in their study emphasize that an organization is only good as its top people. In the early part of the twentieth century, a French industrialist by the name of Henri Fayol wrote that all managers perform five management functions, namely; planning, organizing, commanding, coordinating, and controlling (Robbins et al., 2009: 5). Therefore, a lack of control in any leadership role is an indication of deficiency on the part of the leaders of that particular organization and this may have multiple negative consequences in the operations of the organization. Modification

project delays at Koeberg Power Station have been identified as one of the implications found as a result of poor leadership through this research study.

Element 5 (Insufficient risk management in terms of risk analysis, response and control) is among the loop 1 elements which are driven by element 1 (Poor leadership). A description of element 5 is given in Table 4-3 and the description explicates the difficulty experienced by the project team during execution of modification projects due to inadequate identification and management of risks during the planning phase of the modification projects. PMBOK(R)_Guide (2013: 310) defines project risk as an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality. This definition resonates well with the research findings with respect to schedule and scope. When a modification project gets delayed, the scope creep becomes evident due to inadequate risk identification, analysis, and control. The relationship between risk management and scope creep is illustrated by element 5 aggravating element 8 (Scope creep) and vice versa and this relationship is demonstrated by loop 1 of MPDF model (refer figure 5-13). Consequently, the combination of these two elements affects the schedules of modification projects and causes delays thereof.

In addition, element 8 (Scope creep) has a positive relationship with element 7 (Poor scope management, definition) as shown in Figure 4-13. Poor scope definition is recognized by industry practitioners as one of the leading causes of project failure, adversely affecting projects in the areas of cost, schedule, and operational characteristics (Cho and Gibson Jr, 2001: 115). Koeberg Power Station is not exempted from this view. Participants indicated that one of the challenges with regard to scope definition is the fact that modification projects are done with the intention of to improve the existing plant components or systems. Consequently, some technical aspects may not be clear during the design phase of the project and numerous design field changes may be required during the execution phase. On the other hand, the scope creep generated because of this problem will need to be managed through the scope review board process. The combination of these competing factors results in modification project delays.

Two examples were given by the participants regarding the lack of risk identification and scope management of definition which resulted in modification project delays. A modification project of retrofitting turbine rotors to increase the electric power output of Koeberg Power Station units was implemented. However, when the unit was placed in service to produce electricity, excessive vibrations of the turbine rotors were experienced and the unit shutdown had to take place. This delayed the modification project and the outage project. Had the risks been identified during the design phase of the turbine rotors, mitigation measures could have been incorporated in the design. Another example shared by participants was the foreign

material intrusion found after the implementation phase of the generator rotor replacement project. The impact of failure to identify the risk of having foreign material intrusion to the system resulted into a delay of the modification and outage projects and consequently affected the availability of electricity to the national grid.

Element 6 (Lessons not learnt) as a project delay factor grouped under loop 1 signifies a process issue in the Koeberg Power Station organization. Participants indicated that, although Koeberg Power Station has a method of capturing lessons learnt, the data quality and retrieval methods of are lacking with respect to the captured information or knowledge. The project team is obliged to capture lessons learnt from their respective projects; however, due to other project priorities at a time when the learning is acquired, the learning does not receive due diligence. Consequently, learning across functional departments is lacking and a repetition of similar mistakes is experienced which results in project delays.

Element 9 (Bureaucratic commercial and investment processes) is also driven by element 1 (Poor leadership) and other loop 1 elements. Table 4-3 gives a description of element 9 which relates to inefficient procurement processes, ineffective approval process, and lack of control by leaders to ensure required modification project approvals are done in good time. The combination of these factors leads to modification project delays. Bommer et al. (2002: 21) suggested that project management typically involves the planning, organizing, executing, and monitoring of a complex set of interrelated tasks, as well as coping with uncertainties, crises, and bureaucracy. The last part of the statement regarding project management (Coping with uncertainty, crises, and bureaucracy) coincides with the structural link between element 21 (Proficiency of project manager) and element 9 shown in the model (refer to Figure 4-13). If the project manager is competent in the project management field, he or she will be able to cope with the bureaucracy of the organization and bring about the project on time. However, if the project manager is not competent in managing projects, project delays will be evident. Participants indicated that the bureaucratic nature of processes is intended to enforce good governance within the organization. However, Bommer et al. (2002: 21) argued that, while set systems, processes, and routines are important to the smooth functioning of an organization, they can bring a negative side to operating systems and organizational culture as they can hamper the development of innovative ways for dealing with new situations.

Table 4-3 provides a description of element 10 (Inaccuracy of execution duration on the plan) in which project managers are presented with two challenges. One challenge is limited knowledge with regard to interfacing the modification project with the existing plan components or systems which is sometimes experienced by project teams. Due to this limited knowledge, project managers may underestimate the duration of executing their

modification project activities. The second challenge is the predetermined required outage project duration. Eskom top management (executive level) strategically drive the planning of Eskom power station outages for maintenance purposes and make decisions on how long a particular power station unit should be unavailable to produce the electrical energy for the national grid. This decision has an impact on project managers at Koeberg Power Station as they are expected to work within the timeframe provided to them for their modification projects, without considering the actual critical path of the project. These two challenges result in element 10, which subsequently results in delay of modification projects and outage projects. It should be noted that element 10 has an intertwined relationship with the other loop 1 elements as previously mentioned.

Element 11 (Cross-functional structure is not effective) refers to situations whereby conflicting priorities are experienced between a function of a particular department's and an activity of a particular modification project as described in Table 4-3. This presents a weak matrix organization described by PMBOK(R)_Guide (2013: 23). A weak matrix organization maintains many of the characteristics of a functional organization, and the role of the project manager is more of a coordinator or expediter (PMBOK(R)_Guide, 2013: 23). CITI_APM_Study_Guide (2006: 12) further identifies the following disadvantages relating to a matrix organization:

- The functional manager might decide to give priority to Project A against the wishes of Project B and this may lead to conflict and delay in the delivery of projects.
- Personnel working in a matrix have two managers, and any person working within such a matrix might receive conflicting instructions from the project manager and the functional manager.

A correlation exists between element 13 (Lengthy project management processes with multiple departments involved) and element 11 as one element aggravates the other. The project management process at Koeberg Power Station requires the involvement of multiple departments under the matrix organization structure described above. Bommer et al. (2002: 22) argue that, because of the existing operating systems and the organizational culture, the choice of a project management process appropriate to the magnitude and criticality of the project is often not considered. A one-size-fits-all culture emerges for conducting projects of vastly different scopes and dimensions. Participants indicated that it sometimes the case with modification projects at Koeberg Power Station and this results in the delay of projects.

Element 15 (Resource constraints) refer to the manpower constraints experienced by project managers when forming their teams. The manpower includes Eskom project leaders, subject matter experts, and design engineers. Participants also posited that the specialized nature of

nuclear modification projects sometimes requires resources to be sourced from the international community. Failure of a project manager to source the specialized team might result in project delays.

4.2.3.3 Top management decision as a project delay factor

Element 2 (Top management decision) is aggravated by all fifteen elements under loop 1 of MPDF model. It is important to note that element 2 does not aggravate the fifteen elements of loop 1 and this is shown by an arrow extending from the fifteen elements of loop 1 to element 2 (Top management decision). Vote number 1 and vote number 2 (refer to Figure 4-12) resulted into a relationship indicated by an arrow extending from loop 1 to element 2. Figure 4-12 indicates that there is no other elements on loop 1 other than element 1 assessed against element 2. However, the relationship between element 2 and element 1 includes all other elements under loop 2 due to the fact that element 1 has an intertwined relationship with other loop 1 elements.

Table 4-3 gives a description of element 2 (Top management decision) and the description relates to decision making by top management for strategic planning purposes. Top management decision was identified as a project delay factor as top management may decide to suspend or discontinue a certain modification project due to lack of funding and resources. Another perspective may be a case where top management are compelled to make tough decision in response to the consequences displayed by poor leadership and poor project management. The MPDF model (Figure 4-13) indicates that this factor can be driven by various project delay factors from loop 1 such as element 1 (Poor leadership).

4.2.3.4 Loop 2 project delay factors

Loop 2 with element 3 (Poor coordination) and element 12 (PM does not fully understand how modification projects fit into an outage project) have a similar relationship with the fifteen elements of loop 1 as element 2 explained in § 4.2.3.43. The similarity in relationship of element 2 and loop 3 elements also extends between loop 2 elements to loop 3 elements. However, element 3 and element 12 have on their own an intertwined relationship which makes up loop 2. Participants responded or voted “Yes” on both vote number 30 and 31 as shown in Figure 4-12 and thus this resulted in the formation of loop 2 shown in Figure 4-13. Loop 2 means that when a project manager doesn’t fully understand how a modification project fits into an outage project, poor coordination will result. This makes a sense as it explains that the knowledge and ability to integrate projects and project tasks by a project manager will lead to his or her ability to exercise proper controls over projects. Inversely, lack

of coordination by the project manager will prevent him or her from acquiring the necessary knowledge and experience to integrate modification projects into outage projects.

4.2.3.5 Loop 3 project delay factors

Loop 3 elements, element 4 (Delayed delivery of material or spares) and element 19 (Outage project strategy and goals) are aggravated by element 2 (Top management decision) as shown in Figure 4-13. This relationship represents top management decisions towards funding of modification projects and thus affecting the outage project strategy or goals as the implementation of some modification projects may be delayed. Vote 46 of Figure 4-12 indicates that element 2 aggravates element 19. Similarly, vote 9 in Figure 4-12 shows that element 2 causes element 4. Furthermore, vote 10 and vote 47 by participants in Figure 4-12 are both “No” to the imposed question assessing the interrelationship among loop 3 elements and element 2. This combination of votes between element 2 and both loop 3 elements resulted in an arrow extending from element 2 to loop 3 elements (refer Figure 5-13). This arrow indicates that elements 4 and 19 are aggravated by element 2, yet element 2 is not aggravated by the combination of elements 4 and 19.

The end product of project delay factors, caused by a number of factors or elements is a combination of element 4 (Delayed delivery of material or spares) and element 19 (Outage project strategy and goals) as shown in loop 3 of Figure 4-13. Loop 3 represents an interrelationship between elements 4 and 19 in which one element aggravates the other and vice versa. The software generated loop 3 as a consequence of responses or vote choices made by participants when the question was posed to them about these two elements. Participants voted “Yes” on the questions regarding the relationship between element 4 (Delayed delivery of material or spares) and element 19 (Outage project strategy or goal) as shown in vote 49 and vote 50 of Figure 4-12, and this resulted in a loop relationship generated between these two elements. The researcher is of the view that the voting by the participants regarding elements 4 and 19 is particularly true and practically realistic or possible. For instance, if a certain plant component or system requires a modification project and the modification project is due to be implemented during a specific outage project (i.e. outage project 1), a delay in material and spares delivery for this modification project will affect the outage project strategy or goals. The outage strategy might be to perform major maintenance and implement significant modification projects during a particular outage (outage project 1), and perform less maintenance and implement no modification projects during the second cycle of the outage project (outage project 2). Delayed delivery of spares might mean the modification project will not be implemented as planned. When the spares arrive, the available opportunity (outage project 2) may not be suitable for implementation of

the modification project. On the contrary, outage project strategies or goals may also influence a need to procure certain materials or spares in an urgent and expedited manner. Failure of supplier(s) to deliver the materials or spares on time, will affect the outage project strategy or goal.

4.3 Comparison of research findings and literature review

One of the research study objectives was to determine whether a gap or correlation exists between the factors identified through the research study and the factors the project management fraternity believe to have a significant contribution on untimely delivery of projects. Table 4-4 illustrates the comparisons between project delay factors identified through the research study at Koeberg Power Station and delay factors identified by other researchers. A total of twelve project delay factors from the research study correspond with the project delay factors identified by other authors collated through the literature review.

The most common project delay factor found by various authors is “poor planning”. This factor was identified by Walker in 1995, and became predominant in the past three to five years (year 2011 to 2013) when research studies relating to identification of factors causing project delays were conducted by other authors as shown in Table 4-4. Poor planning as a project delay factor appears under loop 1 of MPDF model (refer Figure 4-13). According to the model, loop 1 project delay factors are the drivers of other project delay factors positioned on the right hand side of the model. Therefore, poor planning is also characterized by being the driver of factors such as “poor coordination”, “PM not fully understanding how modification projects fit into outage project”, “Top management decisions”, “Delayed materials or spares” and “Outage project strategy or goals” as shown in Figure 4-13. Due to poor planning, top management at Koeberg Power Station are compelled to take tough decisions regarding the modification projects. These decisions may include temporary suspension of some modification projects. Decision taken may affect outage project strategies and delivery of material for modification projects. Therefore, poor planning is considered to be one of determinants that lead to untimely delivery of modification projects at Koeberg Power Station.

Scope creep has also been identified by five researchers as one of the determinants of project delays as shown in Table 4-4. It is one of the project delay factors grouped under loop 1 of the MPDF model (refer to Figure 4-13). Chan and Kumaraswamy (1997) identified scope creep as necessary variation works. This demonstrates that sometimes the scope creep could be due to work that is necessary to achieve the project objectives or goals. One of project delay factors identified through this research study related to scope creep is “Poor scope management or definition” shown in Table 4-3. Proper scope definition can help to

address and reduce the amount of work identified during the execution phase of the projects. Therefore, although “Poor scope management or definition” could not be directly matched with any project delay factor identified by other authors through literature review, this factor is directly linked with the scope creep.

Table 4-4: Comparison of research findings delay factors with literature review

Project Delay Factors from the Research Findings	Project Delay Factors from Literature	
	Factors	Author
Poor co-ordination	Effective resource coordination	Walker (9995)
	Lack of coordination between different parties	Mulla and Waghmare (2015)
	Poor coordination	Sunjka and Jacob (2013)
Delayed delivery of materials, spares	Material procurement	Frimpong et al, 2003
Insufficient risk management in terms of risk analysis, response and control	The ability of an organization to manage risk	Walker (9995)
	Poor risk management	Chan and Kumaraswamy (1997)
Scope creep and scope management, definition	Necessary variation works	Chan and Kumaraswamy (1997)
	Variation orders, change of work scope by owner during construction	Marzouk and IE-Rasas (2012)
	Excessive change orders by the client	Ling and Lau (2001: 421)
	Change orders by client during construction	Baloyi and Bekker (2011)
	Change in work scope	Mulla and Waghmare (2015)
Inaccuracy of execution duration on the plan	Inaccurate estimation of time and cost	Mulla and Waghmare (2015)
	Unrealistic contract duration by the clients	Sunjka and Jacob (2013)
Lengthy project management process with multiple departments involved	Multiple contracts in which one contractor was dependent on the other	Ling and Lau (2001: 421)
Resource constraints	Shortage of skilled labour	Baloyi and Bekker (2011)
	Shortage of qualified engineers	Albogamy et al (2012)
Poor communication	Ineffective communication among the project participants	Ling and Lau (2001: 421)
Project cost underestimation	Inaccurate estimate of time and cost	By Mulla and Waghmare (2015)
	Underestimation of the cost of project	Fugar and Agyakwah-Baah (2010)
Poor planning	Inadequate planning by the contractors	Sunjka and Jacob (2013)

Table 4-4: Comparison of research findings delay factors with literature review

Project Delay Factors from the Research Findings	Project Delay Factors from Literature	
	Factors	Author
	Poor planning and schedule of the project by the contractor	Albogamy et al (2012)
	Ineffective planning and scheduling of projects	Marzouk and IE-Rasas (2012)
	Poor planning and schedule	Baloyi and Bekker (2011)
	Suitability to project time	Haseeb et al (2011)
	Planning capability	Walker (9995)
Proficiency of a project manager	Poor professional management	Fugar and Agyakwah-Baah (2010)

Poor coordination is also a project delay factor identified three times by various authors from the reviewed literature as shown in Table 4-4. According to Figure 4-13, poor coordination is driven by loop 1 project delay factors. These include, but are not limited to, “Scope creep” and “Poor planning” described above. However, it can be argued that poor leadership may be the main driver towards poor coordination as poor leadership is also one of identified project delay factors grouped under loop 1 of Figure 4-13.

The project delay factors “Poor risk management”, “Inaccurate estimation of time durations”, “Project cost underestimation”, and “Resource constraints” have been identified twice by various authors from the reviewed literature. These factors appear under loop 1 of Figure 4-13). Therefore, these factors could be viewed as one of the determinants of modification project delays which will aggravate all delay factors on the right hand side of the MPDF model.

“Material procurement”, “Multiple contracts in which one contractor was dependent on the other contractor”, and “Ineffective communication among the project participants” have been identified once by other authors from the reviewed literature. “Multiple contracts in which one contractor was dependent on the other contractor” project delay factor has been matched with “Lengthy project management process with multiple departments involved” project delay factor identified during this research study. This has been done because the bases of identifying these two project delay factors were similar. Ling and Lau (2001: 421) argue that inadequacy on the single point contact and single point of responsibility to coordinate information exchange among contractors caused project delay of a large-scale power plant project in East Asia. Similarly, the participants on this research study indicated that a similar

challenge is experienced at Koeberg Power Station where a project activities cycle from one department to another and this often causes modification project delay.

The main determinant “Proficiency of a project manager” of modification project delays which aggravates all other project delay factors at Koeberg Power Station could not be matched with any project delays identified by authors from the reviewed literature. However, it can be argued that “Proficiency of a project manager” includes attributes such as good leadership, competency, and skill of a project manager in communication, planning, coordination, risk management, scope management, and others. Failure in the “Proficiency of a project manager” to exhibit the aforementioned attributes will result in poor leadership, poor communication, poor risk management, and poor scope management. This relationship can also be observed from the model in Figure 4-13. Therefore, although “Proficiency of a project manager” delay factor may not be directly matched with any of the project delay factors identified through literature review, an inextricable link exists between this factor and the factors mentioned above which form part of loop 1 of the model.

In addition, Price (2005 48) also posited that poor project manager competency accounts for 60% of project failures. Evidently, the need for cultivating effective project managers is critical because a project’s success or failure can be vital to organizational interests and the influence of the project manager is crucial to the success of the project (Price, 2005 48). Project managers are always faced with challenges of figuring out what to do with the implementation of their projects, despite uncertainty, great diversity, and an enormous amount of potentially relevant information (El-Sabaa, 1999: 1). El-Sabaa (1999: 1) further suggests that the project managers try to get things done through a large and diverse set of people despite having little direct control over most of them.

The research study has also revealed that some project delay factors are unique to modification projects at Koeberg Power Station and could not be matched with any project delay factors identified by other researchers through the reviewed literature. These factors include:

- poor leadership;
- top management decision;
- lessons not learnt;
- bureaucratic commercial and investment processes;
- cross-functional structure is not effective;
- pm not fully understand how modification project fit into outage project;
- delayed regulatory approvals;

- lack of discipline in executing the plan; and
- outage project strategy or goals.

CHAPTER 5 – CONCLUSION AND RECOMMENDATIONS

5.1 Review of research objective and conclusion

This section will provide conclusion to the report by discussing and reviewing whether the research objectives have been achieved. A total of five research objectives were identified in the research proposal (see § 1.6 of this document) and are discussed below:

To identify factors contributing to the untimely delivery of plant system modification projects at Koeberg Power Station.

The research study adopted Interactive Management methodology approach to identify factors causing modification project delays at Koeberg power station. This involved idea generation and nominal group technique (see § 4.2.1.6). A total of 21 project delay factors (see Table 4-3) were found to be the cause of modification project delays at Koeberg Power Station.

To evaluate interrelationships among identified project delay factors to establish which factors drive the others.

Interpretive Structural Modelling workshop as part of Interactive Management was used to determine the interrelationship among identified factors causing modification project delays at Koeberg power station (see § 4.2.2). A total number of six participants attended the interpretive structural modelling workshop. The participants comprised of one system engineer, two project managers from nuclear project management department, two project managers from the outage department and one project leader from the operations department. Facilitating the workshop session with Interpretive Structural Modelling software (Concept Star), triggering question was posed to the participants to determine if interrelationship exists among identified modification project delay factors. A model (refer figure 4-13) depicting interrelationship among 21 identified project delays was produced from the workshop session.

To analyse identified factors and determine the main determinants of untimely delivery of plant system modification projects.

Section 4.2.3 present the analysis of the modification project delay factor's model (refer Figure 4-13). The analysis revealed that "proficiency of a project manager" is the main determinant of modification project delay factors. This project delay factor "proficiency of a project manager" appears to be the driver of all other 20 project delay factors identified through the nominal group technique.

To assess whether a gap or correlation exists between the factors identified through the study and the factors the project management fraternity believe to have a great contribution on the untimely delivery of projects.

Correlation was assessed and identified among certain project delay factors identified through the literature review. This is presented under § 2.4 of this document (refer Table 2-7). Furthermore, a comparison was made between project delay factors from the literature and 21 modification project delay factors (see § 4.2.3 of this document). Correlation was found existing between 12 modification project delay factors identified through this research study and project delay factors identified through the literature review. A total of 9 modification project delay factors identified through this study were found to be unique to Koeberg Power Station. It is important to note that also some of the previous researchers on the subject of project delay factors found certain factors to be unique in areas where they conducted their research studies.

To recommend mitigating measures that Koeberg Power Station may consider in addressing the consequences of identified project delay factors on modification projects.

According to modification project delay factors' model (MPDF), refer Figure 4-13, some project delay factors are the drivers of other project delay factors. Therefore, it is assumed that if Koeberg Power Station focuses on addressing project delay factors which has been identified to be drivers of other project delays, the impact of other factors on project delays will significantly be reduce / mitigated. It is recommended for Koeberg Power Station to focus on addressing the "proficiency of the project manager" and some of project delay factors which appear under loop 1 of the model (refer Figure 4-13).

Section 1.1.3 of this document presents two conflicting views existing among Koeberg Power Station staff regarding the factors causing project delays at Koeberg Power Station. One view claims that the planning strategy of projects is a major contributing factor resulting in project delays at Koeberg Power Station. On the other hand, the other view holds that the major contributing factor is the lack of accountability and commitment to adhere to established project time schedules. The research findings coincide with both views:

- planning strategy factor has been identified in this study as "poor planning" (refer Figure 4-13); and
- lack of commitment to execute the established project plan has been identified as lack of discipline in executing the plan (refer Figure 4-13).

In addition, § 4.3 of this document demonstrates that poor planning is the most common project delay factor identified by other researchers as revealed by the reviewed literature.

Lack of discipline in executing the plan has been found to be unique to Koeberg Power station. However, both these project delay factors are represented under loop 1 of the MPDF model (refer Figure 4-13) and have not been found as major determinant of project delays at Koeberg Power Station. The major determinant of project delay at Koeberg Power Station has been identified to be “proficiency of a project manager” (refer Figure 4-13).

5.2 Research limitations

- The research method (interactive management) is only effective if the targeted population is educated, knowledgeable, and have sound experience of the subject under study.
- An interactive structural modelling workshop requires all participants to be actively engaged in the session at the same time in the same room. To assemble all participants under one roof may be a challenge as the workshop schedule may conflict with participant’s priorities and schedules.
- The questionnaire for collecting research data is of the open-ended type and this will require participants to spend considerable amount of time to carefully think of significant factors causing modification project delays.
- Some participants may possess dominant personal characteristics which may suppress the views of other participants and lead ideas of participants with dominant personal character being favoured.

5.3 Recommendations

This section provides recommendations to address identified modification project delay factors discussed in § 4.2.3 of this document. Furthermore, § 5.4 further articulate propositions for possible research work to deal with the challenge of project delays. The main determinant of modification project delays at Koeberg Power Station identified through this research study is a “Proficiency of a project manager”. Following “Proficiency of a project manager”, the second level of modification project delays is represented by loop 1 project delay factors as shown in the modification project delay factors’ model (MPDF model) Figure 4-13. Recommendations will focus on the main determinant and also incorporate the loop 1 project delay factors as they appear on level 2 of the MPDF model (see Figure 4-13). It is assumed that once the main determinant “Proficiency of a project manager” and loop 1 project delays are addressed, the impact of the driven modification delay factors will significantly be reduced or mitigated.

5.3.1 Proficiency of a project manager

According to the produced MPDF model (refer to Figure 4-13), proficiency of a project manager is a driver of poor leadership and other project delay factors. Fugar and Agyakwah-Baah (2010: 114) recommended the following which he claims to be an attempt to address the deficiency in the skill set of project managers and the team in terms of underestimation of project cost and time, poor scheduling and control, and poor site management:

- Establishment of continual education by an authorized association for members of the association to go through the technical and managerial competency evaluations. The acquisition of a certain number of credit hours in continual education should be a criterion for membership renewal.

In the Koeberg Power Station context, Project Management South Africa (PMSA) exists in South Africa as a national association presenting the project management professionals. Koeberg Power Station may encourage the registration and participation of project managers to PMSA to help with their skill development in the project management field. Minimum requirements in terms of qualification and experience in the project management field are described for registering with different categories with PMSA. Once the registration is approved, members of each category are expected to earn continuing professional development (CPD) points through participation on training designed to advance the skills of project managers in managing projects. Registered project managers are required to maintain and enhance their competence and have a responsibility to keep themselves abreast of developments and knowledge in the area of project management expertise in order to maintain their competence. Therefore, project managers at Koeberg Power Station may benefit from being registered with the PMSA as their involvement in the PMSA activities could help with improving their proficiency in managing projects.

Furthermore, the following are additional aspects which may help Koeberg Power Station project managers to improve their proficiency in managing modification projects:

- **Understanding of the organizational processes:** Koeberg Power Station is a nuclear power plant that has established rigid processes for its operational activities. Operational activities includes required maintenance of plant components and systems, design changes to plant components and systems, day-to-day work scheduling and management, quality management of various processes, safety of the plant and personnel, procurement requirements, project management processes, and several others. Koeberg Power Station processes are established to ensure effective control, governance, and proper management of operational activities. El-Sabaa (1999: 2) describes a technical skill the project manager needs

as an understanding of, and proficiency in, a specific kind of activity, particularly one that involves methods, processes, procedures, or techniques.

- **High-level technical knowledge of a nuclear power plant technology:** High level of technical know-how of a nuclear plant will help project managers to make effective decisions with regards to their modification projects. It should be noted that the project manager does not need to have the technical expertise of the nuclear plant technology as subject matter experts will continue to support him or her when making decisions. Successful project managers should have relevant experience or knowledge of the technology required by the projects. This involves specialized knowledge and analytical ability in the use of the tools and techniques of the specific discipline, for example construction engineering or information systems (El-Sabaa, 1999: 2). However, El-Sabaa (1999: 4) identified the technical skill as the least essential project manager skill in comparison to the human skill, and conceptual and organizational skill.

In addition, Marando (2012: 1) identified two management skills which are believed to be the cause for project managers to be unable to successfully lead projects as result of a deficiency of these management skills:

- Commonly referred to as soft skills, interpersonal skills include leadership, communication, negotiation, expectations management, influencing, problem-solving, and decision-making. Soft skills are largely intangible, not associated with a deliverable or a concrete output, and are generally applied without the use of tools or templates.
- Hard skills, that is, the more technical aspects of the project manager's role, generally involve the creation of a tangible deliverable such as a work breakdown structure, project schedule, critical path diagram, earned value reports, project budgets, dashboards, and so forth. These skills are more technical in nature, and they often incorporate the use of tools such as scheduling software, spreadsheets, modelling tools, and a myriad of deliverable templates available.

Notably, certain soft skills described above (i.e. interpersonal skills such leadership and communication) are one of the skills identified to be project delay (factors) determinants shown in the MPDF model (refer to Figure 4-13). This testifies to the argument made by research participants through their voting choice which led to demonstration that "Proficiency of project manager" as a project delay factor is the driver of these project delay factors (poor leadership and communication). Therefore, it can be argued that if "Proficiency of project manager" is addressed, chances of other project delay factors reducing their impact on

project delays could be witnessed. Another project delay factor identified through this study which is interrelated with the proficiency of a project manager is “Project manager not fully understand how modification projects fit into outage project”. This project delay factor can also be addressed by resolving the project manager’s proficiency factor.

Furthermore, Baroudi and Pant (2007: 124) also added that PMBOK predominant emphasis is on the required ‘hard (technical) skills’ at the expense of the ‘soft (human) skills’ for project managers. A more balanced approach between hard and soft skill concepts would see them complementing each other and enhancing project management education in the process. El-Sabaa (1999) posited that human skill, conceptual skill, and technical skill are interrelated, but they can be developed independently.

Muller and Turner (2009: 438) conducted a study to determine whether different types of leadership style were more important depending upon the type of project. Using the emotional intelligence model, Muller and Turner (2009: 438) found the following seven competences categorized under emotional leadership competence: motivation, conscientiousness, sensitivity, influence, self-awareness, emotional resilience, and intuitiveness. In addition, Clarke (2010: 6) conducted a similar study and found that emotional intelligence abilities and empathy may be a significant aspect of individual difference that contributes to behaviours associated with project manager competences in the areas of teamwork, attentiveness, and managing conflict, as well as dimensions of transformational leadership. Clarke (2010: 5) defines emotional intelligence as “the ability to perceive accurately, appraise, and express emotion; the ability to access and/or generate feelings when they facilitate thought; the ability to understand emotion and emotional knowledge; and the ability to regulate emotions to promote emotional and intellectual growth”. Clarke (2010: 17) recommended that organizations should perform screening when selecting project managers based on personality differences, with emotional intelligence providing a subsidiary mechanism. Alternatively, organizations may establish interventions to help improve project managers’ emotional intelligence competence. Therefore, Koeberg Power Station may consider both options suggested by Clarke to address the deficiency in the proficiency and leadership of project managers.

5.3.2 Loop 1 project delay factors

Loop 1 of MPDF model (refer Figure 4-13) represent the second level of project delay factors following the main determinant “proficiency of a project” delay factor. As discussed in § 4.2.3 of this document, loop 1 project delay factors have intertwined relationship among each other. Intertwine relationship means one project factor leads to the other and vice versa. Given this relationship, this section will discuss and provide recommendations towards few of

the loop 1 modification project delay factors with the assumption that if these project delay factors are addressed, other loop 1 project delay factors will significantly be reduced or mitigated.

Poor leadership and poor communication are two of project delay factors identified under loop 1 of the MPDF model (refer Figure 4-13). Communication and coordination skills are some of the skills the project managers need to possess in order to become proficient in managing their projects. For example, Meredith et al (1995) cited by El-Sabaa (1999: 1) categorized the skills needed for a project manager into six skill areas: communication, organizational, team building, leadership, coping, and technological skills. Communication skill involves talking to and convincing a project team to follow a certain route in executing project activities, reporting on the progress made on the project, reporting project highlights, reporting project lowlights, and enthusiastically motivating the team to work towards improving the lowlights to achieve desired goals. Communication and coordination skills go hand in hand in an attempt of organizing project activities to bring about project success.

El-Sabaa (1999: 2) describes conceptual skill as an innate skill of a project manager to envision the project as a whole and extends to visualizing the relationship of an individual project to the parent organization. Recognizing these relationships and perceiving the significant elements in any situation, the project manager should then be able to act in a way that advances the overall welfare of the project and the parent organization. However, conceptual skill at Koeberg Power Station needs to be displayed by both the project managers and the functional managers to effectively deliver modification projects on time. This will help to ensure that project managers and functional managers have an overall viewpoint of projects, which will then address “cross-functional structure is not effective”, “poor leadership” and “lack of discipline in executing the plan” project delay factors identified in this research study. Therefore, the conceptual skill and organizational skill are interrelated (El-Sabaa, 1999: 1).

El-Sabaa (1999: 3) identified characteristics of a good project manager and grouped them under conceptual and organizational skill type. These skills include the skill of planning, organizing, having strong goal orientation, ability to see the project as a whole, ability to visualize the relationship of the individual project to the industry and the community, and strong problem solving orientation. From the El-Sabaa argument, it can be noted that an interrelationship between planning skill and effective coordination exists.

“Project cost underestimation” and “inaccuracy of execution duration of the plan” are some of loop 1 project delay factors. According to Khan (2006: 12), feasibility study comprises the following aspects:

- **Technical feasibility** explores the availability of technological know-how; competency of management and operations teams; availability of land, infrastructure, utilities, etc.
- **Economic feasibility** evaluates the benefit and cost ratios of different technological options available. It also evaluates rates of return for the project over its anticipated lifetime.
- **Financial feasibility** deals with availability of necessary funds and cost of borrowing money based on credit rating of owner organization.

At Koeberg Power Station, project financial estimates are performed by system engineers during the planning phase of the project for financial approval by relevant management committees. These cost estimates consider the feasibility study aspects mentioned above but with limited comprehensiveness. Consequently, the actual costs of project becomes more than the initial estimates as the system engineer focuses on the technical and safety aspects for financial approval. This leads to further funding required for the project and motivations at various levels need to be presented by the project manager and the process of obtaining financial approval result in project delays. Therefore, project financial estimates should be performed by financial experts with the assistance of system engineer to get the correct estimates. This process should be facilitated and overseen by the project manager.

Inaccuracy of execution duration on the plan may be addressed by proper use of lessons learnt and risk management. The technical project team needs to practise due diligence when investigating the anticipated technical modification project interventions. The project manager needs to oversee the process the technical team goes through in finalizing estimated duration for project activities.

Another method which may help addressing “lack of discipline in execution” is the proper structuring of key performance indicators (KPI) for project managers and functional managers. These KPIs need to be aligned with the expected responsibilities of project managers and functional managers as described in the process procedures. In addition, the establishment of KPIs for project managers and functional managers will help ensuring accountability.

5.4 Propositions for possible further research

The proficiency of a project manager has been identified as a main determinant and loop 1 (refer Figure 4-13) elements as major determinant of modification project delays at Koeberg Power Station. This finding is as a result of Interpretive Structural Modelling workshop held with the participants for a case study held at Koeberg Power Station which intended to

evaluate interrelationship among the 21 identified modification project delay factors. Recommendations have been made in § 5.3 of this document suggesting that if these two level drivers are addressed, modification project delays at Koeberg Power Station will be mitigated. Therefore, based on the salient finding from the four major objectives the following propositions can be concluded from the study and possible increase the area of research for the study of project delays:

- Interrelationship exists among factors causing project delays. Baloyi and Bekker (2011:64) also proclaimed that even though they listed project delay factors as stand alone in their research study, interrelationship exist between the two or more project delay factors. Baloyi and Bekker (2011:59) further argue that the research method of extended questionnaire or interviews has been a proven application of identifying project delays. However, this method is not suitable for evaluating interrelationship among the project delay factors. Therefore, interactive management methodology can be used as a solution to determine and evaluate the interrelationships between project delay factors.
- This research study has found that lack of proficiency of a project manager is the main cause of modification project delays at Koeberg Power Station. Therefore, improving the proficiency of a project manager will help to minimize project delays and improve the overall performance of projects in terms of time overrun.
- Conceptual skills are the skills which should be displayed by the line manager and project manager to address some of the major modification project delay factors (i.e. “cross-functional structure is not effective”, “poor leadership” and “lack of discipline in executing the plan”). Therefore, project performance in term of time overrun can be improved by addressing the conceptual skills of line managers and project managers.
- A total of 9 modification project delay factors identified through this research study were found to be unique to Koeberg Power Station. Some project delay factors are unique to an area, field, business or environment in which the project is conducted. Therefore, it is paramount important to consider the environment in which the project is conducted to identify the factors that influence timely delivery of projects.

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APPENDIX 1

Idea Generation Questionnaire for Identifying Factors causing Modification Project Delays

Researcher: Sikholiwe Ntoyanto

Important Notes:

- Research study is conducted to assist the researcher to complete his studies towards MSc in Project Management through University of Cape Town (UCT).
- Koeberg Operating Unit (KOU) has been selected as a case for the research study.
- Information gathered will be made available for possible use in strategic planning by the KOU management and staff to better deal with the challenge of project delays.
- Information obtained through the research study will be kept confidential by the researcher and UCT, and will not be made available for public use.

Please indicate your selection by ticking the appropriate box(s) on the table below:

a	Please indicate your department: <input type="checkbox"/> Nuclear Project Management (NPM) <input type="checkbox"/> Outage Management Department (OMD) <input type="checkbox"/> Work Control <input type="checkbox"/> Engineering Department
c	Please indicate duration of your experience in your department: <input type="checkbox"/> < 2 years <input type="checkbox"/> 2-5 years <input type="checkbox"/> > 5 years
b	Please indicate your current position: <input type="checkbox"/> Department Manager <input type="checkbox"/> Project Manager <input type="checkbox"/> Project Leader/Coordinator <input type="checkbox"/> Other (please specify)
d	Does your department make use of time parameter as one of success criteria for projects? <input type="checkbox"/> Yes <input type="checkbox"/> No
e	At what project phase is time parameter considered to be significant in your department? <input type="checkbox"/> All Phases <input type="checkbox"/> Concept phase <input type="checkbox"/> Definition phase <input type="checkbox"/> Execution Phase

In terms of your experience, please list five significant factors which you believe are leading to delays of modification projects and provide a description of each identified factor.

1		
2		
3		
4		
5		

APPENDIX 2

Information Sheet and Consent Form

Factors causing Delay of Modification Projects at Koeberg Power Station

Good day,

My name is Sikholiwe Ntoyanto and I am conducting research towards a Master's degree in Project Management. I am researching Factors Causing Modification Project Delays and would like to invite you to participate in the project.

Timely delivery of projects is one of the success criteria used to measure the performance of projects within the project management field. Projects which are delayed have various undesirable consequences to organizations, government departments, communities, and other stakeholders who have vested interests in the project. These undesirable consequences include increase in project cost, incomplete product when required which lead to dissatisfied clients and stakeholders, etc. The purpose of my research project is to identify factors causing project delays using the case of Eskom Nuclear Power Station. I am interested in finding out the key factors causing project delays and determine if interrelationship exists among the identified factors.

Please understand that you do not have to participate and that your participation is voluntary. The choice to participate is yours alone. If you choose not to participate, there will be no negative consequence. If you choose to participate, but wish to withdraw at any time, you will be free to do so without negative consequence. However, I would be grateful if you would assist me by allowing me to interview you.

You will be requested to respond to the questionnaire which will be provided to you as part of the research study. To complete the questionnaire will probably require fifteen minutes of time. Consequently, individual interviews will be conducted with you for the purpose of clarifying information gathered through questionnaires and this will take between 15 to 30 minutes. A workshop of approximately four hours will be arranged with all participants to assess interrelationships among factors identified using Interpretive Structural Modelling.

Information gathered will be made available for possible use in strategic planning by the Koeberg Power Station management and staff to better deal with the challenge of project delays. However, the final research report will not be made available to the Koeberg Power Station Management and staff.

Please note there is no anticipated risk of harm might ensue, all information gathered will be treated with high anonymity. However, if the participant feels uncomfortable to share or

elaborate on any information during interviews, the researcher will honour the participant's feelings by terminating the interview session.

All information gathered will be treated with high anonymity. However, the intended workshop will require all participants to be on the same venue and share ideas and knowledge. The sequence of the received ideas or information will be changed for the workshop so to achieve the anonymity of the source of the information gathered.

Name of participant Date

Signature of participant

APPENDIX 3

Ethic Approval

Application for Approval of Ethics in Research (EIR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

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.uct.ac.za/ucteberesearch/ethics.pdf>

APPLICANT'S DETAILS	
Name of principal researcher, student or external applicant	
Department	
Preferred email address of applicant	
If a Student	Your Degree (e.g., MSc, PhD, etc.)
	Name of Supervisor (if supervised):
If this is a research contract, indicate the source of funding/sponsorship	
Project Title	

- 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.

SIGNED BY		Full name	Signature	Date
Principal Researcher/ Student/External applicant		SIRIHOLOWE NTOYANTO		31/05/2016
APPLICATION APPROVED BY		Full name		Date
Supervisor (where applicable)		NIEN-TSU TUAN		31 MAY 2016
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).		ABIMOLA KUNDAPO		06/06/2016
Chair, Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.				

Signed