TRIPLE CONSTRAINT CONSIDERATIONS IN THE MANAGEMENT OF CONSTRUCTION PROJECTS: A SOUTH AFRICAN PERSPECTIVE

by

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DECLARATION

I hereby declare that the work presented in this mini-dissertation is to the best of my knowledge original, except where recognised otherwise in the text and no part of this document has been previously submitted by me for a degree of any kind at this or any other academic institution.

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ABSTRACT

The triple constraint considerations in construction projects determine failure or success of projects. The key reasons of a winning project comprise of identification, monitoring, control and management of projects risks. Projects, over the years, failed to be completed within the contracted triple constraints.

The persistent failure of construction projects in South Africa contributes to lack of development in skills and infrastructure. It is hypothesized that a deeper comprehension of the triple constraint and strategic management may supplement success of construction projects.

It is difficult to complete projects within the stipulated triple constraint elements due to the high degree of unforeseen circumstances. Although the success of construction projects is confined to the triple constraint, the projects successes can also be influenced by other external factors and intra-management of the triple constraint including trade-offs.

The ever escalating societal demand makes it a necessity to keep up through intensive investigation into construction projects. Communication breakdown is one of the sources of errors and is therefore essential for practicality of the survey in the investigation. A questionnaire was chosen for the survey.

The collected data was organised into qualifications and experience and was presented in a tabular and graphical formats. Due to the anticipated reluctance to participation, a larger number of people were engaged.

Contrary to the contextual information, the fieldwork survey indicates that projects are successful relative to the triple constraint elements. The success or failure of projects is largely founded on the triple constraint elements except for contractors who in addition to the triple constraint cite other factors.

ABSTRACT

The scarcity of engineering and construction skills in South African government is hurting success of construction projects and therefore infrastructure and skills development and sustainability.

In conclusion, both the contextual and fieldwork survey attribute failure of construction projects to lack of understanding and poor management of the triple constraint elements and trade-offs. These conclusions are however limited to failure to survey all project management data, sample size, ability to address questions and honesty of participants.

A further study into a bigger sample of this specific study is proposed.

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DEFINITION OF KEY WORDS

This section of the investigation is intended to provide a brief description of key terms used in the research investigation.

Consultant:	A professional who provides professional advice in a particular area
Construction:	A process consisting of assembling infrastructure in civil engineering
Contractor:	An organisation that contracts with owner or developer for construction of a facility
Fieldwork:	A collection of data outside a workplace
Project:	An undertaking that produces a service by a target date and within an agreed cost
Project Cost:	The money budgeted to do work in a project
Project Failure:	Failure to meet minimum requirements of the triple constraint in a project
Project Scope:	The work that needs to be accomplished to deliver a service with the specified features and functions
Project Success:	An achievement to meet minimum requirements of the triple constraint in a project
Project Time:	The measure of duration of work in a project

Trade-off: A situation that involves losing one element of the triple constraint in return for gaining another element

Triple Constraint: Balancing scope, time and cost goals

CHAPTER 1: OVERVIEW OF THE INVESTIGATION

1.1 Chapter Purpose

The objectives of this chapter are to: (1) Provide the preliminary contextual information of the research, (2) Describe the rationale of the research, (3) Formulate the problem statement of the research, and (4) Outline research objectives and propositions. The chapter further outlines the approach and the layout of the paper investigation.

1.2 Background Information

The triple constraint considerations for construction projects are at the core of decision making. Failure to understand and interpret it correctly can doom a project even if all the other project management tasks are carried out satisfactory (Dobson, 2004). It is a commonplace in the literature to link the triple constraint with project failure or success.

Management of daily household activities or projects is one of the oldest natural sciences or applied sciences. A number of projects are nonetheless not accomplished within the set constraints. Some project managers are therefore not fully matured. One of the key reasons of unsuccessfulness of projects is failure to identify, monitor, control and manage projects risks. Making use of a monitoring and feedback system could possibly have reduced this (Pretorius, 2001).

1.3 Introduction

People engage in daily household activities without realizing that by doing so they are managing these activities or projects and they are therefore project managers. Typically, all household activities that people accomplish on daily basis are characterised of definite deadlines, namely the commencement time and the completion time, to achieve certain objectives at the disposal of certain quantity of resources. These characteristics are referred to as project constraints. The daily activities are usually unrecognisable as a result of their small size, acquaintance, repetition, continuity and that they are normally accomplished by a single person (Gido, 2003).

Projects can be large or small and involve one person or thousands of people and can be done in one day or take years to complete (Augsburg Education). Irrespective of size, projects are normally not completed within the set constraints, that is, they fail. Over the past years a well-known and foremost number of construction projects have failed to be completed within the estimated time, budget, scope or a combination of them.

Business in construction is continuously changing and companies failing to adapt and respond to the complexity of the new environment tend to experience survival problems (Enshassi, 2009).

The research is intended to address and enhance factors that could diminish failures in South African construction projects.

1.4 Rationale of the Research

The fluency of failure of construction projects in South Africa cost government billions of money which could possibly have been used on other development projects. This could have been a solution to among others, lack of basic services to the needy people of South Africa and skills development. A preliminary review of the literature in this field suggests that in many cases projects fail because they do not deliver in terms of the strategic business objectives and/or higher purpose of the project.

Among others, the technological advancement, globalisation and lack of basic infrastructure have sparked the need for excellence in project management of construction projects. The construction industry plays a key role in the economic growth of South Africa; hence failure is not an option. The research will benefit project/contracts managers, engineers, government agencies and people of South Africa at large.

1.5 Problem Statement

All construction projects are initially budgeted for and appropriately timed for implementation of intended scope of works. These constraints are set with caution. However, in most cases, a large number of projects fail to be completed within the estimated constraint or constraints. Furthermore, project constraints are interconnected; meaning failure for a single constraint could affect the other constraint or constraints negatively. It is hypothesized that a deeper comprehension of the triple constraint dynamics and the strategic management thereof may supplement the delivery of project success within the construction industry.

1.6 Research Objectives

The primary objective of the research is to assess the triple constraint and determine sources of failures in order to increase the success rate of construction projects in South Africa and to give priority on the triple constraint. A literature review will be conducted in order to uncover the knowledge foundation of the triple constraint and capture the main factors contributing to project failure and success within the construction industry.

1.7 Research Propositions and Hypotheses

The high occurrence of construction failures in South Africa makes an investigation timely and necessary. The research results will enable project managers, contracts managers and engineers to recognise and focus on the critical project management factors in the construction field. The expected outcomes contributing to the high rate of failure of construction projects as per the theoretical discoveries are:

- Lack of an appropriate project value system, i.e. not achieving the delivery targets and strategic value (Van Wyngaard, 2011);
- Lack of expertise in South African construction industry (Greye, 2011);
- Lack of basic project management skills (Hallikas, 2012);
- Lack of communication between the members of project team (Pretorius, 2001);
- Binding provisions of the contract (Hallikas, 2012); and
- Lack of monitoring and feedback system (Pretorius, 2001).

The expected outcomes contributing to the high rate of failure of South African construction projects as a proposition are:

- Failure to effectively manage the triple constraint in line with the project objectives and principle results;
- Lack of technical skills from the client;
- Client's influence on technical issues;
- Political interference;
- Unethical conduct; and

- Poor transfer of knowledge to the next generation.

1.8 Research Approach

The introductory part of the investigation describes the theme of the research and the rationale of investigation.

A literature review will be conducted in order to collect and present all necessary findings. The core section of the research will comprise of questionnaires as research instrument. This instrument is presumed to be the most reasonable method to source information from the people without taking much of their busy schedule. Questionnaires will also determine a practical experience from the ground.

The research methodology in terms of data gathering is proposed as follows: (1) Literature study in support of the rationale of the research, and (2) Questionnaires in support of the problem statement and the research hypothesis. The investigation will mainly focus on ways with which the effective management of the triple constraint can improve the success of the construction industry in South Africa.

The report concludes by formulating a number of recommendations in order to bridge the gap between the different perceptions regarding projects failure in order to enhance the level of service implementation in South Africa.

1.9 Organisation of the Research

The chapter structure of the research is outlined as follows:

- Chapter 1 (Overview of the Investigation): This chapter presents the background information and the justification of conducting a research;

- Chapter 2 (Theory and Research Survey): This chapter entails literature study of the success and failure of construction projects;
- Chapter 3 (Research Design and Methodology): This chapter presents the methodology followed during both fieldwork and analysis of data and the anticipated inadequacies;
- Chapter 4 (Presentation and Analysis of Results): This chapter entails presentation of the surveyed data and interpretation of the main findings;
- Chapter 5 (Conclusion and Recommendations): This chapter entails summary of findings, presents conclusions and recommendations and discusses gaps in the data;
- Chapter 6 (Appendices): This chapter appends instruments used in the fieldwork and some surveyed information and some analysed results; and
- Chapter 7 (List of References): This chapter entails list of sources consulted.

1.10 Chapter Summary

The triple constraint considerations in construction projects determine failure or success of projects. The key reasons of a winning project comprise of identification, monitoring, control and management of projects risks. Projects, irrespective of size, fail to be completed within the triple constraint elements, especially in the complexity of the new environment.

The persistent failure of construction projects in South Africa contributes to lack of development in skills and infrastructure. The solution to this will therefore benefit economic developments in South Africa. It is hypothesised that a deeper comprehension of the triple constraint and strategic management may supplement success of construction projects.

CHAPTER 2: THEORY AND RESEARCH SURVEY

2.1 Chapter Purpose

The objectives of this chapter are as follows: (1) To uncover the contextual information of the successes and failures of construction projects in South Africa, (2) To disclose theories and concepts discovered in the construction industry with a superior attention to the triple constraint of a project, (3) To explicitly define and analyse the concept of the triple constraint, (4) To extensively analyse the triple constraint independently, (5) To evaluate the relationship between the triple constraint, and (6) To assess management of the triple constraint.

The report further investigates external factors influencing construction projects unfavourably.

2.2 Introduction

It is necessary to initially understand the two elementary terms, “project” and “project management”, prior to investigating the triple constraint in project management. A project is an endeavour in which human, financial and material resources are organised in a novel way to undertake a unique scope of work, of given specification (performance) within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives (Duma, 2005). Projects can be both simple and complex to carry out. Projects regarded as simple such as daily household activities can be carried out by a single person with ease.

Big projects such as construction of a stadium are more complex to be carried out by a single person; hence a science of project management is used to manage activities and people. Project management is described as the use of knowledge, skills, tools and techniques to plan and implement activities to meet

or exceed stakeholders' needs and expectations from a project (Education Training Unit, 2004).

The investigation will solely concentrate on construction projects which are widely on civil engineering practice. Civil engineering works include steel, mechanical and electrical construction needed in the development of transport infrastructure, water storage, reticulation and sewerage systems, power lines, fuel tanks, mine headgears and bins, bunkers or silos (Vertenten).

Over the years quite a number of big projects have failed such as the Tacoma Narrows Suspension Bridge and Sydney Opera House in Australia to mention two (Pretorius, 2001). Based on this statement, the science of project management in construction projects is not been fully comprehended particularly in regards to the triple constraint.

This Chapter is intended to collect and present the discovered information on the success and failure of the construction projects in South Africa and give a detailed description of the triple constraint.

2.3 Historical Background

Projects in one form or another have been undertaken for millennia (Weaver, 2007):

- The ancient Egyptians constructed the pyramids some 4 500 years ago;
- Numerous transcontinental railways were constructed during the 19th century; and
- Buildings of different sizes and complexity have been erected for as long as mankind has occupied permanent settlements.

A project management science was during these periods not practiced. It was only in the latter half of 20th century that people started talking about project management (Weaver, 2007).

The engineering and construction practices have become more complex sciences in the South African modern practice. Among other factors, the complexity is highly influenced by technological advancement, external influences and non-ethical drives. As a result of this complexity, and also of the rising cost structure, the responsibilities of management in the control of technical projects have become very important and also more difficult (Vertenten).

Many organisations claim that using project management provides advantages such as (Augsburg Education):

- Better control of financial, physical and human resources;
- Improved customer relations;
- Shorter development times;
- Lower costs;
- Higher quality and increased reliability;
- Higher profit margins;
- Improved productivity;
- Better internal coordination; and
- Higher worker morale.

2.4 Determination of Projects Failure

A good thing about a successful project is that everybody wins. The project constraints need to be delivered in line with the requirements of the key stakeholders involved, for everyone to win. For a project to be deemed successful, it supposed to fully meet minimum requirements of these constraints.

The minimum requirements are the scope, time allocated to complete the scope, budget allocated to complete the scope and customer satisfaction.

The construction industry is complex in its nature because it comprises large numbers of parties as owners (clients), contractors, consultants, stakeholders and regulators. Despite this complexity, the industry plays a major role in the development and achievement of society's goals (Enshassi, 2009).

There are easier ways to identify when the project fails or failed, for instance when the project is aborted and everyone involved in the project is laid off. But there are less obvious kinds of failures which are not easy to spot (Green):

- When the project doesn't do what it suppose to;
- When the project costs a lot more than expected;
- When the project takes longer than expected; and
- When the customer is dissatisfied of the project.

All these variables (constraints) should be closely and appropriately managed to ensure that the project goals are accomplished successfully. Projects fail in almost every instance because of one or more of the key project variables have not been managed effectively (Ward, 2003). Appendix A further discusses factors influencing projects success in information technology.

2.5 Project Rationalisation

The most overlooked question in project management is 'why', for example (Dobson, 2004): Why is this project undertaken? Why not a different project? Why this direction? Why this outcome? Why these specifications? Why not other ones?

The following conclusions in terms of project justification were drawn (Van Wyngaard, 2011):

- Effective projects bring form and function to ideas or needs, and add value;
- The rationality for undertaking a project should be clearly defined and understood by all stakeholders;
- The higher purpose (rationale) of the project should tie-up with the overall strategy of the business;
- A project may be perceived as successful even when it failed to fully deliver within the planned constraints; a project may also be perceived as unsuccessful even when it did meet all the required constraints. The higher purpose of the project should fundamentally be the driver of the project;
- SMART objectives are the building blocks towards the achievement of the project higher purpose. The challenge is to optimise the allocation and integration of inputs needed to meet these objectives;
- Triple constraint considerations are central to project management; and
- Effective project management yields delivery of project objectives and adds value through the achievement of the project higher purpose.

2.6 Introduction to the Triple Constraint

Apart from the requirement of customer satisfaction, a project is further constrained to "scope" of work, "time" to complete the scope of work and "cost" to accomplish the set scope of works. These constraints are popularly referred to as the "Project Management Triangle" or "Triple Constraint". Refer to Figure 1 underneath for a schematic representation of the triple constraint.

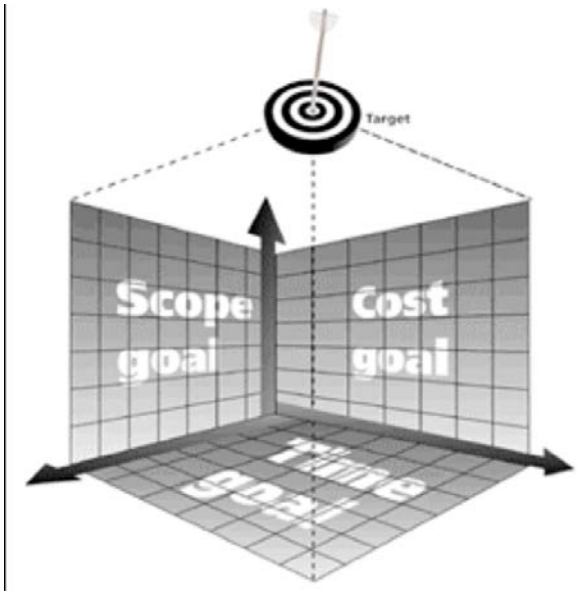

Figure 1: Triple Constraint of Project Management (Van Wyngaard, 2011)

The triple constraint elements for a successful project are defined as follows (Augsburg Education):

- **Scope**: What work will be done as part of the project? What unique product, service or result does the customer or sponsor expect from the project?
- **Time**: How long should it take to complete the project? What is the project's schedule?
- **Cost**: What should it cost to complete the project? What is the project's budget?

The triple constraint is used to gauge whether a project's objectives are being met (Project Management Knowledge). Imagine a project with unlimited constraints, the project team might probably not achieve much for the reason that they might insist on unlimited iterations to perfect the service, especially if there is unlimited budgetary convenience for the service and this might take too long to be completed.

2.7 Defining the Triple Constraint

Once a construction project is started, unforeseen circumstances may jeopardise the achievement of the project objective with respect to scope, cost or time (Gido, 2003).

- The cost of some of the materials may be higher than originally estimated;
- Inclement weather may cause a delay; and
- Additional redesign and modifications to a sophisticated piece of automated machinery may be required to get it to meet the performance specifications.

It is therefore difficult to satisfy the triple constraint (Young, 1996). The triple constraint are hereunder defined and examined for a better understanding.

2.7.1 Project Scope

The scope of work describes the work to be performed or the services to be provided (USCS, 2003). Scope is a term used to describe qualitative and quantitative components of a project to accomplish a project objective successfully.

The scope of works is normally subdivided into smaller and manageable tasks using a technique of Work Breakdown Structure (WBS). Refer to Appendix B for an illustration of Work Breakdown Structure. WBS is defined as a deliverable-oriented hierarchical decomposition of the work to be executed by the project team, to accomplish the project objectives and create the required deliverables (Project Management Institute, 2004).

Based on the design and construction experience of the author, it is deduced that the scope of works has three components including: (1) Quality, (2) Specifications, and (3) Standards to be achieved.

2.7.1.1 Quality

Quality is the ability to manage a project and provide the product or service in conformance with the user requirements on time and to budget, and where possible maximizing profits (Flett, 2001).

Apart from establishment that quality is described as a major component of the scope of a final service (Encyclopaedia, 2011); quality is established as one of the key factors constraining successful project delivery within the South African construction industry.

Some of the key dimensions of quality are features, reliability, conformance, durability, accuracy, completeness, serviceability, aesthetics and ethics among others. The positive or negative influence of quality lasts long after "cost success" and "schedule compliance" have been discounted or even forgotten (Duma, 2005). Appendix C further elaborates on the concept of quality.

2.7.1.2 Specification

A specification is described as a clear and accurate description of the technical requirements for a material, service, including the procedure by which it will be determined that the specifications for the items are available (USCS, 2003).

The distinction between the concepts of quality and degree of merit (grade) needs to be considered. Across literature authors warn that project teams often confuse quality with degree of merit in terms of characteristics, or grade (Van Wyngaard, 2011). The International Organisation for Standardisation defines grade as a category assigned to products or services having the same functional use but different technical characteristics.

Low quality is always a problem; low grade may not be. The PMBOK (Project Management Body of Knowledge) uses a software product as an example and relates quality to the number of defects and grade to the number of features. It can hence be argued that the quality of product deliverables is not a definitive component of project scope, but rather the grade of the product is.

2.7.1.3 Standard

A standard is a requirement of service delivery set by the local authority or any of the recognised institutions.

Scope is therefore an important constraint of a project for the reason that it expresses exactly what should be done and how should be done to achieve the required results and to satisfy the customer needs. However, it is crucial for the scope of works to be described clearly and unambiguously.

Apart from the components of the scope of works discussed above, there are three basic requirements surrounding the scope of work (UCSC, 2008): (1) Scope clarity, (2) Scope precision, and (3) Scope completeness.

2.7.1.4 Scope Clarity

If the scope of work is not sufficiently defined, some contractors may not wish to propose because of uncertainty about the risks involved or the relationship of the work to their particular capabilities. If the scope of work is too restrictive, competent contractors may feel that their creativity or alternative approaches will be inhibited by the customer and therefore may choose not to respond (UCSC, 2008).

2.7.1.5 Scope Precision

The scope of work is the contractual vehicle for expressing exactly the specific agreement of the contractor and the customer. Since it defines the scope of work to be performed, its precision has a direct effect on efficient contract administration. Any work outside that scope will be considered new procurement with resulting increased costs (UCSC, 2008).

2.7.1.6 Scope Completeness

To be legal and binding, the scope of work must be complete. It must delineate the entire scope of work to be performed and specify all the tasks within that scope. Any scope of work must cover the following points (UCSC, 2008):

- What needs to be done;
- Who will do what;
- When it should be done;
- Where it should be done; and
- How contract performance will be judged.

2.7.2 Project Time

The project time is defined as the actual duration estimated for execution and completion of the scope of work. It has two components, namely scheduling and schedule control (Steyn, 2002, 2003).

The project scheduling is necessary to determine when work must be done and to communicate the information to determine what resources (manpower, equipment, facilities and funds) should be available at any specific time (Steyn, 2002, 2003).

Scheduling provides a number of benefits including the following:

- It provides more certainty about the end date;
- It ensures more efficient utilisation of resources and eliminates much frustration;
- Without project schedules it is not possible for an individual to determine his/her workload; and
- A project schedule is necessary to determine the cash flow.

The duration of the project is estimated using several techniques including (Gido, 2003):

- Program evaluation and review technique (PERT);
- Critical path method (CPM); and
- Gantt chart.

Illustrations of these techniques are attached in Appendix D for ease of reference.

Schedule control is simply referred to as a management of project schedule so as to accomplish goals set for the project. Initial plans of schedule for most projects (if not all) tend to change due to unanticipated occurrences through the project time. Schedule control involves four corrective steps which should be iterated to achieve the acceptable schedule (Gido, 2003).

- Analysing the schedule to determine which areas may need corrective action;
- Deciding what specific corrective actions should be taken;
- Revising the plan to incorporate the chosen corrective actions; and
- Recalculating the schedule to evaluate the effects of the planned corrective actions.

Appendix E further demonstrates schematic representation of a project schedule control process.

2.7.3 Project Cost

The third and last element of the triple constraint is the cost. The project cost is referred to resources that need to be applied or assigned to the project in order to accomplish the proposed scope of work. Resources can be labour, material,

facilities, machinery and equipment, escalation, contingency, risk management, quality management, third party resources and any other influencing factors.

There are several methods that can be used to estimate the project cost, listed underneath is the most familiar methods (Knipe, 2002): (1) Analogous estimating, (2) Parametric modelling, (3) Activity-based costing, and (4) Bottom-up estimating. The other familiar method is Vendor bid analysis (Encyclopaedia, 2011).

Appendix F gives further information of these estimating methods.

2.8 Relationships between the Triple Constraint

Constraints are anything that either restricts the actions of the project team or dictates the actions of the project team (Egeland). Any of the triple constraint elements, scope, time or cost could deviate from the initial planning due to unanticipated circumstances. The triple constraint trade-offs therefore requires cautious and proper planning.

It is a well-known statistic that construction projects fail to be implemented precisely as planned. Among other things, construction projects are carried out in an open environment or/and on and under the ground, and are therefore exposed to environmental influences and complexities of ground structure. Experienced project managers know the project will proceed as planned, but they don't know how it will deviate (Rosenau).

It is therefore notable that construction projects need continuous modification of the triple constraint throughout the project time in order to complete the project successfully. For the project to be completed positively, at least one of the variables (the triple constraint) must be fixed, or constrained, to provide a basis for planning the project (Ward, 2003).

These three elements (the triple constraint) of a project are known to work in tandem with one another, where one of these elements is restricted or extended,

the other two elements will then also need to be either extended/increased in some way or restricted/reduced in some way (Enterprise-PM).

The trade-off dynamics inherent to the triple constraint variables of scope (S), time (T) and cost (C) may be described by the following three key relationships (Van Wyngaard, 2011):

- Relationship 1, S↑ α T↑ C↑, which signifies that scope targets can be delivered at the expense of time and/or cost targets;
- Relationship 2, T↓ α S↓ C↑, which signifies that time targets can be delivered at the expense of scope and/or cost targets; and
- Relationship 3, C↓ α S↓ T↑, which signifies that cost targets can be delivered at the expense of scope and/or time targets.

where the up-arrow ↑ implies an increase and the down-arrow ↓ implies a reduction or decrease.

For the reason that projects are unique and a onetime endeavour (Gido, 2003), they will therefore have different challenges. Some projects will be driven by the scope, some will be driven by the time and some will be driven by the cost. Hereunder is measure of the level of impact and relationship between the triple constraint.

2.8.1 Scope-driven Projects

Most of the time, if scope is constraint, one of the other constraints, time and cost, has to give (Egeland). The measure of success of the project will as a result be driven by the accomplishment of the identified scope of works irrespective of time or cost.

2.8.2 Time-driven Projects

Time can also be a critical project constraint in the form of an enforced deadline. The success of the project will therefore be entirely based on the completion of scope of works within the identified time and regardless of the project cost.

2.8.3 Cost-driven Projects

Some projects may be limited of cost as per the directive by the client. The constraint of a project cost might seriously limit the project team's ability to obtain resources and might potentially limit the scope of the project (Egeland) and hence time. The success of the project will therefore be critical of the project cost notwithstanding the scope and time.

2.9 External Influences in Construction Projects

Projects are characteristically unique (Gido, 2003), meaning all projects are more likely to experience different anxieties and disruptions in their lifetimes. Apart from the management of the triple constraint within the project, successes of construction projects in South Africa can also be essentially influenced by external factors as indicated underneath:

2.9.1 The State of Being a Developing Country

Many developing countries do not have a mature construction industry consisting of well-established contracting and consulting companies. Lack of access to financing, excessively complex contract documents, failure to ensure fair procurement practices, the high cost of importing equipment and the fluctuations of demand for construction often mean that the private sector of the construction industry has not had the opportunity to establish itself sufficiently to bid for major infrastructure projects (Smith, 2002).

2.9.2 Population and Human Resources

There is a need of infrastructure development in developing countries, which can only be fulfilled through the implementation of well-managed engineering projects (Smith, 2002). The problem is compounded by (1) Exponential population growth, (2) Rapid migration from rural to urban areas, (3) Illegal migration from neighbouring countries to South Africa (Cross, 2009), and (4) Lack of necessary skills in construction industry (Coetzer, 2010).

2.9.3 Materials, Equipment and Plant

There is generally a shortage of reliable and operable construction plant in developing countries, and it is often not possible to hire plant because plant hire companies do not exist (Smith, 2002).

2.9.4 Finance and Economics

Although there is a great need for new projects in developing countries, there is also a lack of funds from the normal sources expected in the developed countries (Smith, 2002).

2.9.5 Unethical Conduct

One of the responsibilities to customers and the public includes refraining from offering or accepting inappropriate payments, gifts or other forms of compensation for personal gain, unless in conformity with applicable laws or customs of the country where project management services are being provided (Augsburg Education). It is not unusual to read of substandard material and provision of level of service in construction projects.

2.9.6 Conflict

Project team is usually made of a group of people with their hopes, desires and needs. These differences lead to conflict and when such differences surface, they often influence project stability destructively. It is of paramount importance that roles and responsibilities are clearly defined because many conflicts arise from situations where roles and responsibilities are not clear (Young, 1996).

Conflict is found to be one of the causes of client dissatisfaction which impacts on projects negatively in the South African construction industry (Enshassi, 2009).

2.9.7 Other Leading Factors

Other essential factors influencing the construction industry include: (1) Poor management of Black Economic Empowerment (BEE) policy; (2) People joining the field of construction without relevant qualifications, awareness and enthusiasm in construction; (3) Directives from the management and the customer, (4) Socio-cultural factors, (5) Community participation, (6) Appropriate technology and technology transfer, (7) Multiple stakeholders, (8) Political interference, (9) Climate, (10) Nominal communication, and (11) Abundant remedial works.

2.10 Managing the Triple Constraint

As described above in Sections 2.7 and 2.8, the triple constraint elements are interrelated to each other. A problem with one of them affects the others as follows: (1) Project scope has a direct influence to both the project cost and the project time, (2) A delay in the project time has a direct influence to the project cost, and (3) Unavailability of resources on time has a direct influence to the project time.

A 97% of successful projects were led by experienced project managers who can help influence all of these factors to improve the probability of project success (Augsburg Education), a human factor in the management of the project is therefore critical and should be well managed.

A good management of the triple constraint could save South Africa billions of money which could be used to address the current backlog in infrastructure development. One of the well-recognized techniques in managing the triple constraint is trade-offs. Apart from the technique of trade-offs, project managers should further undertake the following activities: (1) Interpretation of the triple constraint, (2) Educating the client, and (3) Communication.

2.10.1 Trade-offs

Construction projects involve a certain degree of uncertainty and it is therefore infrequent to complete projects within the estimated constraints. Due to the uncertainty, amendments to the triple constraint are bound to happen through trading-offs. The amendment or management of the triple constraint involves making trade-offs between scope, time, and cost goals for a project (Augsburg Education). This is carried-out with respect to the critical constraint of a project, it might be scope, time or cost.

Dobson's 'hierarchy of constraints' theorem defines a project by listing the triple constraint elements in order of flexibility, from least to most, in a hierarchy of driver, middle and weak constraint (Dobson, 2004). The driver constraint is derived from the project purpose and is the constraint that has to be met otherwise the project fails, i.e. it is the driver if the penalty for failing to meet it is greatest. The middle and weak constraints have greater flexibility, but is not necessarily the least important.

Dobson's theorem proposes that exploitation of the flexibility in the weaker constraints can be used as a tool to meet the absolute requirement of the driver whilst supporting the development of a strategy for managing risks and resources on the project, "we can exploit the constraints that are more flexible and even accept the failures that are less damaging to ensure that we do not fail where

failure is not an option – the right kind of failure is not only an option, but sometimes it is a desirable one" (Dobson, as cited in Van Wyngaard, 2011).

2.10.2 Interpretation of the Triple Constraint

Current literature in the triple constraint domain suggests that the relationships between the key project variables are poorly understood by project teams and not adequately managed (Van Wyngaard, 2011).

By understanding the Triple Constraint and the ramifications associated with adjusting any one of its components (constraints), a project manager will be able to plan projects better, analyse projects risks and protect the company from the problems of unrealistic client expectations (Enterprise-PM).

2.10.3 Educating the Client

There is a chronic shortage of municipal engineers in South Africa (SAPA, 2012).

If a client does not have a good understanding of project management and its related issues, which is often the case, one will have the task of educating them, at least on a basic level (Enterprise-PM). Clients often need to be enlightened that, if a project is to be completed at a certain level of quality, then a certain amount of time and money need also to be invested in the project. Projects that have time restrictions will need to increase the resources assigned to it or have the quality or scope reduced.

2.10.4 Communication

Communication is one the key measures of the project success. It develops high-quality relationship among the members of the project team. Successful project managers make an effort to encourage frequent, unstructured conversations both with and between project team members (Kendrick, 2004).

The communication needs thorough understanding and skills to logically and effectively pass information. The following information exchange qualities are essential in effective communication: (1) Active listening, (2) Ability to express oneself, (3) Ability to reach agreement, and (4) Quality, relevance and timing of communication.

Effective monitoring and tracking of the project is dependent on good communication in the team, between you and the team and your key stakeholders (Young, 1996, 1998).

2.11 Chapter Summary

A project must meet minimum requirements of the triple constraint to be deemed successful and a number projects in South Africa have failed over the years. It is difficult to satisfy the triple constraint especially because of unanticipated circumstances that have potential to endanger project success.

The triple constraint elements restrict and dictate the actions of the project team and work in tandem with one another. For the reason that projects are unique, they will have unalike challenges, i.e. different projects will be driven by dissimilar triple constraint element.

Although success of construction projects is confined to the triple constraint, the projects successes can also be influenced by other external factors and intra-management of the triple constraint including trade-offs.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Chapter Purpose

The objectives of this chapter are fourfold: (1) To demonstrate hypothetical conclusions presumed prior to the research, (2) To determine and describe methods used in the fieldwork, (3) To depict the potential shortcomings and 0practicality of the collected data, and (4) To determine and describe appropriate interventions engaged to diminish the potential shortcomings and to increase the practicality of the collected data.

3.2 Survey Techniques

As the societal demand escalate, number of projects, complexity and scope of engineering and construction projects increase, the stakes may endanger the survival of corporations and threaten the stability of countries that approach these projects unprepared (Chihuri, 2010). It is therefore a necessity to keep up through intensive investigation of the engineering and construction projects.

Chapter 1: Overview of the Investigation, demonstrates discoveries in the construction industry as well as propositions made. The discoveries are founded from the previous studies made on the construction projects. The proposition is established from the empirical experiences through: (1) Management of construction projects, (2) Interaction with project managers, engineers and colleagues, (3) Meetings with clients and local authorities, and (4) Current affairs on service deliveries.

The preceding Chapter 2: Theory and Research Survey, determines the investigated contextual information on the success factors and failure factors of the construction project in South Africa. The investigation was sourced from articles, dissertations, books and internet.

The foremost critical data collection technique is described and designed underneath.

3.3 Fieldwork Practice and Survey Design

One of the most frequent sources of errors and misunderstandings in the management of a project and working with people is miscommunications (Oberlender, 1993). It is therefore important that the designed methods of communication are unpretentious and easy to understand. This will strengthen the practicality of the surveyed information and the research will therefore be reliable and correctly represent the actual circumstances on the ground.

The following instruments were proposed for the survey (Thames Valley University): Questionnaires and Interviews. Interviews were not favoured for the survey and were therefore not used for the reasons that they: (1) Are time consuming, (2) Can be expensive, (3) Have geographic limitations, (4) Can be bias, (5) Can be prejudiced, (6) Need to be set up, and (7) Can be embarrassing.

The instrument of questionnaires was chosen for the survey for the reasons that they (Thames Valley University): (1) Can be emailed or faxed, (2) Can cover a larger number of people, (3) Have a wide geographic coverage, (4) Are relatively cheap, (5) Need no prior arrangements, (6) Avoids embarrassment on the part of respondent, (7) Can be anonymous, and (8) May never be bias.

The use of two methods would have been favoured for triangulation (crosschecking of data using multiple data sources) of the surveyed data so as to ensure the reliability and validity of data.

The following characteristics were considered in the design of questionnaire to enhance interest and eagerness to partake and to avoid influence to responses: (1) Questions have to be relatively short, simple, and to the point, (2) Use familiar words, (3) Indicate assurance of confidentiality, (3) Indicate the reason for research, (4) Indicate an estimate of research completion time and availability of results, and (5) Details of the researcher.

The questionnaires comprised of the following items as illustrated in Figure G1 and Figure G2 in Appendix G: (1) Experience, (2) Qualification, and (3) Professional registration with ECSA (Engineering Council of South Africa).

The survey was conducted in South Africa and the following professionals were targeted for participation: (1) Project managers, (2) Civil engineers, (3) Civil engineering technologists, (4) Civil engineering technicians, and (5) Contracts managers. The abovementioned professionals were nominated due to the following reasons:

- Project Managers have vast knowledge and skills in project management and have also studied advanced project management courses;
- Civil Engineers are generally project managers of the construction projects and they understand technicalities of designs and construction;
- Civil Engineering Technologists possess good qualities of construction both at the supervision level and management level;
- Civil Engineering Technicians have an immediate access of challenges on site and will therefore have a better understanding of challenges on site; and
- Contract Managers are specialists in construction management and will therefore have a vast experience in construction.

The designed questionnaires were circulated to the participants through the email and by hand.

3.4 Capturing, Editing and Interpretation of Data

The collected data was captured and summarised in tabular arrangement. It was further evaluated and separated into the following categories: (1) Experience in project management, and (2) Qualification in civil engineering.

The reasons for separation of the collected data into categories indicated above were to obtain different perspective or interpretation of the understanding of the source of project failures. People with different experience and qualification normally have different interpretation to incidents.

To make the collected data more consistent and representative, it was evaluated for consistency and the outlying data omitted and not considered in the report.

The surveyed data will be communicated in tabular arrangement and in graphical demonstration. The tabular arrangement is a suitable method for detailing information and comparing information with ease. The graphical demonstration is the most convenient method to convey information (1) Holistically, (2) Quickly, (3) Easier, and (4) With a better understanding.

3.5 Practicality and Shortcomings of Fieldwork Survey

Although people in the construction industry are targeted for the survey, it is expected that some participants might not partake with the anticipated interest or enthusiasm due to time constraints or any other reasons. Based on the historic questionnaires surveys, questionnaires have a reputation of low response rate, even though inducements may help (Thames Valley University).

The researcher will therefore engage as many people as possible. This will help the researcher obtain a reasonable number of feedbacks from the respondents and therefore obtain clarity on the real factors contributing to failures and successes of construction projects, and how this may be related to the triple constraint.

There are two types of errors anticipated in the data collection (Thames Valley University): (1) Sampling error, and (2) Non-sampling error. Sampling error is not so critical because it can be managed and hence reduced with the sampling size. It is expected that the researcher will experience challenges with the non-sampling error for the reason that they cannot be eliminated. Sources of non-sampling error include: (1) Researcher error, and (2) Respondent error.

Examples of researcher and respondent errors may include the following:

- Researcher errors: (1) Unclear definitions, (2) Reliability and validity issues, and (3) Missing data; and
- Respondent errors: (1) Inability to answer (2) Unwillingness, (3) Cheating, (4) Unavailability, and (5) Low response rate.

3.6 Chapter Summary

The ever escalating societal demand makes it a necessity to keep up through intensive investigation into construction projects. Miscommunication in working with people is considered one of the sources of errors and misunderstanding and consequently communication is essential for practicality of the survey in the investigation. An instrument of questionnaire was chosen as the best communication method.

The collected data was organised into qualifications and experience to obtain different perspectives. A tabular and graphical representation was chosen for presentation of the results for their ease of understanding.

It is anticipated that some people targeted for the survey may not respond to the questionnaires, hence a large number of people were engaged.

CHAPTER 4: PRESENTATION AND ANALYSIS OF RESULTS

4.1 Chapter Purpose

Questionnaires were distributed to civil engineering practitioners and construction managers for the survey. The purpose of this chapter is to present and interpret the surveyed data and link with the conventional hypothesis in Chapter 1 and the investigated contextual information in Chapter 2.

4.2 Introduction

This research is aimed at assessing the triple constraint and determining sources of failures in order to increase the success rate of construction projects in South Africa and to give priority on the triple constraint. Further to the literature study, a questionnaire survey was conducted among civil engineering and project and construction management professionals, and the responses are analysed and interpreted hereunder.

4.3 Screening of Participants

A total of 277 questionnaires were distributed and 35 of them were fully completed as indicated in Table H1, Table H2, Table H3 and Table H4 in Appendix H. The response rate for the questionnaire was thus 13% with an average of eight years of experience in construction management. The 35 responses received were screened for eligibility as follows:

- Responses with unrelated qualifications and no construction experience and project management principles were omitted from the list; and

- Eligible responses were edited for consistency and other minor effects.

Of the 35 responses received, eight were neglected. Table 1 underneath illustrates a detailed list of respondents with experiences and the rate of response.

Table 1: Summary of Surveyed Participants

Description	Experience (Years)	Number	Response Rate
Professional Engineers	5 to 10	1	9%
	Over 20	2	
Unregistered Engineers	0 to 3	5	26%
	3 to 5	1	
	5 to 10	1	
	10 to 20	2	
Unregistered Technologists	10 to 20	2	6%
Unregistered Technicians	0 to 3	7	31%
	3 to 5	3	
	5 to 10	1	
Unregistered Project Managers	10 to 20	1	3%
Construction Management System Managers	5 to 10	1	3%
Non-Technical Responses (Omitted)	3 to 20	8	23%
Total Responses	Average of 8	35	13%
Total Questionnaires Distributed		277	

4.4 Overview of the Survey

As indicated in Table 1 above, 27 responses were analysed for the investigation. Table 2 and Figure 2 underneath demonstrate details and graphical representation of the overall survey of the 27 responses, respectively. The responses were distributed into 67% for consultants, 18% for government employees and 15% for contractors.

Of the 27 responses, 70% believes that projects were successful and an average of 80% believes that the triple constraint elements were clearly defined.

Table 2: Summary of Survey of Project Features

Item	Description	Successes		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	19	70%	7	26%	1	4%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	22	81%	5	19%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	21	78%	6	22%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	22	81%	5	19%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	22	81%	4	15%	1	4%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	24	89%	3	11%	0	0%

An 81% believes that the triple constraint trade-offs were well-managed and 89% believes that adequate communication provisions were well in place to address corrective actions. A 4% of responses were uncertain of success or failure of projects and trade-offs of the triple constraint elements.

The edited questionnaire responses are depicted in Table I1, Table I2 and Table I3 in Appendix I for further information.

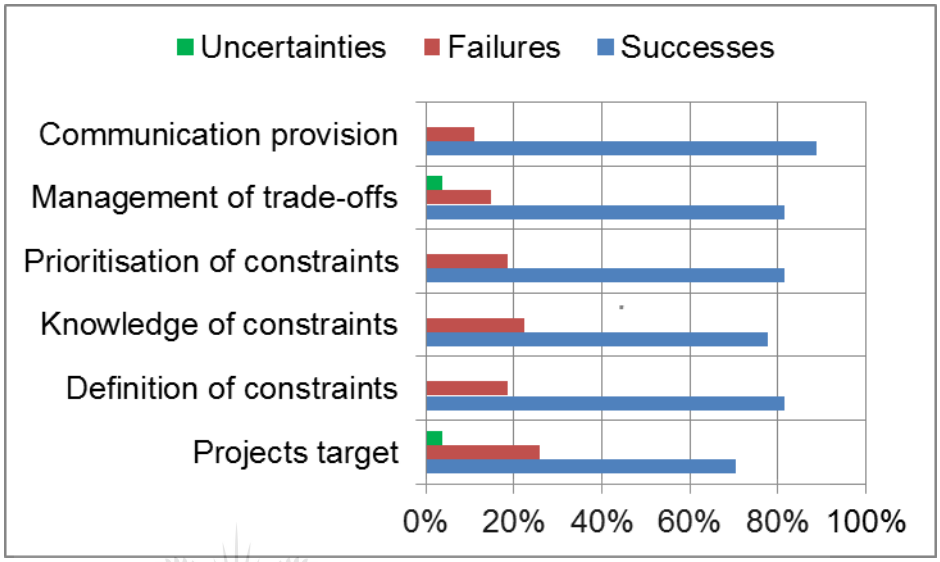

Figure 2: Graphical Representation of Summary of Survey of Project Features

As indicated in Table 3 and Figure 3 below, 74%, 74% and 70% of responses evaluate projects through scope, time and cost respectively. A 2% of responses use others forms of criteria while 1% was uncertain of the criteria used to evaluate projects.

Table 3: Summary of Survey of Project Evaluation Criteria

Scope	Time	Cost	*Others	Uncertain
20	20	19	2	1
74%	74%	70%	7%	4%
*Client-satisfaction; Employment; Communication, Profit x2; Durability; Conformance				

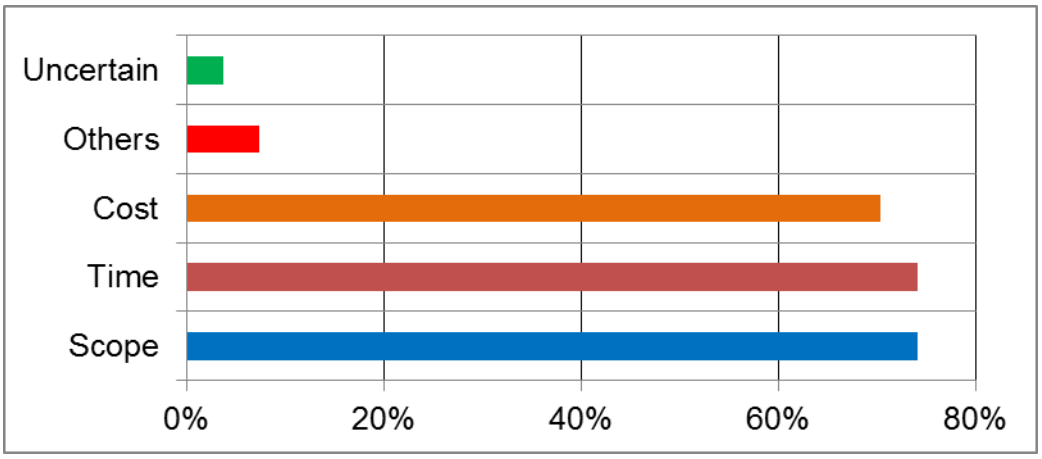

Figure 3: Graphical Representation of Summary of Survey of Project Evaluation Criteria

4.5 Responses from Professional Engineers

Table 4: Survey of Project Features by Professional Engineers

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	3	100%	0	0%	0	0%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	2	67%	1	33%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	3	100%	0	0%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	3	100%	0	0%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	3	100%	0	0%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	3	100%	0	0%	0	0%

A survey from the professional engineers as detailed in Table 4 above and graphically illustrated in Figure 4 below indicates that: (1) Projects are generally successful, (2) The triple constraint elements are well-known by the project team and correctly prioritized, (3) The triple constraint trade-offs are monitored and

managed very well throughout the project, and (4) There are adequate communication provisions in place.

However, 67% indicates that the project mission and the triple constraint are adequately defined while 33% disagrees.

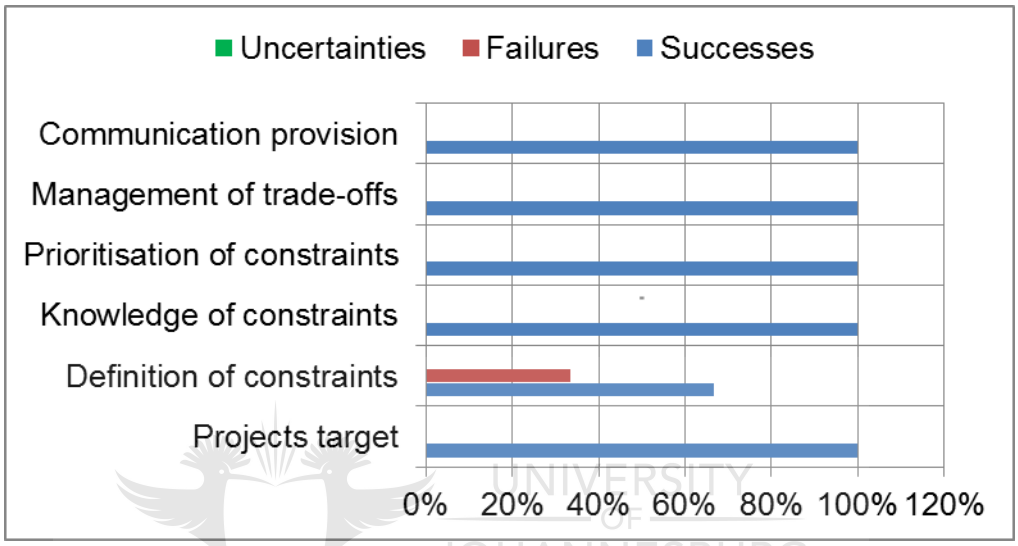

Figure 4: Graphical Representation of Survey of Project Features by Professional Engineers

The professional engineers with over 20 years of experience indicate that all the features of the projects are generally achieved successfully as detailed and illustrated in Table J1 and Figure J1 in Appendix J respectively.

The criteria used by the professional engineers to determine the success or failure of the projects are scope, time and cost as indicated in Table 5 and Figure 5 below.

Table 5: Survey of Project Evaluation Criteria by Professional Engineers

Scope	Time	Cost	Others	Uncertain
3	3	3	0	0
100%	100%	100%	0%	0%

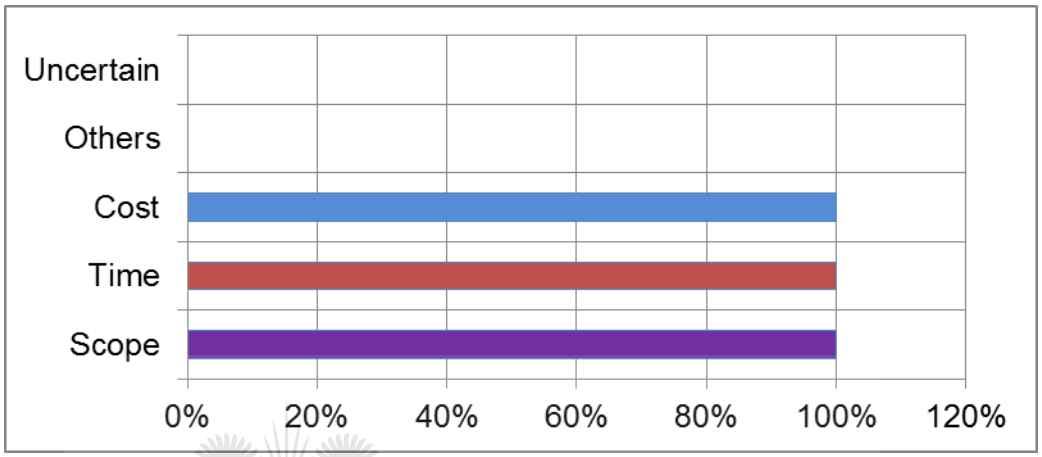

Figure 5: Graphical Representation of Survey of Evaluation Criteria by Professional Engineers

4.6 Responses from Unregistered Engineers

Table 6: Survey of Project Features by Unregistered Engineers

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	6	67%	3	33%	0	0%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	6	67%	3	33%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	6	67%	3	33%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	6	67%	3	33%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	7	78%	2	22%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	7	78%	2	22%	0	0%

Over 67% of unregistered engineers are of a view that: (1) Projects are successful, (2) The triple constraint elements are well defined, prioritized well-known by the project team, (3) The triple constraint trade-offs are well monitored and managed, and (4) There are adequate communication provisions in place for

the duration of the project. Refer to Table 6 above and Figure 6 below for the detailed and graphical interpretation of the survey.

A maximum of 33% of unregistered engineers indicate that projects are unsuccessful and the triple constraints are not adequately defined, known or prioritized. They further indicate that the triple constraint trade-offs are not monitored or managed and communication is inadequate.

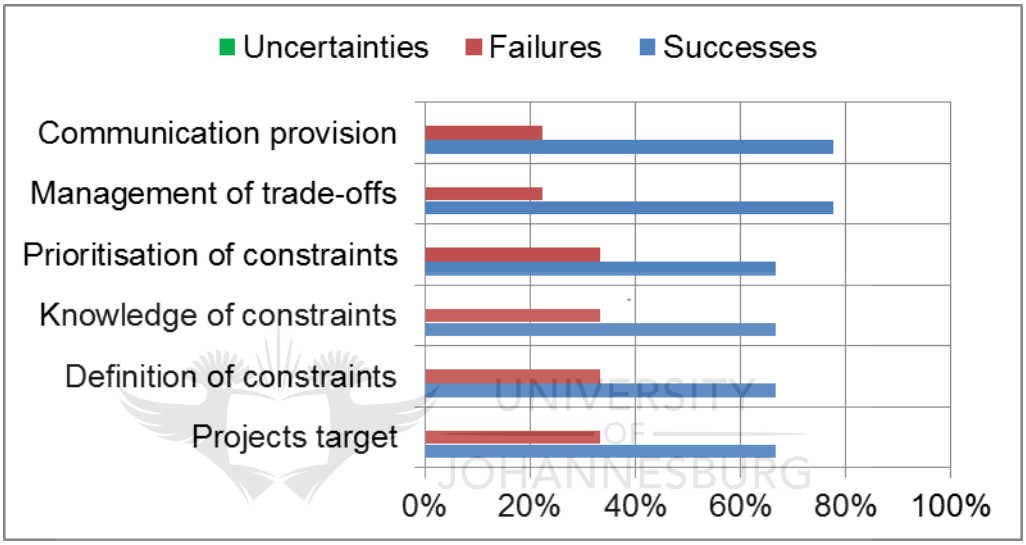

Figure 6: Graphical Representation of Survey of Project Features by Unregistered Engineers

The unregistered engineers with 17 to 20 years of experience in project and construction management indicate that projects are successfully completed as referenced in Figure K1 in Appendix K. 100% base the success or failure of the project on the scope and 50% base the success or failure on time as illustrated in Figure K2 in Appendix K.

A survey conducted on an engineer with a 5 year working experience and a Master's Degree in Project Management as illustrated in Table 7 below shows that: (1) Projects are generally unsuccessful, (2) Projects' mission and the triple constraint are not clearly defined, and (3) The triple constraint are not prioritised.

It was however indicated that: (1) The project team has knowledge of the triple constraint, (2) The triple constraint trade-offs are well monitored and managed, and (3) There are adequate communication provisions.

Table 7: Survey by Unregistered Engineer with Master's Degree in Project Management

Item	Description	1
1	How many years have you been in project / construction management?	5
2	Please indicate, how would you describe your job title?	Engineer
3	Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	MIng
4	Are you professionally registered? (Yes / No) (If yes, please specify institution)	No
5	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	No
6	What were the criteria used to determine projects success or failure?	Cost Time Scope
7	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	No
8	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	Yes
9	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	No
10	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes
11	Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes

An average of 82% of unregistered engineers weighs the success or failure of the projects on scope, time and cost of the project. In addition to the triple

constraint, 11% uses other factors to measure the success as shown in Table 8 and Figure 7 below.

Table 8: Survey of Project Evaluation Criteria by Unregistered Engineers

Scope	Time	Cost	*Others	Uncertain
8	6	8	1	0
89%	67%	89%	11%	0%
*Profit; Durability; Conformance				

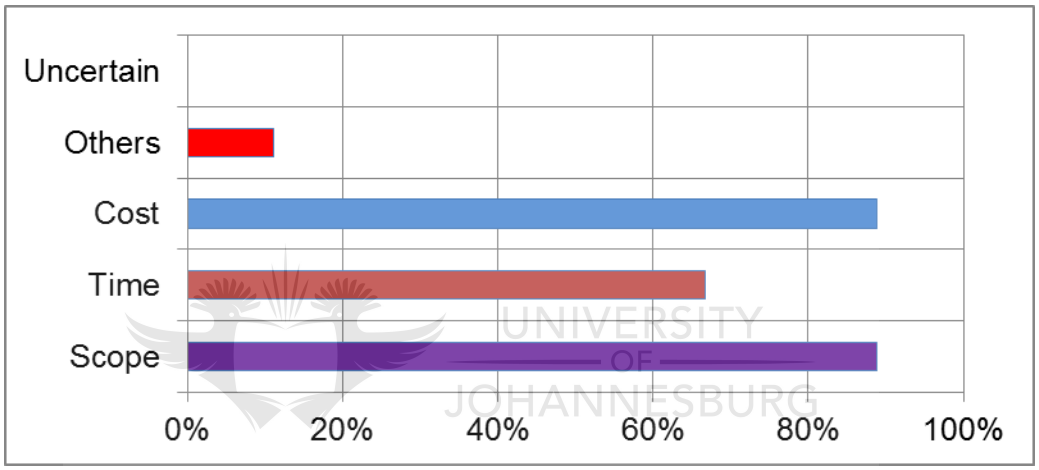

Figure 7: Graphical Representation of Survey of Project Evaluation Criteria by Unregistered Engineers

An engineer with 5year experience and a Master's Degree in Project Management as shown in Table 7 above uses scope, time and cost to measure the success or failure of the construction projects.

4.7 Responses from Unregistered Technologists

Table 9: Survey of Project Features by Unregistered Technologists

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	2	100%	0	0%	0	0%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	2	100%	0	0%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	2	100%	0	0%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	2	100%	0	0%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	1	50%	0	0%	1	50%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	2	100%	0	0%	0	0%

The survey conducted on unregistered technologists depicts that: (1) Projects are generally successful, (2) and the triple constraint elements are fairly defined, prioritized and well-known by the project team. Half of the model is uncertain of the triple constraint trade-offs and the other half is certain that trade-offs are monitored and well managed throughout the project.

Refer to Table 9 above for the details and Figure 8 below for the graphical illustration.

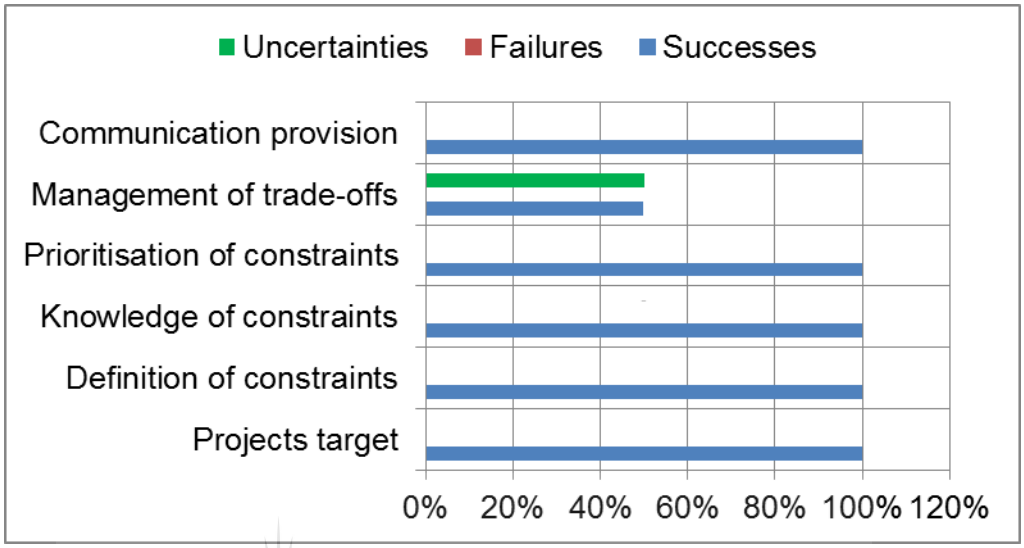

Figure 8: Graphical Representation of Survey of Project Features by Unregistered Technologists

Table 10 and Figure 9 below shows that 50% of the technologists are uncertain of the criteria used while the other 50% uses time as a criterion for success or failure.

Table 10: Survey of Project Evaluation Criteria by Unregistered Technologists

Scope	Time	Cost	*Others	Uncertain
0	1	0	1	1
0%	50%	0%	50%	50%
*Profit				

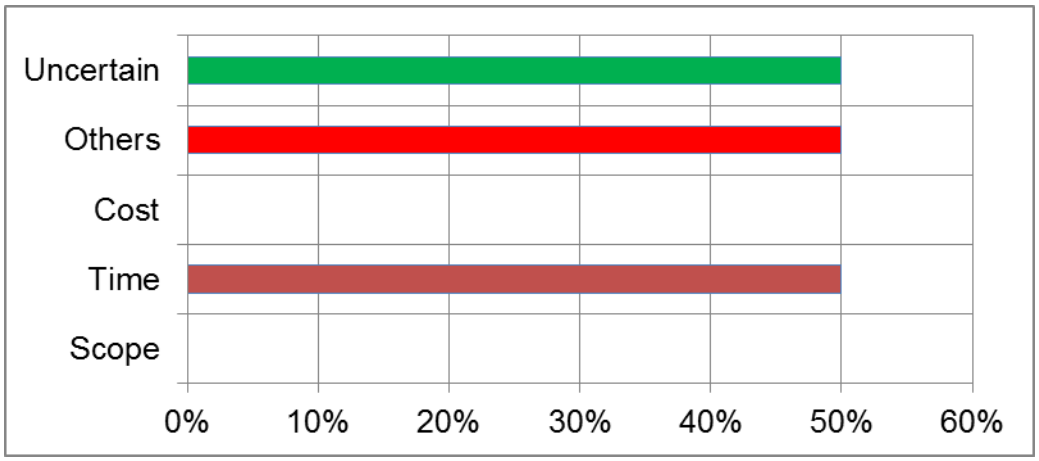

Figure 9: Graphical Representation of Survey of Project Evaluation Criteria by Unregistered Technologists

4.8 Responses from Unregistered Technicians

Table 11: Survey of Project Features by Unregistered Technicians

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	8	73%	2	18%	1	9%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	11	100%	0	0%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	10	91%	1	9%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	10	91%	1	9%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	10	91%	1	9%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	11	100%	0	0%	0	0%

A minimum of 70% of a model of unregistered technicians is certain that: (1) Projects meet delivery targets, (2) The triple constraint elements are defined and prioritized and the project team is familiar with them, and (3) The triple constraint trade-offs are well monitored and managed. The model is also certain that there are adequate communication provisions in the project team over the project

duration. Refer to Table 11 above and Figure 10 below for details and graphical representation respectively.

Maximum of 18% of the model indicates that the construction projects do not achieve the delivery targets while 9% is uncertain of the success or failure of the construction projects.

The model shows that the project team do not know the triple constraint elements and the triple constraint are not prioritized properly, hence the triple constraint trade-offs are not appropriately monitored or managed.

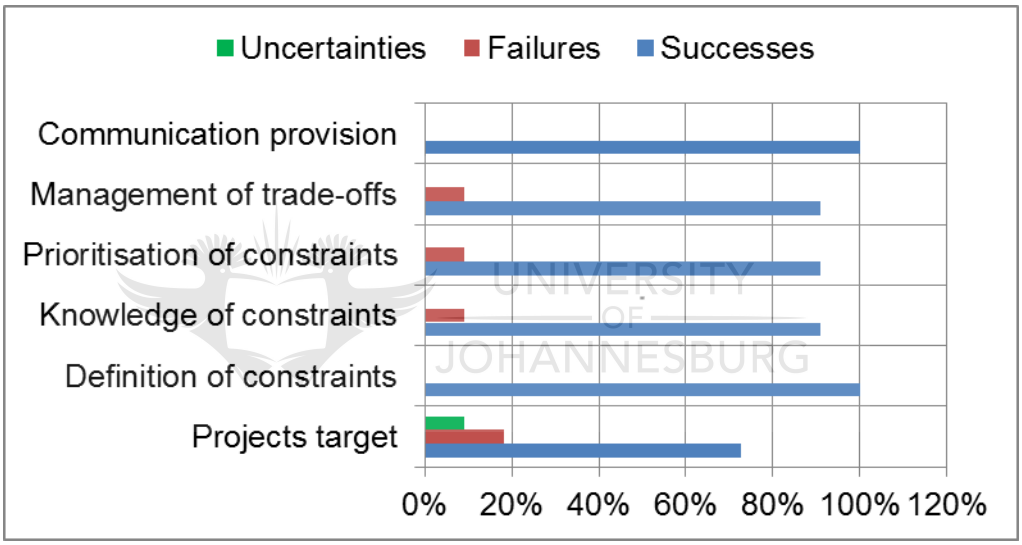

Figure 10: Graphical Representation of Survey of Project Features by Unregistered Technicians

Over 70% of unregistered technicians use scope, time and cost to assess the success or failure of the projects whereas 9% of the model uses other factors as shown in Table 12 and Figure 11 below.

Table 12: Survey of Project Evaluation Criteria by Unregistered Technicians

Scope	Time	Cost	*Others	Uncertain
9	10	8	1	0
82%	91%	73%	9%	0%
*Communication				

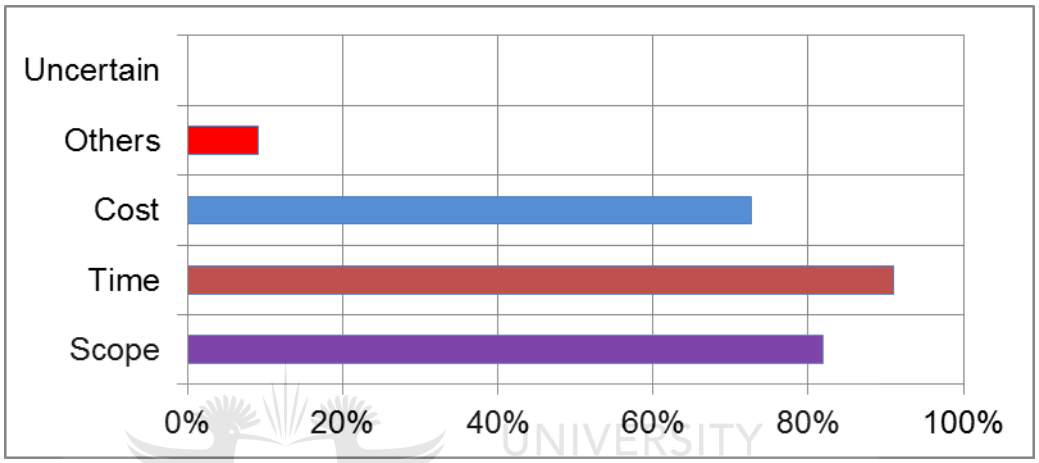

Figure 11: Graphical Representation of Survey of Project Evaluation Criteria by Unregistered Technicians

The 2% unregistered technicians (see Table 11 above) who advise that projects are unsuccessful, base their evaluation criteria on time (100%), cost (100%) and scope (50%).

4.9 Responses from Project Managers and Project Management System Managers

Responses were received from two other professionals in the field of project and construction management, i.e. one Project Manager and one Construction Management System Manager.

A graphical representation in Figure 12 below demonstrates that: (1) Projects are all unsuccessful and the project team does not have knowledge of the triple

constraint, (2) The triple constraint in almost 50% of the projects are not clearly defined and prioritized in line with the project mission, (3) The triple constraint trade-offs in half the projects are not monitored and constructively managed in line with the project mission, and (4) Lastly, half of the projects do not have adequate communication provisions to address corrective actions.

Refer to Columns 10 and 11 in Table I2 in Appendix I for a detailed response and Table L2 in Appendix L for the summarized findings.

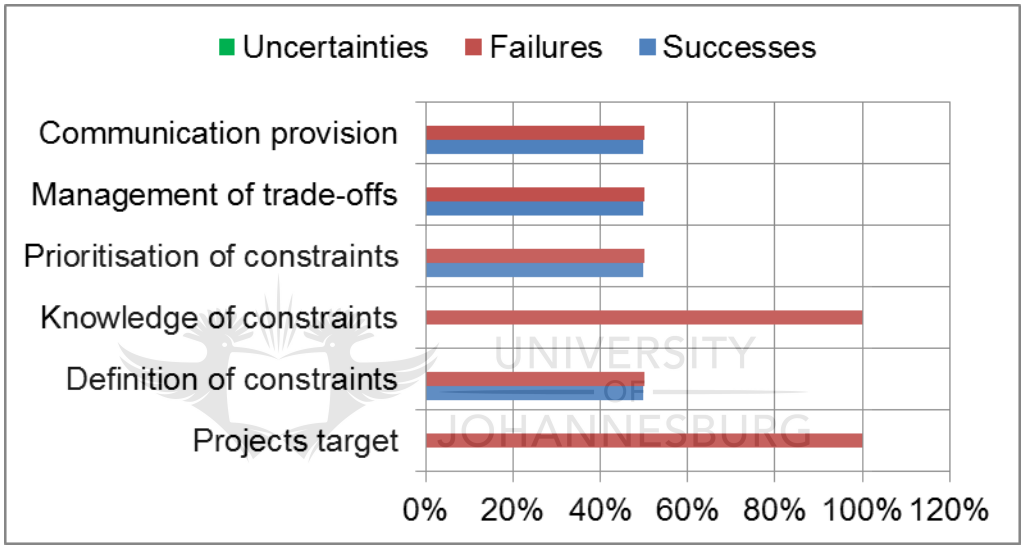

Figure 12: Graphical Representation of Survey of Project Features by Project Managers and Project Management System Managers

The criteria used to assess the success of the projects are time and other factors as indicated in Figure 13 below. Other evaluation criteria used are satisfaction and employment. For further details in project evaluation criteria refer to Table L2 in Appendix L.

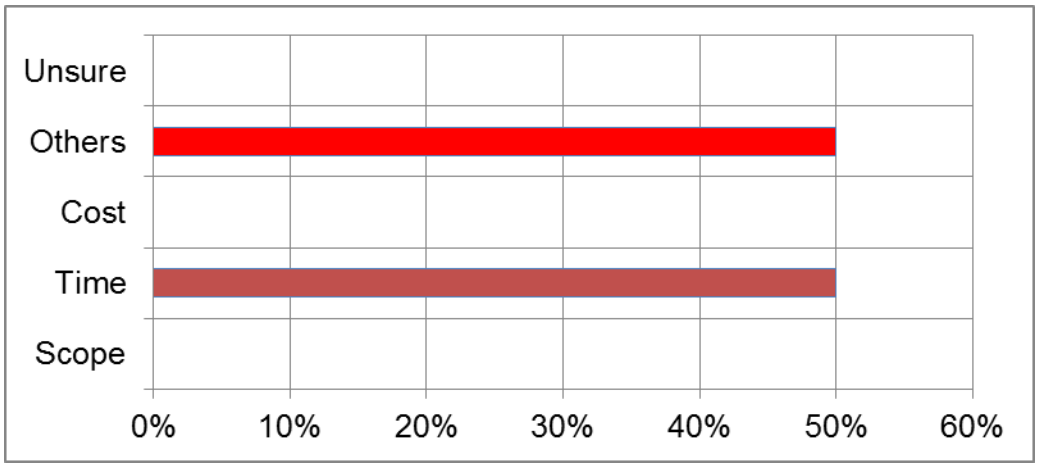

Figure 13: Graphical Representation of Survey of Project Evaluation Criteria by Project Managers and Project Management System Managers

4.10 Comparison of Responses from Consultants, Contractors and Provincial Government

The research questionnaire did not allow for an indication of a type of service provision, i.e. consulting services, contracting services or provincial government, see questionnaire in Figure G1 and Figure G2 in Appendix G. An independent analysis and comparison was influenced by strong opposing views between the three service providers.

More than 75% of the surveyed consultants indicates that project are generally successful and the triple constraint are well-known, well-prioritised in line with the mission and are well monitored and managed regarding the trade-offs. Figure 14 below illustrates graphical representation of the survey. Consultants further indicate that communication provisions to address corrective actions among the project team are in place.

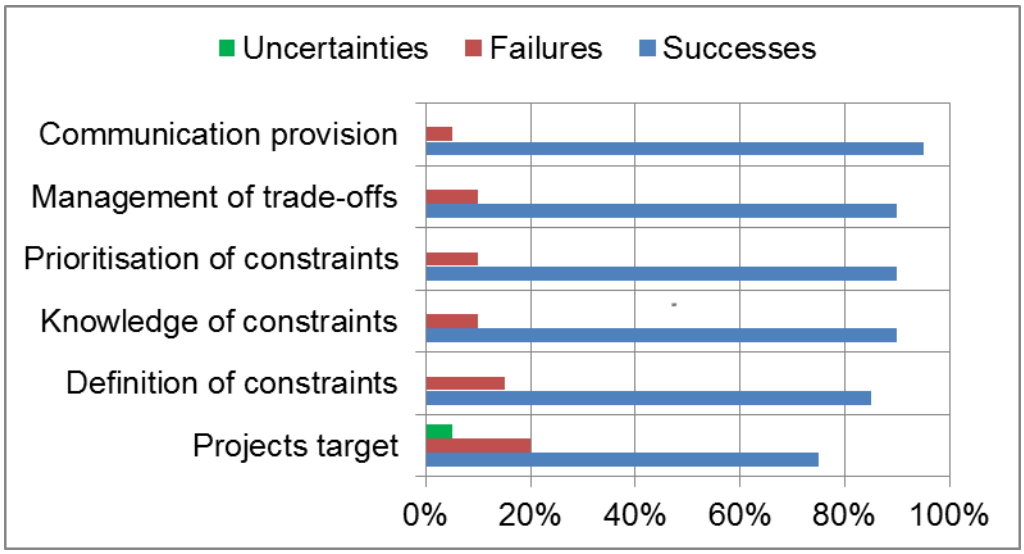

Figure 14: Graphical Representation of Survey of Project Features by Consultants

A survey conducted on contractors shows mixed reactions. An average of 43% indicates that projects are unsuccessful, communication provisions do not address corrective actions and the triple constraint are not known or prioritised and therefore trade-offs are not properly managed. Another average of 58% agrees with the consultants that projects are well managed. Figure 15 underneath depicts graphical representation of the survey.

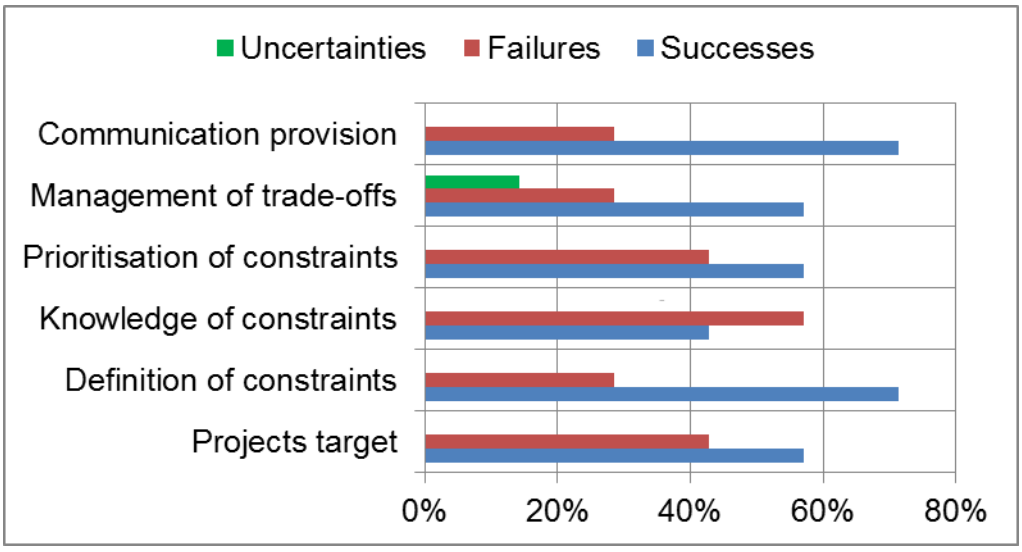

Figure 15: Graphical Representation of Survey of Project Features by Contractors

Figure 16 underneath shows responses received from the provincial government. Most of the responses deemed inadequate for analysis were received from this sector. Of the adequate responses received 60% indicates that projects are successful and 100% shows that the triple constraints and trade-offs are well managed and the communication among the project team is satisfactory.

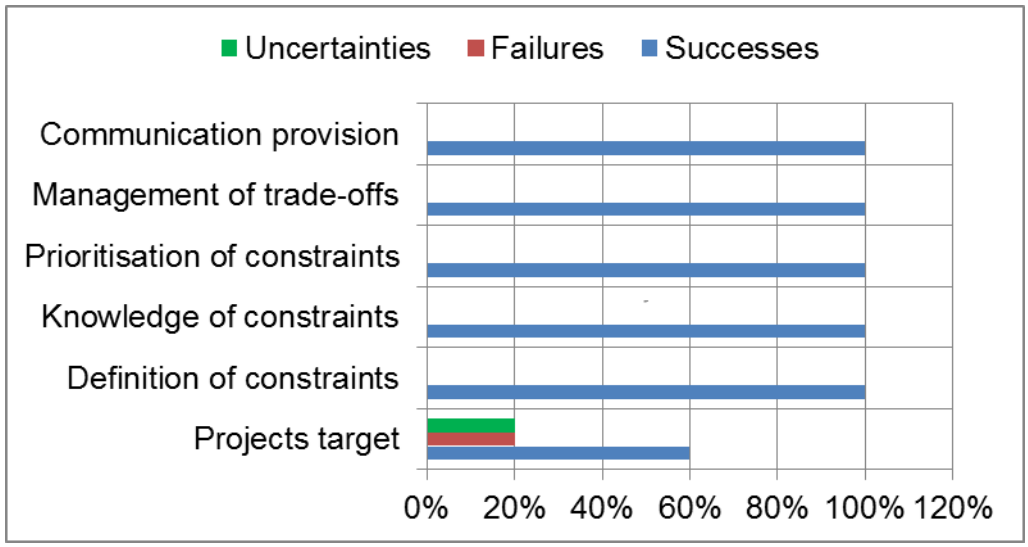

Figure 16: Graphical Representation of Survey of Project Features by Provincial Government

Tables M1, M2 and M3 in Appendix M illustrate detailed survey by consultants, contractors and provincial government.

According to Figure 17 below, consultants use scope, time and cost to evaluate success of the projects while about 5% uses other factors.

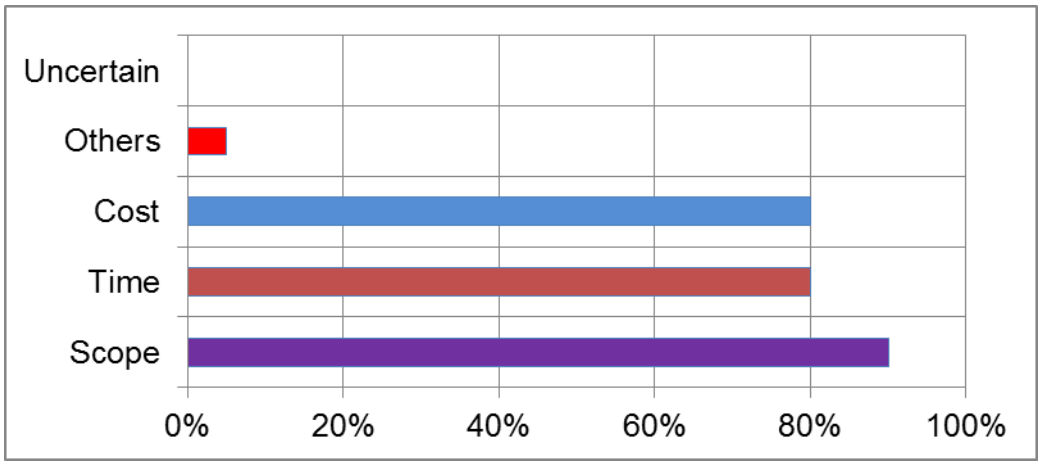

Figure 17: Graphical Representation of Survey of Project Evaluation Criteria by Consultants

In contrast to consultants, the criteria used by contractors is broader as shown in Figure 18 below. About 57% use time, only 29% use time and cost and 43% use other factors to measure success of projects whereas 14% is uncertain of the evaluation criteria.

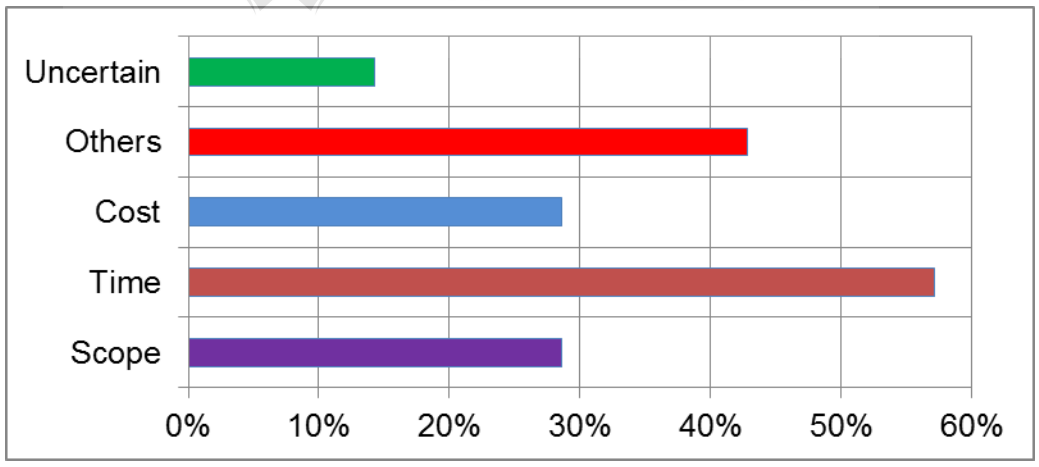

Figure 18: Graphical Representation of Survey of Project Evaluation Criteria by Contractors

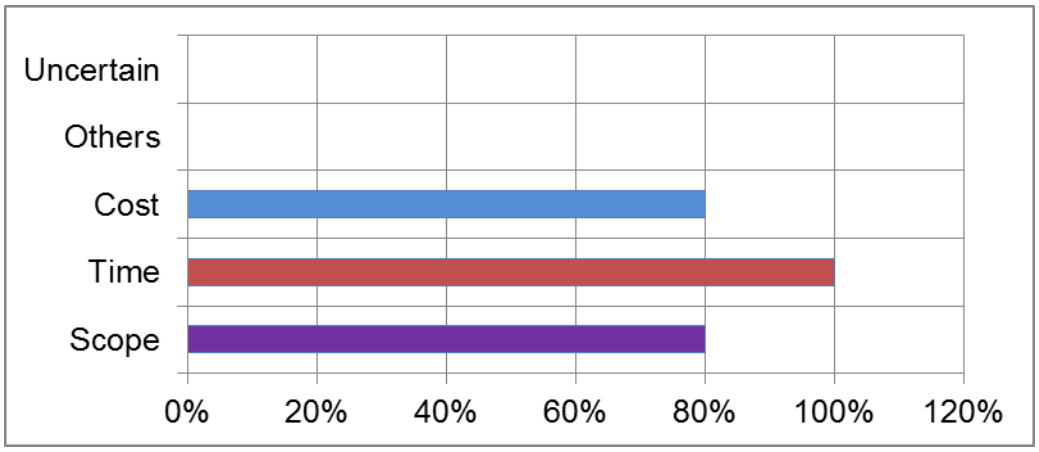

Figure 19: Graphical Representation of Survey of Project Evaluation Criteria by Provincial Government

The provincial government weighs the success of projects fully on the project time and at 80% for both scope and cost. It is however noted that the research was conducted on technicians with maximum of two-year experience. Refer to Figure 19 for graphical representation.

Tables M4, M5 and M6 in Appendix M illustrate detailed survey by consultants, contractors and provincial government.

4.11 Discussion of Findings

A generic response from the survey shows that 70% of the construction projects are successful as Table 2 above illustrates. The criterion on which the assessment is prepared is based on the scope (74% of participants), time (74% of participants) and cost (70% of participants). The criterion used to assess the projects is in line with the triple constraint of the project management science for the project to be deemed successful.

In contrary, the theoretical investigation indicates that projects are unsuccessful in line with the minimum requirements of the triple constraint. The conflicting findings raise the following questions: Is meeting the scope of works enough to

deem the project successful? Is reaching the stipulated time enough to deem the project successful? Is exhausting the budget enough to deem the project successful? Is it meeting two or three of the triple constraint?

It seems issuance of a completion certificate is enough to deem the project successful. Completing the scope of works, i.e. meeting the scope requirements of the client irrespective of time taken or budget exceeded is enough to deem the project successful. Perhaps the following questions should have been included in the questionnaire: Were the projects' scope of works completed? Were the projects completed in time? Were the projects completed within the budgeted cost?

This could have painted the picture much clearer as to how one determines project success or failure in construction projects. This could also help with an indication as to how the triple constraint elements are managed. This could however have diminished the response rate.

Efficient, effective and successful implementation of construction projects is very authoritative in the modern business, especially in a developing country and a globalized world. The reward of sound project management is (Steyn, 2002 and 2003):

- A satisfied customer;
- An increased future business and an improved market share;
- An improved reputation and possibly an improved career prospects; and
- A gain of experience and a share of satisfaction and recognition.

4.12 Chapter Summary

A total of 27 responses from 35 acknowledged responses were analysed. Contrary to the contextual information investigated in Chapter 2, the survey indicates that projects are successful as evaluated on the triple constraint elements.

The survey conducted on engineers, technologists and technicians (most of which are consultants) indicate that the construction projects are successful. Contrarily, project managers, project management system managers, one engineer and one technologist (all contractors) reveal that the construction projects are unsuccessful which endorses findings in Chapter 2.

The consultants are largely grounding the success or failure of construction projects on the triple constraint elements, whereas the contractors found the success or failure on the triple constraint and other factors.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter Purpose

The objectives of this chapter are to: (1) Determine findings from the theoretical and fieldwork survey, (2) Provide recommendations to consolidate findings, and (3) Make conclusions in line with the theoretical and fieldwork survey. The chapter further discusses limitations encountered and proposes future investigation.

5.2 Summary of Findings

The following findings were drawn from contextual and fieldwork survey.

5.2.1 Main Findings from Contextual Survey

The foremost sources of failure in construction industry as investigated in the theoretical appraisal are:

- The triple constraint work in tandem, i.e. when one of them fails, the other two is affected in some way;
- The success or failure of projects may be determined by one, two or all of the triple constraint;
- Management of the triple constraint trade-offs over the project duration is critical and essential, yet is poorly managed;
- The triple constraint are poorly understood and inadequately managed;

- Clients, especially local and provincial government institutions, do not have necessary skills; and
- Logical and effective exchange of information within the project team.

5.2.2 Additional Findings from Contextual Survey

Supplemental sources of failure in construction industry as indicated in the theoretical investigation are:

- Lack of mature construction industry in developing countries;
- Lack of necessary skills especially in relation to the population size;
- Lack of reliable and readily available construction machinery;
- Unethical conducts leading to substandard material and diminished level of service; and
- Unclear roles and responsibilities leading to conflict within the project team.

5.2.3 Main Findings from Fieldwork Survey

The construction projects are successfully completed according to seventy per cent (70%) of the responses received, whereas 4% is uncertain of the success or failure of projects. The main sources of success as per 70% are:

- 100% for adequate communication provisions to address corrective actions;
- 95% for prioritisation of the triple constraint in line with the projects mission;
- 89% for clear definition of projects mission and the triple constraint;

- 84% for good knowledge of the triple constraint principles and an understanding of key relationships between them;
- 84% for monitoring and constructive management of the triple constraint trade-offs in line with the projects mission;
- 79% for the project scope (element of the triple constraint);
- 79% for the project time (element of the triple constraint); and
- 74% for the project cost (element of the triple constraint).

Twenty-six per cent (26%) of the responses from the fieldwork investigation advised that projects fail. This comprise of 22% of the consultant, 18% of the government employees and 15% of contractors. The foremost sources of failure in construction projects according to the 26% are:

- 71% for the project cost (element of the triple constraint);
- 57% for the project time (element of the triple constraint);
- 57% for lack of prioritisation of the triple constraint elements in line with the projects mission;
- 43% for the project scope (element of the triple constraint);
- 43% for lack of clear definition of projects mission and the triple constraint;
- 43% for lack of good knowledge of the triple constraint and an understanding of the relationships between them; and
- 29% for lack of monitoring and constructive management of the triple constraint in line with the projects mission.

5.2.4 Additional Findings from Fieldwork Survey

Additional sources of failure as advised by the 26% of responses who indicated that construction projects are unsuccessful are:

- 43% for lack of adequate communication provisions; and
- 14% for each of the following factors which are not elements of the triple constraint:
    - Client-satisfaction;
    - Employment;
    - Profit;
    - Durability; and
    - Conformance.

5.3 Recommendations

Shortage of engineers in South Africa is one of the reasons for project failures especially in local and provincial government institutions. The lack of technical management expertise, particularly in municipal and provincial government departments is likely to be the single greatest stumbling block to sustain development and growth (Coetzer, 2010). Engineering and construction and project management studies ought to be encouraged in the young and upcoming professionals.

The number of qualified civil engineers in the public sector has decreased considerably over the past few years (Grey, 2011). These positions are therefore occupied by unqualified people and people with less qualifications and limited knowledge in engineering and construction management.

Involvement of unqualified people in civil engineering and construction management is not only a governmental challenge; it also embraces both

consultants and contractors. With the current backlog in infrastructural developments and lack of construction management skills, failure in construction projects is expected to persist.

Apart from the shortage of related skills in the country, the employment of senior staff in the local government institutions is politically motivated and establishes creation of a depoliticized professional officialdom (Coetzer, 2010). Because of this, performance of senior staff in construction projects cannot be adequately measured; hence success of projects is likely to be unfavorably affected.

Indications of projects failure in strategies capability, i.e. the ability to visualize a future and achieve it are (Robertson, 2009):

- Technology mythology: There is lack of understanding, inadequate knowledge, experience, etc.;
- Executive custody: Leaders at all levels must be held accountable;
- Engineering approach: There is lack of a systematic and thorough approach designed to prevent failure and thereby achieve success;
- Information management: There is an inability to measure the results of what we are doing and inability to use measurements; and
- People/soft issues: Human adaptability versus wisdom and competence, which equates to the synthesis between relevant knowledge and relevant experience.

In addition to the above, the concept of the triple constraint should not be overlooked and presumed that the project team is well-informed of the triple constraint. The project team should be reminded of the triple constraint at the commencement of the projects or throughout the projects duration particularly when there is potential or foreseeable failure.

5.4 Conclusions

Based on the abovementioned findings, the following conclusions were drawn.

5.4.1 Main Conclusions from Contextual Survey

According to the contextual survey, the persistent failure of construction projects is linked to:

- Poor understanding and management of the triple constraint elements;
- Poor management of the triple constraint trade-offs;
- Inefficient information exchange among the project team; and
- Dearth of engineering and construction management skills.

5.4.2 Main Conclusions from Fieldwork Survey

Most of the successful construction projects are attributed to an ability of the project team to:

- Provide adequate communication among them;
- Prioritisation of the triple constraint elements;
- Clear definition of the projects mission and the triple constraint;
- Good knowledge and relationships between the triple constraint and management thereof; and
- Work within the triple constraint elements.

Most of the construction projects which failed are attributed to an incapability of the project team to:

- Work within the specified triple constraint elements;
- Prioritise the triple constraint elements;
- Monitor and manage the triple constraint trade-offs; and
- Provide adequate communication among them.

5.5 Research Limitations

Apart from the limitations listed underneath, a case study in construction and project management was necessary to consolidate findings of this research.

5.5.1 Shortcomings of Contextual Survey

The following shortcomings in the contextual research survey were identified:

- The accuracy of the contextual information may be flawed by an inappropriate use of unrelated information;
- The contextual information on project management is overwhelming and the contextual survey may not exhibit a complete survey appropriate to the research; and
- The naming conventions of the triple constraint and designation of its elements are heterogeneous and not consistent across project management literature. A variety of the triple constraint concepts exist which extends beyond the traditional dimensions of scope, time and cost.

5.5.2 Shortcomings of Fieldwork Survey

The following shortcomings in the fieldwork survey were identified:

- The generalization is limited by how well the sample represents the population;
- The results are based on a small sample, a larger sample would represent a more authentic results;
- The participants may not be comfortable with the system used to garner information;
- The results are limited by the ability to address appropriate questions;
- The results are limited by the ability of the statistical test to detect significant differences or relationships;
- The results are limited by the honesty and authenticity of participants; and
- The survey questionnaire was disseminated via email and by hand. The surveyed data was therefore limited to people with access to emails and people who were encountered during the survey.

5.6 Proposed Future Investigation

The following subjects should be considered for further research:

- This specific research subject should be re-investigated with a larger pool of sample to get wider practical views. Due to differences in the interpretation of the triple constraint elements, survey questions should be unpacked, i.e. questions should not be generalized, questions should be specific to an element, e.g. scope, time and cost;
- One of the objectives of the construction projects implemented by local and provincial government is to transfer technical and business skills to the local and surrounding community. With the current failure on

construction projects, high rate of unemployment, dearth of technical and business skills and limited knowledge and understanding of the triple constraint, these objectives fade. An investigation into the subcontracting of local members of the community in the construction projects should be pursued;

- A 100% of participants who advised that construction projects are successful cited adequate communication provision as the source of success. Even though merely 43% of participants who advised that construction projects fail due to inadequate communication provision, it is advised that adequate communication provision is one of the sources of projects failure in South African Construction Industry. An investigation into communication in construction projects should be pursued;

- A sustainable engineering and construction skill in local and provincial government is essential to the development and sustainability of infrastructure in South Africa. It is therefore significant to pursue an investigation into the betterment and sustainability of skills in management of construction projects and maintenance of infrastructure in local government; and

- The naming conventions of the triple constraint and designation of its elements are heterogeneous and not consistent across project management literature. A variety of the triple constraint concepts exist which extends beyond the traditional dimensions of scope, time and cost. An investigation into the concept of the triple constraint should be undertaken to consolidate the triple constraint concept. This would diminish the existing limitations around the concept of the triple constraint in project management literature.

5.7 Chapter Summary

It was hypothesized in Chapter 1 that a deeper comprehension of the triple constraint and strategic management may supplement success of construction

projects. This was confirmed in the research although additional evidence is necessary to conclude.

Both the contextual and fieldwork survey characterise failure of construction project to lack of understanding and poor management of the triple constraint elements and trade-offs.

The scarcity of skills in engineering and construction management in South African government is hurting the construction projects and hence infrastructure development.

The conclusions are however limited to failure to survey all project management data, sample size, ability to address questions and honesty of participants.

A further study into a bigger sample of this specific study is proposed.

CHAPTER 6: APPENDICES

Appendix A: Projects Success Factors

Table A1 underneath summarizes the results of the 2001 Standish Group study describing, in order of importance, what factors contribute most to the success of information technology projects.

Table A1: What Helps Projects Succeed (Augsburg Education)?

No	Description
1	Executive support
2	User involvement
3	Experienced project manager
4	Clear business objectives
5	Minimized scope
6	Standard software infrastructure
7	Firm basic requirement
8	Formal methodology
9	Reliable estimates
10	Other criteria, such as small milestones, proper planning, competent staff and ownership

It is also indicated that 97% of successful projects were led by experienced project managers who can help influence all of these factors to improve the probability of project success (Augsburg Education).

Appendix B: Work Breakdown Structure

An illustration of a Work Breakdown Structure (WBS) is hereunder depicted in Figure B1.

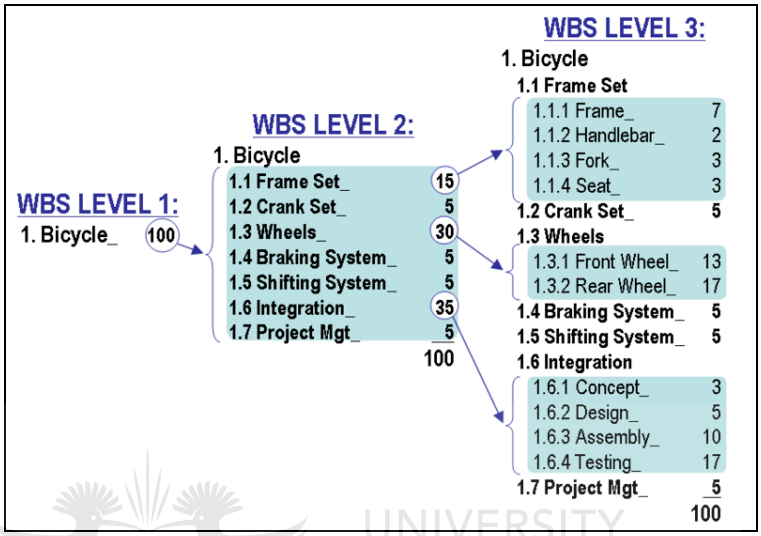

Figure B1: Work Breakdown Structure (Encyclopeadia, 2012).

Appendix C: Quality (Component of Scope of Works)

Quality revolves around four aspects (Duma, 2005): (1) Customer satisfaction, (2) Continuous improvement, (3) People involvement, and (4) Use of qualitative methods.

It further comprises of four pillars (Duma, 2005): (1) Customer satisfaction, (2) Process improvement, (3) Fact-based management, and (4) Empowered performance.

C1 Customer Satisfaction

Feedback from customers is vital to every organization. This keeps all stakeholders up to date with methods and results, and they will know that:

- The project is under control;
- The quality of deliverables will be acceptable; and
- The project will be within budget and schedule.

C2 Process Improvement

In any given process, there is always variation in the output. Steps must be taken to improve variation on output, even when the variations appear to be at satisfactory levels. Process improvement leads to reduced costs, higher productivity and higher reliability. Process improvement should accomplish three objectives in a project:

- It should bring processes under control;
- It should keep processes under control and make them capable; and
- It should continuously improve the processes aimed toward the best target value.

C3 Fact-based Management

An organization manages by facts if it fulfills the following criteria: (1) Uses quality processes to identify and capture data and trends that determine what is factually true about performance, and (2) Structures itself to be responsible to diverse stakeholders that voice the truth.

There are tools used by project teams to improve the transformation process. Some quality improvement tools are: (1) Quality circles (brainstorming, cause-and-effect diagrams), (2) Data gathering and analysis (histograms and graphs, control charts, Pareto analysis), and (3) Statistical process control. Some of these quality improvement tools are discussed in the following sections.

C4 Empowered Performance

Project leaders should be in a position to introduce new members into performance norms of cooperative competence and power sharing, which leads to empowered performance. The following are elements required for the implementation of empowerment:

- Individuals must be educated and trained;
- Individuals must be led;
- Individuals need to be mentored;
- Direction must be given;
- Individuals must be given authority as well as responsibility;
- The working environment must be suitable; and
- Individuals must be rewarded.

Quality has three levels of management (Flett, 2001): (1) Meeting the specification, (2) Quality management, and (3) Total quality management.

C5 Meeting the specification (Quality control)

The first level of quality is where a project is carried out to solely meet the contractual specification. This presupposes the clients know what their own optimal requirements are. Specifications that stem from the design phase of the project life cycle frequently do not involve the contractors or suppliers who are going to execute the project. Therefore the client may get what was specified but this may not be what they really need.

C6 Meeting the real requirements (Quality management)

Defining the next level of quality is where a project organization goes beyond just meeting the original contractual specification; it actively provides what it believes is the most appropriate product or service. At the second level of quality the role of the project organization is seen as more than just meeting the contractual specification: the client and contractor are working together to ensure a successful outcome. This may involve revising the specifications as the client and contractor learn what is really required and what is feasible.

C7 Learning and improving from the project experience (Total quality management)

The third level of quality is arguably the most important level of quality. This is a quasi-theoretical state in which a project organization continually increases its knowledge database through capturing the experiences of past projects. This knowledge is used to feed-forward to increase the success of future projects. This relates to both clients and contractors in that both learn and accumulate experience. The concept of 'continuous improvement' is embodied in Total Quality Management (TQM) with the mechanisms that provide the feedback firmly based on standards from quality management.

Appendix D: Techniques of Time Scheduling

There are four well-known techniques of time scheduling in project management, namely (Gido, 2003): (1) Program evaluation and review technique (PERT), (2) Critical path method (CPM), (3) Graphical evaluation and review technique (GERT), and (4) Gantt chart.

The Gantt chart is the most popular technique used in projects because of its ease of application (Gido, 2003). Examples of these techniques are attached underneath in Figure D1, Figure D2 and Figure D3.

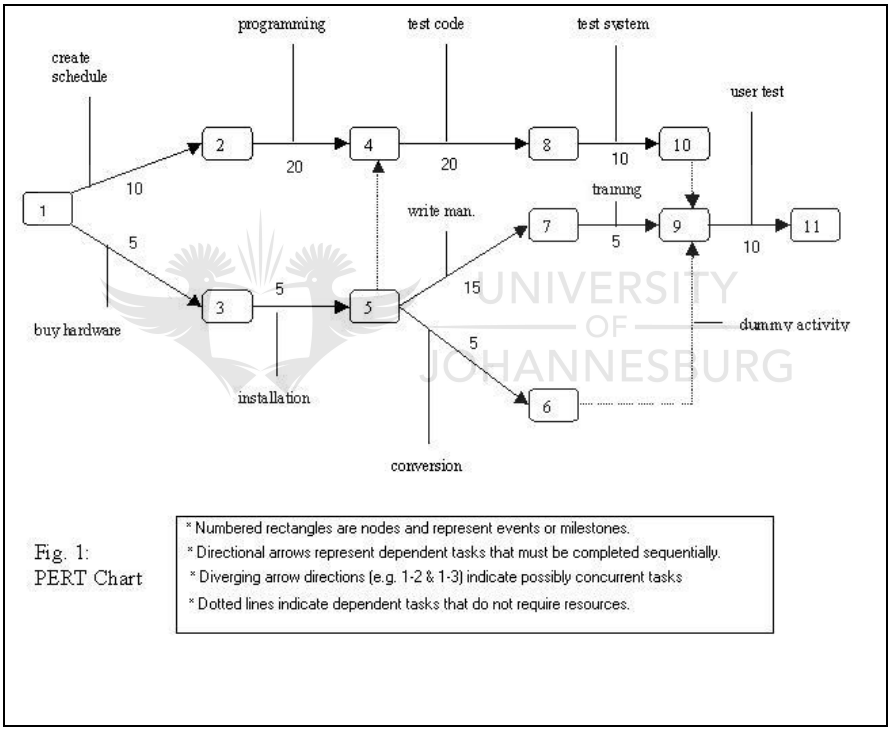

Figure D1: Program Evaluation and Review Technique (Tech Target, 2012)

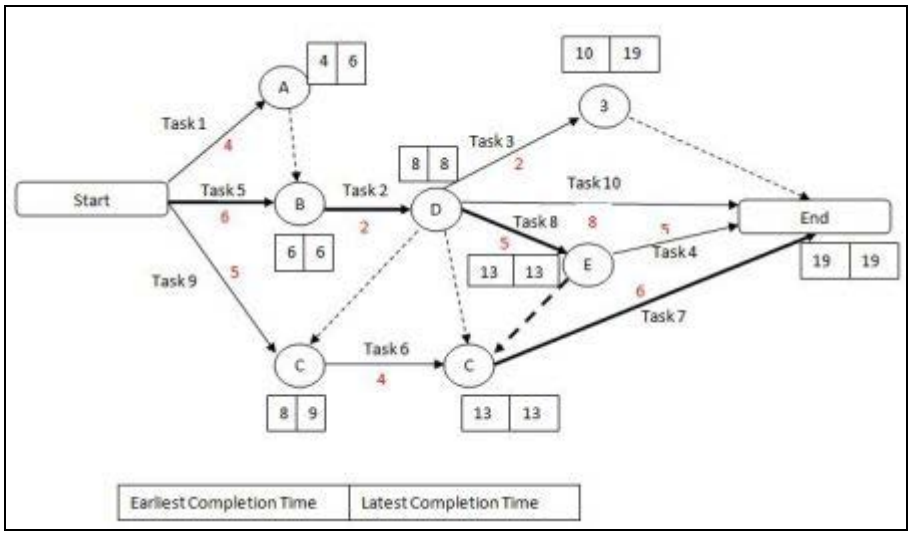

Figure D2: Critical Path Method (Tutorial Point)

ID	Task Name	Predecessors	Duration
1	Start		0 days
2	a	1	4 days
3	b	1	5.33 days
4	c	2	5.17 days
5	d	2	6.33 days
6	e	3,4	5.17 days
7	f	5	4.5 days
8	g	6	5.17 days
9	Finish	7,8	0 days

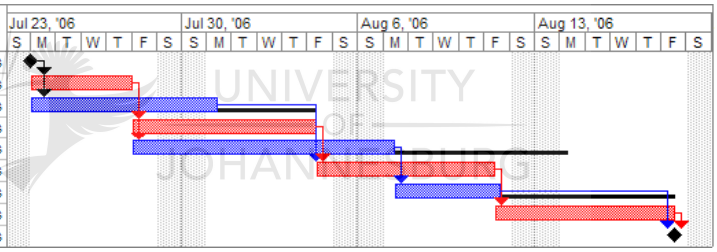

Figure D3: Gantt Chart (Encyclopaedia, 2012)

Appendix E: Project Control Process

A Figure E1 hereunder illustrates the steps in the project control process.

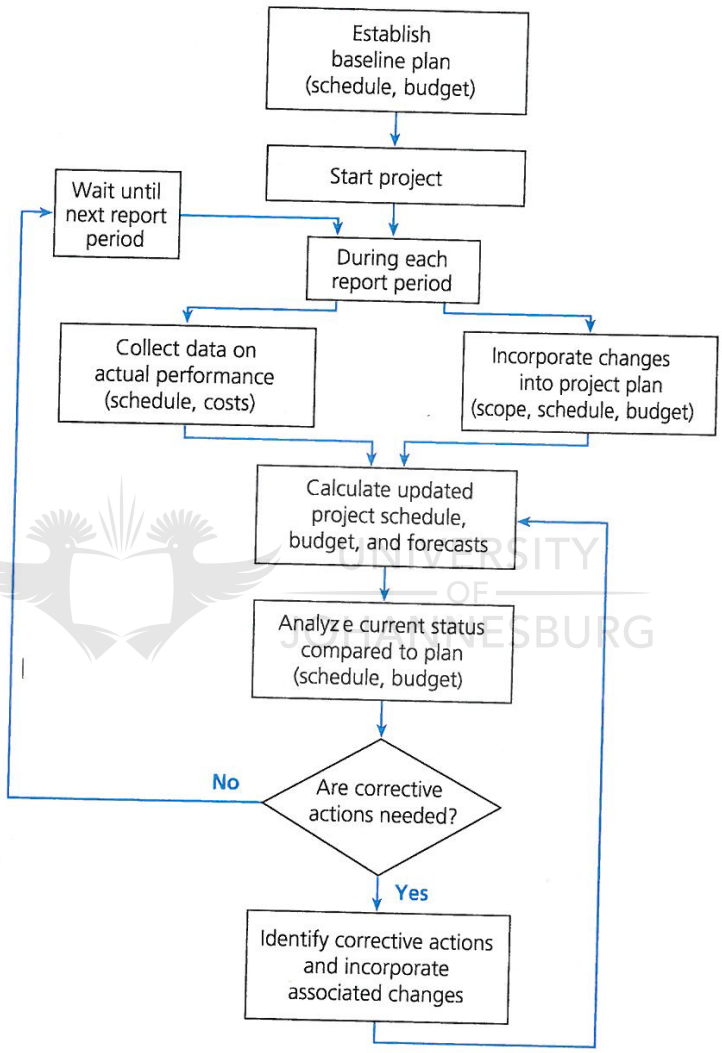

Figure E1: Project Process Control (Gido, 2003).

Appendix F: Methods of Project Cost Estimation

The most familiar methods of project cost estimation are briefly described hereunder.

F1 Analogous Estimating (Top-down Estimating)

This method uses the actual cost of the previous, similar project as the basis for estimating the cost of the current project (Knipe, 2002). It is frequently used to estimate total project costs when there is limited amount detailed information about the project. It is generally less costly than other techniques, but is also generally less accurate.

F2 Parametric Modelling

Parametric modelling involves using project characteristics in a mathematical model to predict projects cost (Knipe, 2002). Both the cost and accuracy of parametric models varies widely. They are most likely to be reliable when the historical information used to develop the model was accurate, the parameters used in the model are readily quantifiable and model is scalable (i.e., it works as well for large project as it does for a small one)

F3 Activity-based Costing

Activity-based Costing (ABC) is a management system designed to control activities than incur costs as a consequence of resources being consumed (Knipe, 2002). Traditional methodologies place the emphasis on direct costs, but overheads in a project represent a far greater percentage of total cost than in the past. The ABC reflects the best estimate of what it will cost to complete the project.

F4 Bottom-up Estimating

Bottom-up estimate is often prepared by contractors to support their pricing proposal bid process (Knipe, 2002). This involves using a detailed Work Breakdown Structure (WBS) and pricing each activity that makes up the project. This method may be laborious and time consuming, but it can result in a fairly accurate estimate if the work content is well understood.

F5 Vendor Bid Analysis

Vendor Bid Analysis is method dependent on the taking the average of several bids by vendors for the project (Encyclopaedia, 2011). This method is unreliable as dependent on bids which might be incorrect and misleading.

Appendix G: Research Questionnaire

A questionnaire distributed for a survey in project and construction management is depicted in Figure G1 and Figure G2 below.

Project / Construction Management Questionnaire	
This questionnaire relates to your generic project / construction management experience	
1	**Biographical Details**
1.1	How many years have you been in project / construction management?
1.2	Please indicate, how would you describe your job title?
1.3	Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)
1.4	Are you professionally registered? (Yes / No) (If yes, please specify institution)
2	**Managerial Questions**
The Triple Constraint Definition The project management body of knowledge (PMBOK) states that every project is governed by the Triple Constraint, a critical project management concept that reflects a framework for evaluating competing demands. For the purposes of this survey, Scope, Time and Cost comprise the three key Triple Constraint variables. Project Time addresses the scheduling and duration of the project, Cost addresses the budget and resources of the project, and Scope addresses the requirements and work of the project.	
2.1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)

Figure G1: Questionnaire (Page 1 of 2)

Project / Construction Management Questionnaire (Continued)	
This questionnaire relates to your generic project / construction management experience	
2	**Managerial Questions (Continued)**
2.2	What were the criteria used to determine projects success or failure?
2.3	Have the projects mission and triple constraint been clearly defined as part of the projects plan?
2.4	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)
2.5	Have the triple constraint elements been appropriately prioritised in line with the projects mission?
2.6	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?
2.7	Have adequate communication provisions been put in place to address corrective actions where and when needed?

Figure G2: Questionnaire (Page 2 of 2)

Appendix H: Raw Questionnaire Responses

Raw information as received from the participants is shown in Table H1, Table H2, Table H3 and Table H4.

Table H1: Raw Questionnaire Reponses (Page 1 of 4)

Description	1	2	3	4	5	6	7	8	9
How many years have you been in project / construction management?	3	38	3	5	12	5	5	1	20
Please indicate, how would you describe your job title?	Engineer & Project Manager	Senior Engineer	Engineer	Engineer	Project Manager	Technician	Project Administrator	Junior Manager	Managing Director
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	BIng	BIng	BIng	MIng	BTech	ND	ND	BIng	MIng
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	Yes, ECSA & SAICE	No	No	No	No	No	No	No
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	Not always	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
What were the criteria used to determine projects success or failure?	Quality Budget Time	Scope Time Cost	Time Quality Cost	Budget Time Quality	N/A	Time Cost Quality	Time Budget Satisfactory Safety	Scope Time Budget	Scope
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table H2: Raw Questionnaire Reponses (Page 2 of 4)

Description	10	11	12	13	14	15	16	17	18
How many years have you been in project / construction management?	2	13	6	1	2	23	8	4	15
Please indicate, how would you describe your job title?	Technician	Project and Contracts Manager	Programming & Management Leader	Engineer	Engineer	Senior Engineer	Consulting Engineer	Technician	Contractor
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	ND	MIng (Construction & Project management)	ND & Construction Management System	BIng	BIng	BIng	MIng	ND	N/A
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	No	Yes, Quality Engineering System	No	No	Yes, ECSA	Yes, ECSA	No	Uncertain
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
What were the criteria used to determine projects success or failure?	Cost Time Scope	Client-satisfaction Employment	Time	Cost	Time Budget Scope	Time Quality Cost	Scope Budget Time	Communication & Quality	Scope
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Uncertain
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes

Table H3: Raw Questionnaire Reponses (Page 3 of 4)

Description	19	20	21	22	23	24	25	26	27
How many years have you been in project / construction management?	2	1	2	2	1	4	5	6	7
Please indicate, how would you describe your job title?	Assistant Project Manager	Assistant Project Manager	Assistant Project Manager	Assistant Project Manager	Assistant Project Manager	Manager	Assistant Project Manager	Project Manager	Business Owner
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	ND	ND	ND	ND	ND	ND	B Admin in Local Government	ND	BIng
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	No	No	No	No	No	No	No	No
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	Yes	No	Yes	Yes	Uncertain	Yes	Yes	No	No
What were the criteria used to determine projects success or failure?	Time Cost Performance	Time Cost	Time Cost Quality	Time Cost Performance	Time Quality	Time Cost	Time	Time Scope Quality Cost	Cost Profit Quality Durability Conformance
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No

Table H4: Raw Questionnaire Reponses (Page 4 of 4)

Description	28	29	30	31	32	33	34	35
How many years have you been in project / construction management?	12	3	15	6	4	7	16	17
Please indicate, how would you describe your job title?	CEO	Resident Engineer	Project Manager	Project Manager	Projects Coordinator	Construction Manager	Project Manager	Engineer & Branch Director
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	BTech	ND	Btech Public Administration	ND	BTech	Non-Technical	BTech	BIng
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	No	No	No	No	No	No	No
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
What were the criteria used to determine projects success or failure?	Scope Time Budget	Time Quality	Scope Time	Scope Cost Time	Meetings Progress Report	Scope	Profit Time	Scope Cost
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	Yes	Yes	N/A	Yes	No	Uncertain	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix I: Edited Questionnaire Responses

Table I1: Edited Questionnaire Reponses (Page 1 of 3)

Description	1	2	3	4	5	6	7	8	9
How many years have you been in project / construction management?	3	38	3	5	12	5	1	20	2
Please indicate, how would you describe your job title?	Engineer & Project Manager	Engineer	Engineer	Engineer	Technologist & Project Manager	Technician	Engineer & Project Manager	Engineer & Managing Director	Technician
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	BIng	BIng	BIng	MIng	BTech	ND	BIng	MIng	ND
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	Yes, ECSA & SAICE	No	No	No	No	No	No	No
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
What were the criteria used to determine projects success or failure?	Scope Cost Time	Scope Time Cost	Time Scope Cost	Cost Time Scope	No Answer	Time Cost Scope	Scope Time Cost	Scope	Cost Time Scope
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table I2: Edited Questionnaire Responses (Page 2 of 3)

Description	10	11	12	13	14	15	16	17	18
How many years have you been in project / construction management?	13	6	1	2	23	8	4	2	1
Please indicate, how would you describe your job title?	Project and Contracts Manager	Construction Management System Manager	Engineer	Engineer	Engineer	Engineer	Technician	Technician & Assistant Project Manager	Technician & Assistant Project Manager
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	MIng (Construction & Project Management)	Construction Management System	BIng	BIng	BIng	MIng	ND	ND	ND
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	No	No	No	Yes, ECSA	Yes, ECSA	No	No	No
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	No	No	No	Yes	Yes	Yes	Yes	Yes	No
What were the criteria used to determine projects success or failure?	Satisfaction Employment	Time	Cost	Time Cost Scope	Time Scope Cost	Scope Cost Time	Communication & Scope	Time Cost Scope	Time Cost
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Table I3: Edited Questionnaire Responses (Page 3 of 3)

Description	19	20	21	22	23	24	25	26	27
How many years have you been in project / construction management?	2	2	1	4	6	7	3	16	17
Please indicate, how would you describe your job title?	Technician & Assistant Project Manager	Technician & Assistant Project Manager	Technician & Assistant Project Manager	Technician & Project Manager	Technician & Project Manager	Engineer & Contractor	Technician & Resident Engineer	Technologist & Project Manager	Engineer & Branch Director
Please indicate, which of the following best suits you? DIng / MIng / BIng / BTech / ND / Other (Please specify)	ND	ND	ND	ND	ND	BIng	ND	BTech	BIng
Are you professionally registered? (Yes / No) (If yes, please specify institution)	No	No	No	No	No	No	No	No	No
Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	Yes	Yes	Uncertain	Yes	No	No	Yes	Yes	Yes
What were the criteria used to determine projects success or failure?	Time Cost Scope	Time Cost Scope	Time Quality	Time Cost	Time Scope Cost	Cost Profit Scope Durability Conformance	Time Scope	Profit Time	Scope Cost
Have the projects mission and triple constraint been clearly defined as part of the projects plan?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Have the triple constraint elements been appropriately prioritised in line with the projects mission?	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	Yes	Yes	Yes	No	Yes	Yes	Yes	Uncertain	Yes
Have adequate communication provisions been put in place to address corrective actions where and when needed?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

Appendix J: Responses from Experienced Professional Engineers

Table J1 and Figure J1 below shows a survey of project features conducted on professional engineers with over 20 years of experience in project and construction management.

Table J1: Survey of Project Features by Professional Engineers with over 20 Years of Experience

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	2	100%	0	0%	0	0%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	2	100%	0	0%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	2	100%	0	0%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	2	100%	0	0%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	2	100%	0	0%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	2	100%	0	0%	0	0%

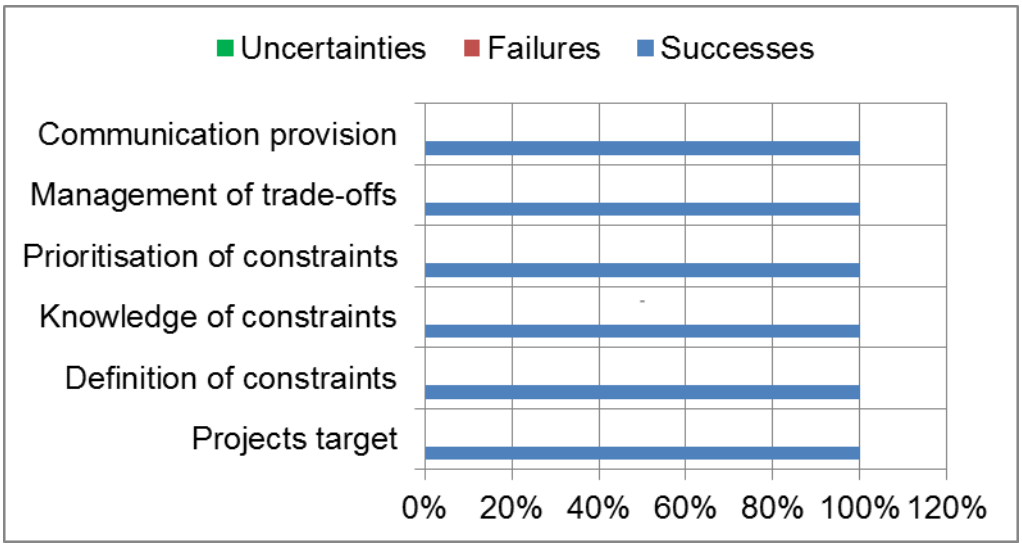

Figure J1: Graphical Representation of Survey of Project Features by Professional Engineers with over 20 Years of Experience

Appendix K: Responses from Experienced Unregistered Engineers

Figure K1 and Figure K2 below shows a survey conducted on unregistered engineers with 17 to 20 years of experience in project and construction management.

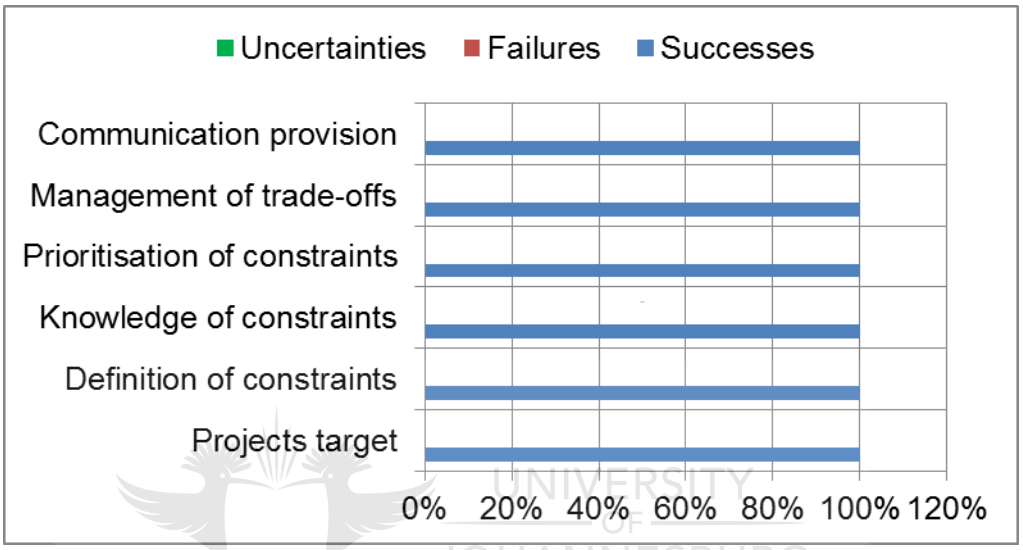

Figure K1: Graphical Representation of Survey of Project Features by Unregistered Engineers between 17 and 20 Years of Experience

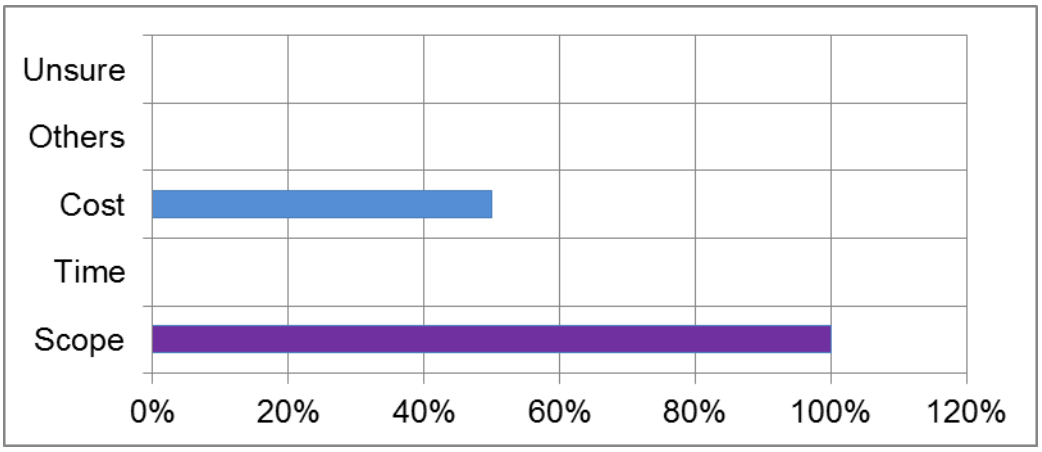

Figure K2: Graphical Representation of Survey of Project Evaluation Criteria by Unregistered Engineers between 17 and 20 Years of Experience

Appendix L: Responses from Project Managers and Project Management System Managers

Table L1 and Table K2 below shows a detailed survey conducted on project managers and project management system managers.

Table L1: Survey on Project Features by Project Managers and Project Management System Managers

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	0	0%	2	100%	0	0%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	1	50%	1	50%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	0	0%	2	100%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	1	50%	1	50%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	1	50%	1	50%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	1	50%	1	50%	0	0%

Table L2: Survey on Project Evaluation Criteria by Project Managers and Project Management System Managers

Scope	Time	Cost	*Others	Uncertain
0	1	0	1	0
0%	50%	0%	50%	0%
*Client-satisfaction; and Employment				

Appendix M: Comparison of Responses from Consultants, Contractors and Provincial Government

Table M1, Table M2, Table M3 and Table M4 below shows detailed survey conducted on consulting service and contracting services.

Table M1: Survey on Project Features by Consulting Services

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	15	75%	4	20%	1	5%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	17	85%	3	15%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	18	90%	2	10%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	18	90%	2	10%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	18	90%	2	10%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	19	95%	1	5%	0	0%

Table M2: Survey on Project Features by Contracting Services

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	4	57%	3	43%	0	0%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	5	71%	2	29%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	3	43%	4	57%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	4	57%	3	43%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	4	57%	2	29%	1	14%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	5	71%	2	29%	0	0%

Table M3: Survey on Project Features by Provincial Government

Item	Description	Succeses		Failures		Uncertainties	
1	Have the projects achieved their delivery targets and/or added strategic value? (i.e. have the projects succeeded or failed)	3	60%	1	20%	1	20%
2	Have the projects mission and triple constraint been clearly defined as part of the projects plan?	5	100%	0	0%	0	0%
3	Did the project team have good knowledge of the triple constraint principles and an understanding of the key relationships between the triple constraint elements? (i.e. were the manager and team members properly trained)	5	100%	0	0%	0	0%
4	Have the triple constraint elements been appropriately prioritised in line with the projects mission?	5	100%	0	0%	0	0%
5	Have the triple constraint trade-offs been monitored and constructively managed in line with the projects mission throughout the projects life cycle?	5	100%	0	0%	0	0%
6	Have adequate communication provisions been put in place to address corrective actions where and when needed?	5	100%	0	0%	0	0%

Table M4: Survey on Project Evaluation Criteria by Consultants

Scope	Time	Cost	*Others	Uncertain
18	16	16	1	0
90%	80%	80%	5%	0%
*Communication				

Table M5: Survey on Project Evaluation Criteria by Contractors

Scope	Time	Cost	*Others	Uncertain
2	4	2	3	1
29%	57%	29%	43%	14%
*Client-satisfaction; Employment; Profit x2; Durability; Conformance				

Table M6: Survey on Project Evaluation Criteria by Provincial Government

Scope	Time	Cost	Others	Uncertain
4	5	4	0	0
80%	100%	80%	0%	0%

CHAPTER 7: LIST OF REFERENCES

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