THE EFFECTS OF RISK MANAGEMENT ON THE SUCCESS OF A PROJECT

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DECLARATION

TO WHOM IT MAY CONCERN

This serves to confirm that I, Premesarie K. Naidoo, ID Number: 811010 0065 084, Student number: 201041795, do hereby declare that the work contained in this minor dissertation submitted for the Masters in Engineering Management degree to the University of Johannesburg, is that of my own, based on a questionnaire survey distributed to selected persons at the Sasol Secunda Organisation, as well as research from the references and bibliography, as captured in Chapters 7 and 8, in this research report.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

In all companies, there exists many opportunities. With these opportunities comes benefits as well as uncertainties and therefore risks. To expedite these opportunities, it is crucial that the expected monetary value associated with the gain of the opportunity exceeds the expected monetary value associated with the loss due to the risk impact.

It is therefore imperative that all projects with associated risks be carefully identified and assessed, with mitigation steps to reduce or eliminate the impact of the risks, if possible.

The management of identifying, assessing and mitigating risks with mitigation and contingent plans or allowances, is known as risk management. Risk management identifies strategies and the relevant stakeholders to best handle risks by seeking innovative but practical solutions, based on experience and sound judgements.

Risk management forms a vital part of project management since risk is present throughout the life cycle of any project. Risks are present in all project management functions. These risks arise due to changes in scope also known as scope creep, unrealistic cost or time estimation and factors influencing quality, etc.

It is believed that risk management is an influencing factor that determines the success of a project.

According to the literature review, the success of a project is defined according to a time - budget - performance model, where the project is regarded as successful if it is completed within the projected timeline and budget and meets all the quality requirements.

This research paper explored the definition of project success at Sasol[1] in Secunda and the influence of risk management on the success of a project. A questionnaire

[1] Sasol in Secunda, will from hereon be defined as and referred to as the organization

survey was distributed to selected persons using email at the organisation to investigate their opinions towards risk management.

From the findings of the study, it was found that this research study is fitting to the theoretical belief that effective risk management is an important influencing factor on the success of a project and that a successful project is defined as a project completed within the projected schedule and budget and meets all requirements.

It was also an objective to determine which of the project management functions should be focussed on to improve project success at the organisation. The project management functions believed to have most risk attached to it, was further compared to the actual project management functions with most risks attached to it during the actual project execution. This has proven to be an opportunity to optimise on which project management functions should be the focus areas, by comparing the belief, to the factors that actually have major risk impacts.

The risk management process at the organisation was further investigated to ensure that it was the most efficient risk management process. Following the research, it can be concluded that the risk management model at the organisation is the most optimised model in accordance with that of literature.

The scope of this dissertation includes risk classification, the process of risk management, risk management techniques based on theory and an investigation into a case study. This theoretical understanding is then compared to the actual research findings based on the questionnaire conducted, on the effects of risk management and its effects on the success of a project.

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Chapter 1

1. Introduction

In almost all businesses nowadays, such as industries, government, financial institutions, engineering companies, etc, projects have become popular and extensive. Projects play an important role in organising, managing and executing the many activities that sustain or expand the operations of the company, and therefore contribute to the continuity of the company.

1.1 What is a project

Projects by definition are temporary endeavours in the form of an assignment, a task or a job that is to be undertaken to create unique changes, services or results of a given specification to meet the needs of the stakeholder or beneficiary, within the constraints of resources, cost and a timeline (Meredith and Mantel, 2010).

They are deliberate actions initiated to improve the current situation of the company, such as the development of new products or improving the customer services, or to support and manage a change process in the company such as the opening of a new branch. Therefore, projects have an important and influential role towards to the profitability of the company. The success of a project can be described as the ultimate goal of the project (de Bakker, 2011).

1.2 What is a successful project

A successful project, based on the article, " Eight key factors to ensuring project success" (Haughey, 2001), is determined by the following factors:

1.2.1 Business Case

There must be a strong business case in place, showing the justification for the project, the list of expected benefits and a nominated person, the Project Sponsor to support and commit to the capital investment and objectives of the project.

1.2.2 Critical success factors

- It is important that the critical success factors be clearly stated and well understood (all ambiguity must be eliminated).
- These factors must be measurable.

1.2.3 Planning

- Planning is a key factor.
- Project milestone deliverables, a realistic time frame with an end date, accurate cost estimates, resources and built in contingencies must be planned properly.
- Therefore, time spent on planning with sufficient detail is time well spent.

1.2.4 Scope creep

- Scope creep is one of the major reasons that projects overrun on both time and cost.
- Having the scope of work properly defined minimises additional scope to the project.

1.2.5 Motivation within the Team

- A motivated team has more ability to deliver a project on time and within budget, than a team that is not motivated and tends to focus on individual targets.
- Positive communication also plays an influential role.

1.2.6 Risk management

- Risk management is the key factor contributing to project success.
- Risk identification, an action plan to minimise these risks and proper communication must be in place.

1.2.7 Saying no

- Saying no can be beneficial towards the success of a project, by ensuring that what was promised, is what will be delivered.
- Hence, promises should not be made on aspects that will not be delivered.
- This also reduces scope creep.

1.2.8 Project End of Life

Since a project has a finite life, project closure is important to prevent resource consumption and scope creep.

The customer may encourage keeping the project open by adding in more features or functionality to the project. This increases the scope of work. It is therefore the responsibility of the project team to adhere to the critical success factors which will support that project deliverables have been met.

It is believed that a successful project with optimum results, is a project where all processes and procedures are executed in accordance to the “rules of a handbook”. And, if there is a failure of a project, it merely implies the process or procedure must be optimised and improved upon.

Successful projects are also described as projects which are properly supported by having the correct techniques and tools in place.

It is believed that if the project schedule, budget and quality requirements are met, then the project is considered as successful (de Bakker *et al*., 2010)

Project schedule, cost and quality form part of the nine functions of project management, which also include:

- scope
- risk
- project management integration
- information and communication
- human resources
- contracts and procurement

Research shows that the project management model has proved to be a dominant business model, to manage successful projects.

The model focuses on the nine functions of project management as mentioned above, by employing knowledge, skill, tools and techniques to plan and implement activities to meet the customers’ expectations of a project (Meredith and Mantel, 2010).

1.3 Project Management

Project management was initiated by the military. It provides powerful planning and control tools to ensure that projects meet the specified performance within the cost and time contract of the project. Its driving forces are the growing demand for complex and customised services and goods, the expansion of human knowledge on exponential levels and the global production-consumption environment (Meredith and Mantel, 2010).

Project management forms a framework to manage a series of elements. These elements include:

- Project definition by accurately defining the objectives of the project
- Categorising the project into various stages of its life cycle and controlling each stage
- Allocating tasks to the different stages and tracking these tasks
- Clarifying roles to ensure effective team work
- Providing quality assurance during the project life cycle
- Highlighting risks and developing procedures to deal with the identified risks

While project management strives to manage the project to ensure it meets the specified performance within the budget and schedule, these functions are highly influenced by risk.

The integration of risk management into all the project management functions are summarised in Table 1 and Figure 1.

Project Management Function	Associated Risk
scope	scope creep or additional expectations result in deviation from the scope objectives
quality	standards and requirements are not met
time	time objectives and restraints
cost	cost objectives and restraints
contracts/procurement	services, materials, performance
human resources	availability of resources, productivity of resources
information/communication	data communication, data exchange accuracy, new ideas
project management integration	life cycle variables, environment variables
risk	risks associated with risks in the project that are overlooked, avoided or optimistically ignored

Table 1:

The integration of risk management with all the project management functions

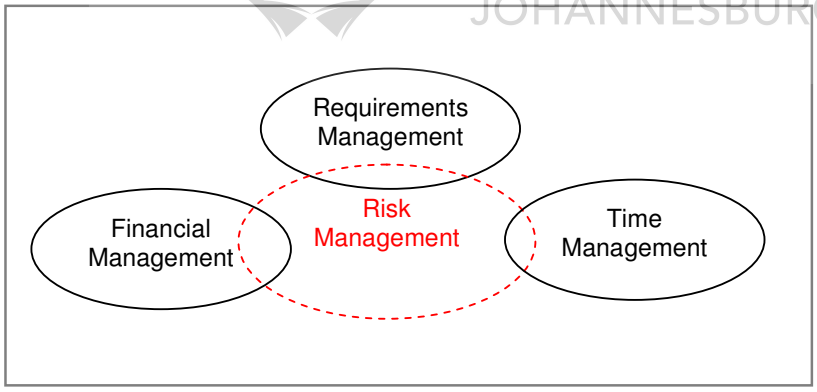

Figure 1:

The integration of risk management into the project management functions of requirements, financial and time management, which are the tradition factors defining project success.

1.4 Risk and its contribution to the success of a project

To be able to manage risks in the company, it is important to understand what a risk is.

Risk is defined as the degree of exposure to a negative event and its consequence on project objectives such as scope, quality, time and cost.

According to Carrero (2005), since risk has not occurred as yet, it may or may not occur. It is therefore a created image or projection of an occurrence that may happen with negative consequences (de Bakker, 2011).

Risk may also be defined as the combination of uncertainty and constraint, as shown in Figure 2 (Tusler, 1998).

Ideally, a low possibility of uncertainty and a corresponding low constraint is desired in a project. A high possibility of uncertainty and a high corresponding constraint is highly undesirable and can have major impacts on the projects. Reducing the risk to an acceptable level can be achieved by reducing either or both, uncertainty and constraint.

In practise however, the opportunity to reduce constraint is not always possible. Hence the focus should be directed at reducing uncertainty.

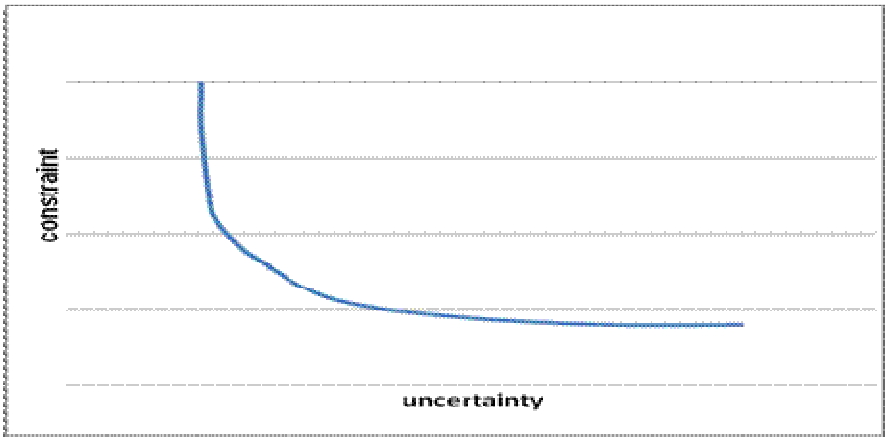

Figure 2:
Constraint versus uncertainty
Source: (Tusler, 1998, Project Risk Management Principles)

In addition to the theory of uncertainty and constraint, is the importance of formal decisions made in the company in the spectrum of uncertainty.

In an ideal situation, these decisions would be made in an environment where there is total certainty; where total certainty refers to all the necessary information required to make decisions of high confidence, is available and all is known. In reality however, due to the lack of availability of information or where unknowns are still unknown, it results in decision making with some degree of uncertainty (Meredith and Mantel, 2010).

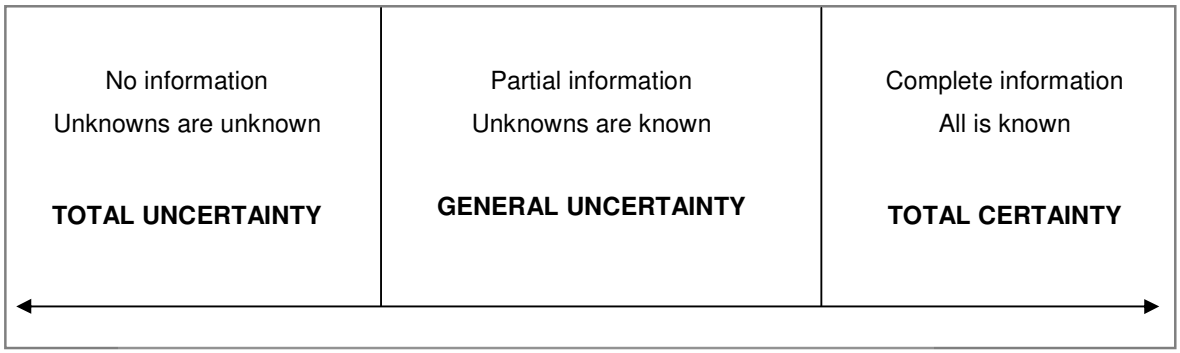

Figure 3:
The scope of risk management in the spectrum of uncertainty

As we progress from total certainty to uncertainty, the potential damage to the project will increase (Kerzner[2], 1995)

Uncertainty is not always unfavourable as opportunities do occur in the spectrum of uncertainty.

While the scope for risk management lies between the two extremes of total certainty and total uncertainty, it focuses on what can go wrong with a project through its life cycle and applies preventative actions or provides contingencies to shift the odds in ones favour (Steyn *et al.*, no date), by targeting at moving uncertainty from risks towards opportunities.

This is also in agreement to Jutte (2010) where it is mentioned that positive risks or opportunities can make the project go faster, better and/or more profitable.

[2] Project Management, A Systems Approach to Planning, Scheduling and Controlling

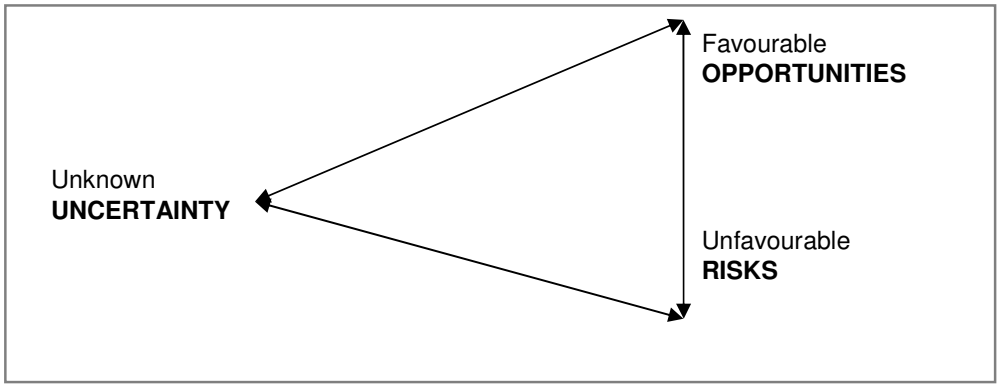

Figure 4:
Shifting uncertainty from risk to opportunities

Therefore, to ensure the survival of the company in the current markets, it requires for opportunities to be identified within the spectrum of uncertainty (Meredith and Mantel, 2010). This however, is dependent on the decision maker being able to estimate the probability of an outcome that could occur and its severity on the project.

One who often finds himself/herself in a situation of perpetual crisis in a project, is one who is most often failing to manage risks properly. Failure to manage risks is often characterised by the inability to make the decisions on what is to be done, when it is to be done and if enough has been done (Tusler, 1998).

Risks are present in every project and cannot be eliminated entirely, but reduced to an acceptable level (Steyn *et al*., no date). These project risks must be managed professionally to limit the company's exposure to financial losses.

The perception of risk management is similar to that of project management. That is, risk management also contributes to the success of a project (de Bakker *et al*., 2010).

This is aligned to the majority of publications that relate risk management to project success, where project success is defined by the traditional time - budget - performance model.

Risk is therefore an important factor which, in the researcher's opinion, influences the success of a project.

1.5 Problem Statement

Project failure is unacceptable for any company in the economic system.

While project failure can be attributed to many factors, time, cost and performance are the three major factors, as concluded from the majority of publications, with risk management playing an important integrated role to all of these project management functions.

It was therefore decided that the generic model of time - budget - performance with the integration of risk management be investigated further, to verify if these are also the major factors that contribute towards project success at the researcher's organisation[3].

An opportunity was also taken to investigate the risk management process at the organisation, to determine if optimisation to the process is possible.

The problem statement or the scope of study is therefore, to identify the following at the researcher's organisation:

a. The definition of project success and if risk management is an important factor contributing to project success
b. Prioritisation of the project management functions according to risk contribution, and
c. Optimisation of the risk management process

The project management functions contributing the most to risk will then become the proposed focus risk management areas at the at the organisation. Also, any optimisation steps identified for the risk management process that would be beneficial to the process at the organisation, will be investigated further and proposed to be included or integrated into the existing process.

[3] As already defined in the Abstract

1.6 Research Objectives

The objectives of this research, in addition to section 1.5 above are as follows:

1.6.1 The definition of project success at the researcher's organisation.

1.6.2 The importance of risk as a factor that influences the success of a project

1.6.3 Prioritisation of the project management functions based on risk contribution

1.6.4 Optimisation of the generic model of risk management at the organisation, *the Risk Matrix Model*

1.6.5 The influence of risk in the different environments in which the project is concerned

1.6.6 Other factors that influence the success of a project

Following this research study, the findings will demonstrate and verify:

1.6.1.1 The definition of project success at the organisation in comparison to the definition of success according to literature, *the time - budget – performance model*

1.6.2.1 The perceived relationship between risk management and project success at the organisation, in comparison to the belief according to theory

1.6.3.1 Identification of focus areas for risk management at the organisation

1.6.4.1 Whether the risk management model at the organisation, using risk impact and risk probability, is the most optimised model or not

1.6.5.1 The influence of risk in specific disciplines such as process engineering, mechanical engineering, electrical engineering, control engineering or reliability engineering, and whether risk is equally present in all disciplines or if it varies between the disciplines, and

1.6.5.2 The influence of risk in specific environments, such as in a production environment (where a saleable product is produced) or in a sustaining environment (utilities)

1.6.6.1 The important of other factors such as communication, senior management support, etc

1.7 Research Questions

It was decided that a questionnaire be the method of choice for the collection of data, since data could be collected from a larger and more diverse group of people. The questionnaire was distributed using email. Data collection using a questionnaire would also be simpler, less expensive and does not require much effort. Data compilation would also be easier. *Refer to Section 4.2.5.1 for the choice of the questionnaire as the preferred method for data collection.*

As an introduction to the questionnaire participant, the field of study, researchers name, research topic and research objectives were listed.

The name, occupation, business unit and the date of completion were requested from the participant.

General information was requested from the participant to determine the level of experience within the business unit. This is to ensure that the appropriate knowledge group is targeted at and that the quality of information will be valuable.

The participant was questioned if he/she was familiar with the rules and regulations of the business unit as this will be indicative of the approach that is employed towards project execution and therefore if all the necessary procedures, such as risk management, is a part of the procedure.

1.8 Research Questions

To address the research objectives, the participant was requested to give input to the following questions:

a. Describe a successful project
b. Explain the relationship between a successful project and risk management
c. Is risk is an important factor to consider when working on a project and asked to elaborate why
d. Requested to rank the nine project management functions according to risk contribution based on work experience
e. Questioned if risk management is an important procedure in project execution

f. List two projects worked on, giving examples of risks that were identified for these projects and the project management function mostly affected
g. Questioned what would have happened if these risks were not identified
h. Questioned about the process steps followed to identify these risks (Question [f.])
i. To suggest additional steps that could potentially optimise the risk management process of identifying, analysing and mitigating risk impacts
j. Questioned if most risks associated are with the process engineering, mechanical engineering, control engineering, electrical engineering, etc and asked to elaborate
k. Questioned on where does risk impacts more - in a production environment (where a saleable product is produced) or in a sustaining environment (utilities) or engineering fraternities.
l. The effects of communication on project success
m. Other factors influencing project success

The Questionnaire is included in Appendix 9.1.

The responses, as received from the selected participants at the organisation, to the above research questions are discussed in Chapter 5.

1.9 Research Report Layout

This mini dissertation consists of 9 chapters.

Chapter 1 includes the introduction to the chosen topic. The problem statement as well as the research objectives and research questions are also included in this chapter.

Chapter 2 is a literature review that investigates what other researchers have already found on risk management. The scope of the literature review study includes risk classification, the risk management study, risk management techniques, contingencies and the importance of communication in the risk management process.

Chapter 3 provides information on the approach of risk management at the organisation.

Chapter 4 provides general information on the different methods of approach when doing a research study. The selection of methods used, as well as reasons as to why these methods were chosen for this research study are included in this chapter.

Chapter 5 provides the actual findings and feedback from the research questionnaire completed for this study.

In chapter 6, all recommendations that arose from the research questionnaire are provided. This chapter concludes the study.

Chapter 7 includes the list of references containing all the books and website articles which are actually referred to in the text of this dissertation.

Chapter 8 includes the bibliography, where useful website articles were consulted with for reading and understanding purposes for indirect writing, but not directly referred to in the text of the dissertation.

Chapter 9 includes all the appendices as well as an investigation into a case study that was done for the National Aeronautics and Space Administration (NASA) and the Space Shuttle Challenger Disaster on 28 January 1986 (Kerzner[4], 2003). Information from this case study was included to show the importance of risk management and its impacts if not managed effectively

1.10 Summary

Projects, defined as temporary endeavours, have become popular and play an important and influential role towards to the profitability of the organisation.

The success of a project can be described as the ultimate goal of the project.

A successful project is determined by a business case, critical success factors, planning, scope creep, motivation within the team, risk management, saying no and a defined project end of life.

[4] Project Management Case Studies

A successful project is also defined as a project, where schedule, budget and quality requirements are met

Schedule, budget and quality, form part of the nine functions of project management. The project management functions also include scope, risk, project management integration, information and communication, human resources and contracts and procurement. Although project management has proved to be a dominant business model to manage successful projects, it is highly influenced by risk, or the degree of exposure to a negative event and its consequence on project objectives such as scope, quality, time and cost.

While risks are present in every project and cannot be eliminated entirely, it can be reduced to an acceptable level to manage finances. It is perceived that risk management contributes to the success of a project, which is aligned to the majority of publications that relate risk management to project success.

Since the researcher is also in agreement to that of risk being an important factor that influences the success of a project, it was decided to investigate this further.

It was decided that the definition of project success be investigated further and that these defining factors be the focussed project management functions to optimise on risk management at the researcher's organisation.

Chapter 2

2. Literature Review : Risk Management

2.1 Introduction to Risk Management

The process of minimising the risk impact on the company's resources, earnings and cash flows is known as risk management. It is a systematic process (Meredith and Mantel, 2010) to manage the company's risk exposure in a manner that will be consistent and acceptable to the law, environment, human safety and the public interest.

Risk management is a process that decides on the measures that will have to be taken to reduce the probability of risks occurring, or to minimise the impact that will occur as a result of the risk.

2.2 Objectives of risk management

The objectives of risk management are to:

- Identify all risk factors that affect the project's objectives for scope, quality, time and cost
- Quantify the impact for each risk factor, and
- Mitigate the impact by influencing the project controllables

2.3 Integrating Risk Management into Project Management

The poor performance of a project as a result of scope definition, quality of the end results, schedules or costs can be attributed to unforeseen risk events which might or might not have been anticipated by project management and the project team, or by foreseen risk events that were not accommodated for, or optimistically ignored.

The associated risk events associated with the project management functions are:

2.3.1 Scope

Risks that arise as a result of changes in the scope of a project to meet project objectives, unclear scope definition, new technology or unfamiliar methods and tools.

2.3.2 Quality

Risks may affect quality by influencing the value of performance, environmental impact, inaccurate metrics or extreme quality requirements.

2.3.3 Time

Delays to the project due to labour, material unavailability, weather, over optimism, omitted tasks or incorrect logic for dependencies become a risk to the time factor for a project.

2.3.4 Cost

The impact on cost due to an accident, fire, theft, price changes, supply shortages pose a risk to inflate the project's original budget

2.3.5 Risk

Insufficient risk management or risks associated with overlooking risks become a risk to the project

2.3.6 Contracts and Procurement

There may be risks associated with contractor insolvency, claims settlement, etc

2.3.7 Human Resources

Strikes, termination of resources resulting in under staffing, incompetent resources resulting in resources mismatched to the task, unique skill requirement, and new resources are risks to a project

2.3.8 Communication

There are risks associated with incorrect communication which result in incorrect actions, and

2.3.9 Project Management Integration

An incorrect start relative to the project life cycle can also be a risk to the project.

The poor performance of a project can also be based on the attitude towards risk. This can be due to lack of understanding towards the project concept and techniques, or technology, etc.

Since the project life cycle is very dynamic and characterised by rapid change, the project risks vary significantly during the different stages of the project. For a typical project consisting of a concept (development) phase and an implementation (termination) phase, the greatest degree of opportunity and uncertainty is encountered during the concept phase. In this phase, since investment is low, the stakes are low.

As the project progresses towards the implementation phase, opportunities and risks reduce because unknowns become known. At this stage, since investments and resources are required, the stakes become high.

Risk management uses a systematic process which focuses at influencing project planning in the earlier concept phase. This reduces uncertainty and capital which will impact the implementation phase, which is most vulnerable.

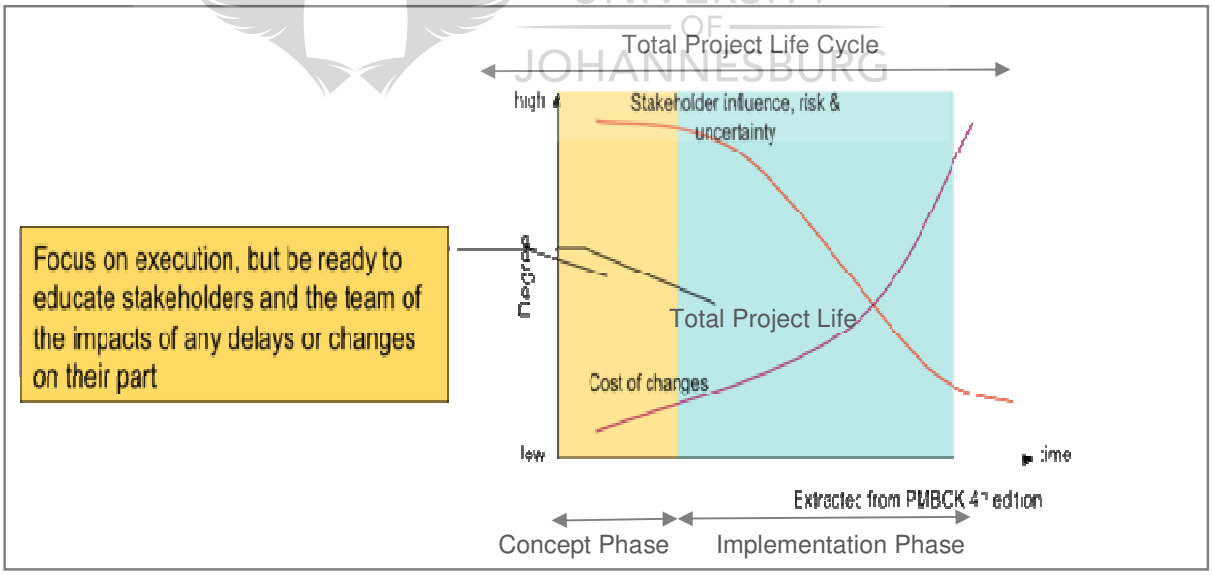

Figure 5
The probability of risk during the different phases in the project life cycle
Source: Google Image which can be found on the following website:
https://wiki.smu.edu.sg/w/is480/images/thumb/d/da/Neuworks_Project_risks_life_cycle.png/700px-Neuworks_Project_risks_life_cycle.png

2.4 The Risk Management Process

A simplistic risk management process consists of risk identification, risk assessment, risk response, risk monitoring and documentation.

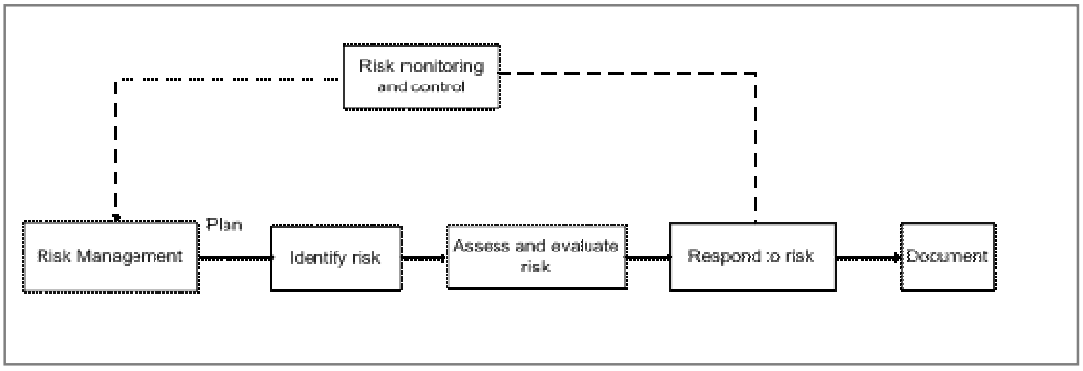

Figure 6
The risk management process
Source: (Steyn et al., no date, Project Management, A Multi-Disciplinary Approach, second edition)

2.4.1 Risk Identification

Risk identification is probably the most important step in the risk management process.

Risks which significantly impact the success of the project can be quantified as high-impact-high probability, high impact-low probability, low impact-high probability and low impact-low probability.

It must be kept in mind that an event with a high impact-low probability such as a natural disaster can result in a catastrophic outcome. Sometimes, insufficient attention is focused on this risk event and this can be a major disadvantage.

In many such cases of a high impact-low probability, the cost of the risk may be massive, but the likelihood that it will occur is so small that the expected cost of the disaster is much less than many smaller, more common risks with far higher probabilities of occurring (Meredith and Mantel, 2010).

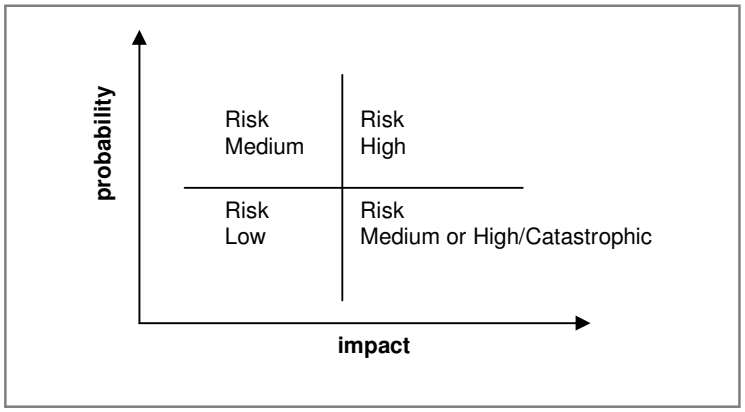

Figure 7
Diagram of risk probability vs. risk impact
Source: (Steyn et al., no date, Project Management, A Multi-Disciplinary Approach, second edition)

Experience and knowledge is essential for risk identification. This can be achieved by involving team members with personal experiences and expertise, or from the knowledge that they gain from talking to experts outside of the risk management team.

It is due to the knowledge and experience for specific risks that a unique risk management team is usually formed for each project dependant on the nature of the project.

Risks can be classified as either business risks or pure, insurable risks (Kerzner[5], 1995).

Kerzner[5] further explains that a business risk occurs when there is a change of profit or loss. Business entities usually employ specifically skilled staff to maximise profits and reduce losses.

A pure, insurable risk is associated with losses only (Kerzner[5], 1995), where these risks can affect direct or indirect property, liability and personnel:

- direct property refers to damage and losses associated with property due to fire, natural disasters, etc
- indirect property refers to renting of temporary or alternate equipment due to damage or destruction of original equipment and if immediate replacement was not possible

[5] Project Management, A Systems Approach to Planning, Scheduling and Controlling.

- liability refers to law suits due to personal/body injury or property damage
- personnel refers to injury to employees.

Risks can also be classified as external unpredictable or external predictable or internal technical or internal non-technical, as shown in Figure 8.

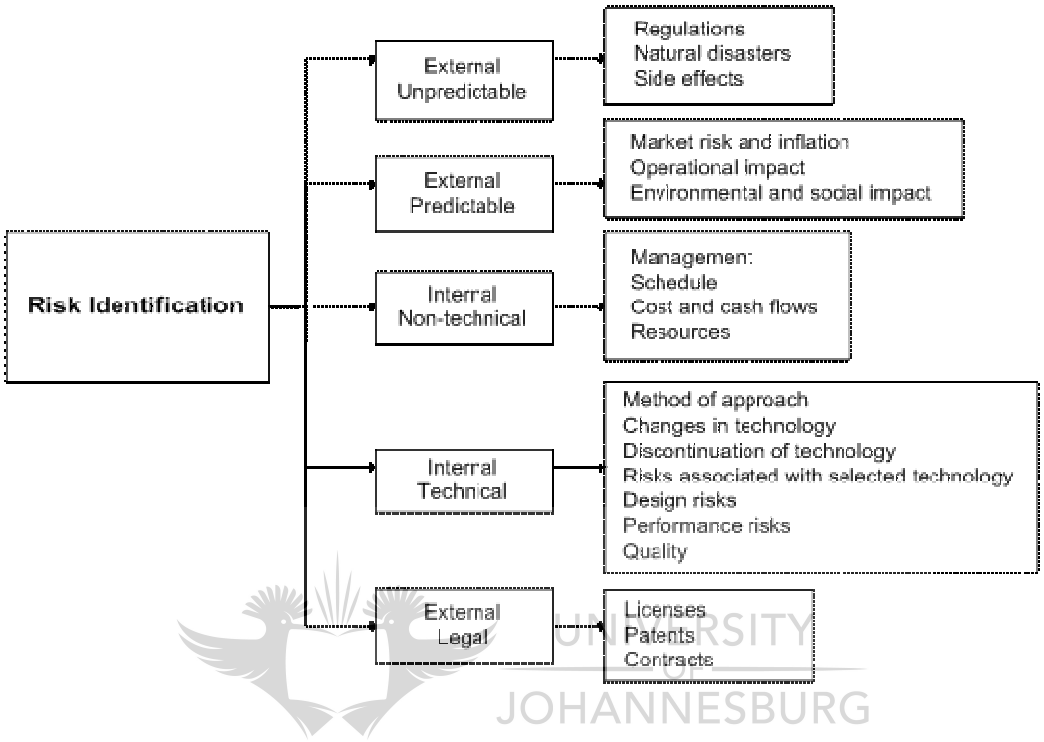

Figure 8
Risk classification
Source: (Kerzner, 1995, Project Management, A systems approach to planning, scheduling and controlling, 5th edition)

Risks may further be classified according to the risk event. The risk event is estimated as the product of the probability and consequence, quantified in terms of a monetary value or time.

$$RiskEvent = \Pr obability \times Consequence$$

Equation 1
Estimation of a risk event
Source: (Steyn et al., no date, Project Management, A Multi-Disciplinary Approach, second edition)

The risk event refers to what might happen to the detriment of the project. The probability refers to how likely will the risk event occur and the impact refers to the severity of the risk event.

It is important and beneficial to have the following in place during risk identification (Steyn *et al.*, no date)

a) Historical information and lessons learnt from similar projects
b) Checklists in the organisation that were compiled for different types of projects
c) A project management plan
d) A work breakdown structure
e) A project schedule, cost breakdown and budgets
f) The technical goals, and
g) All risk categories

The output from a risk identification is the risk register which should contain but is not limited to the following:

a) a risk identification number, risk title
b) risk type or categories
c) list of identified risks and root causes of risk
d) comment or description of each risk identified
e) effect of the risk to the project milestone or business
f) risk status
g) date identified, date last updated, priority
h) potential responses and cost to mitigate, responsible persons for tasks.
i) probability of occurrence
j) owner and signatories

Improving the ability to identify and influence to risks can be a major opportunity to improve the risk management process.

The ultimate responsibility for risk identification and next steps is dependent on the Project Sponsor. The project sponsor, therefore, has the greatest influence on the project scope, quality, time and cost of the project.

2.4.2 Risk Assessment

The objective of a risk assessment is to increase the understanding of the project, identify alternatives, ensure that risks are considered and prioritised adequately, incorporated into the project concept and development phases and the impacts of these risks to other aspects of the project are established. Where risk assessments are based on lack of or no information a contingency allowance is usually budgeted for.

The sequence for a simple risk assessment process following the identification of the risks includes:

a) Risk analysis using qualitative analysis, where the risk is classified as either a low, medium or high risk, and thereafter quantitative analysis, where the risk event is calculated by estimating the probability and impact for a risk, as described in Equation 1.
b) Determining the consequence
c) Response to the consequence
d) Risk prioritisation, and
e) Documentation.

Potential impacts increase as tasks with risk events of high probability are carried out, and decrease when tasks are completed. Since risks vary with change in scope, risk reviews and assessments must be continuous with appropriate adjustments.

There exists many risk assessment techniques which can be used during the risk assessment phase. These include:

a) Information gathering using
   - structured interviews
   - document reviews
   - assumption's analysis, or
   - review of historical records.

b) Risk checklists

c) SWOT Analysis
   - The strength, weakness, opportunity and threats are analysed

d) Brainstorming
   - Members with relevant and competent knowledge try to build new ideas using innovation and imagination

e) Sensitivity
   - Values are placed on the effects if there is a change in an event
   - This is further used to determine the value impacts on cost or schedule of the project

f) Probability
   - A probability distribution is composed for each variable
   - The situation is then considered should there be a change to the variable

g) Delphi Method
   - This method strives for consensus through a panel of experts to arrive at a convergent solution
   - Questionnaires are continuously completed till a consensus is reached

h) Decision Tree Method
   - A graphical tree shape diagram with branches representing different courses of actions with an associated probability is established
   - The lowest risk is usually the preferred path

i) Decision Theory
   - The decision theory is based on forecasting, and the best possible course is chosen.

j) Monte Carlo
   - The Monte Carlo is a simulation using random numbers
   - The variables chosen are allocated a probability
   - Random values are chosen from a frequency curve generated for each variable.
   - The process is repeated
   - A deterministic analysis is done on the combination of the random numbers and probability

k) Statistical Analysis
   - The mean, minimum, maximum, mode, median, standard deviation are estimated

l) Failure Mode and Effect, (Meredith and Mantel, 2010).
   - The possible failure ways are listed
   - The severity (S) of the consequence for each failure is estimated, based on a 10 point scale, where 1 represents no effect and 10 represents a very severe effect.
   - The likelihood (L) for occurrence for each failure is estimated, based on a 10 point scale, where 1 represents remote and 10 is most certain.
   - The ability to detect (D) each failure is estimated. This is based on a 10 point scale, where 1 is detectable and 10 is not detectable
   - The risk priority number RPN is calculated using the following equation

$$RPN = S \times L \times D$$

Equation 2
Estimation of a risk priority number

   - Ways are then considered to reduce the overall S, L and D values for significantly high RPN numbers.

The benefits of a successful risk assessment are:

a) improved project objectives and schedule accuracy
b) improved communication between relevant role players
c) true implications of risk and uncertainty
d) documented support for project contingency allowances and planning for additional tasks, and
e) increased chance for project success

The status of previously identified and new risks must be re-assessed and the probabilities and impacts re-evaluated.

2.4.3 Risk Response

Mitigating project risks require a system strategy, which can be achieved by developing procedures and techniques. This strategy can range from simplicity by accepting small risks to complexity, where comprehensive plans are compiled for major risk events.

Based on this strategy, risks can be:

a) unrecognised, unmanaged or recognised with no action and therefore ignored
b) avoided by taking appropriate steps
c) reduced by mitigation
d) transferred, where risks are transferred to others through contracts or insurances
e) retained and absorbed using contingent allowances, or
f) a combination of the above mentioned

2.4.3.1 Management of a Contingency Allowance

Unexpected problems due to lack of timely information, competence or key role players, incorrect or false predictions, or problems not thought of or overlooked, do surface during the project life cycle. Risk management positively influences these problems through the creation of a contingency plan to enable flexibility to accommodate for the unexpected (de Bakker, 2011)

If however, the contingency cannot accommodate for the impact, they may be a need to change the scope, quality, budget or schedule. If the situation is beyond recall, the project should be aborted to avoid further capital wastage.

The typical approach to applying for contingency allowances can vary from a standard allowance to a percentage, based on past experiences, or careful assessment based on the sum total of the probability and consequence for the risk events identified.

Risks may even have more than one contingency, in which event, an action that will trigger the contingency must be decided upon as well as what would indicate that the contingency action should stop.

2.4.4 Risk Monitoring

Risk monitoring control focuses on monitoring residual risks, identifying new risks, executing risk reduction plans and evaluating its effectiveness throughout the project life cycle (Meredith and Mantel, 2010). It ensures that project assumptions remain valid, if risk assessments have not changed from its previous state, if policies and procedures are being adhered to or if contingency reserves, cost or schedule should be modified in line with new risks identified.

Risk monitoring is done using risk audits, variance and trend analysis, technical performance measurement, etc.

2.4.5 Documentation

Data is often not available, or if data is available, interpretation can be difficult.

Usually the best source of information is historical information within the organisation.

A database is therefore essential to build this reliable source of information for continued risk evaluation.

According to Meredith and Mantel (2010), risk evaluation and analysis activities can be data intensive, but the project team must ensure that permanent records of the following are documented:

a) all assumptions made in preliminary project plan that may be a source of risk
b) identified risks
c) categories used to categorise risks
d) detailed qualitative and quantitative estimates made for each risk. Brief descriptions on the methods used to make the estimates, and
e) minutes of all group meetings including list of actions, methods used to mitigate and resolve risks, including decisions ignored and reasons why, outcomes of estimated risks and results of actions taken to mitigate the risks.

2.5 Communication and Risk Management

Another important factor that positively influences the project risk is project reporting.

When a risk is identified, a person sometimes has the tendency to deny the possibility or the actual presence of a risk or uncertainty, and therefore tries to avoid it or ignore it completely.

In situations where project risks are not shared openly, the positively communicative effect may not occur stifling the success of a project (de Bakker, 2011). General awareness for risks is created by communication. When communication is open and active between members working together on an aligned or agreed upon goal, it improves the effectiveness of the performance.

Communication enables a common definition of a situation by adjustment and synchronisation of one's actions. Better communication and more creative thinking is influenced by risk management. Communication has a positive impact on the project success.

2.6 Summary

Risk management is a systematic process to manage the organisations risk exposure, by minimising the risk impact on the organisation's resources, earnings and cash flows. The objective of risk management is to identify, quantify and mitigate the impacts for all risk factors.

The poor performance of a project as a result of scope definition, quality of the end results, schedules or costs can be attributed to unforeseen risk events which might or might not have been anticipated by project management and the project team, or by foreseen risk events that were not accommodated for, or optimistically ignored.

The associated risk events associated with the project management functions include:

- Scope: risks that arise as a result of changes in the scope or additional expectations result in deviation from the scope objectives
- Quality: risks associated with quality such as inaccurate metrics, extreme quality requirements

- Time: time/schedule objectives not met as a result of delays
- Cost: cost objectives not met as a result of inflation to the project's original budget due to unforeseen occurrences such as accidents, theft, price changes, supply shortages, etc
- Contracts/Procurement: risks associated with contracts for services, materials, performance, etc
- Human Resources: risks associated with human resource factors such as strikes, under staffing, incompetence, unique skill requirement, new resources availability or productivity of resources
- Information/Communication: incorrect communication as a result of data exchange accuracy or attitude
- Project Management Integration: life cycle variables influencing on incorrect start relative to the project life cycle, and
- Risks: insufficient risk management or risks associated with overlooking risks become a risk to the project

A simplistic risk management process consists of risk identification, risk assessment, risk response, risk monitoring and documentation.

- Risk identification based on the appropriate experience and knowledge is essential for risk identification.
- The objective of a risk assessment is to increase the understanding of the project, identify alternatives, ensure that risks are considered and prioritised adequately as well as to establish the impacts of the risks. Risk assessments based on lack of or no information is usually accommodated for using a contingency allowance. Contingencies must be budgeted for.
- Risks may be responded to by taking appropriate steps, reduced by mitigation, transferred, allowed for using contingencies, avoided, or a combination of all the mentioned options.
- Continued risk monitoring control focuses on monitoring residual risks, identifying new risks, executing risk reduction plans and evaluating its effectiveness throughout the project life cycle.
- Documentation is very important. The best source of information is usually historical information within the organisation. It is therefore essential to establish a data base for continued risk evaluation. While risk evaluation and analysis activities can be data intensive, the project team must ensure that permanent records documented.

General awareness or project reporting of risks is created by communication. If project risks are not shared openly, positive communication may not occur which affects the success of a project.

Chapter 3

3. Literature Review: Risk Management at the Organisation[6]

3.1 The approach to Risk Management

Projects at the organisation are executed according to the Business Development and Implementation Model (BD&I). There are three phases on this model. These include the Idea Generation Phase, Front End Loading Phase and the Implementation Phase.

The front end loading phase is further broken down into different stages:

- Pre-feasibility Stage
- Feasibility Stage, and
- Basic Development Stage

The implementation phase further broken down into different stages:

- Execution Stage,
- Start-up Stage, and
- Evaluation and Operation Stage.

Between each stage, a risk review is held to identify and evaluate risks . The risk management process is discussed in further detail in Section 3.4, to follow.

Depending on the project life cycle, complexity and capital cost of the project, projects may be executed by different companies within the organisation. Hence, there may be slight adaptations to the BD&I Model depending on the different company.

3.2 Risk Classification

Project risks at the organisation are classified into the categories of production, supply or feedstock, maintenance, sales or market rise, project execution, financial or

[6] As already defined in the Abstract and Section 1.5

the exchange rate, people and skills, legal issues and safety and health, distribution, technology or strategies, as shown in Attachment 9.9.

The associated risks for each category are as follows:

3.2.1 Supply or feedstock risks

- Feedstock supplies or reserves
- Inbound logistics
- Raw materials
- Purchase services
- Inventory management
- Supplier relationships
- Supplier management

3.2.2 Production risk

- Production costs
- Processes
- Procedures
- Plant availability, machinery availability and utilisation
- Flexibility and capacity
- Quality assurance
- The management of change

3.2.3 Maintenance risks

- Maintenance cost
- Plant integrity
- Procedures
- Asset management
- Essential services such as electricity, water, air, steam, etc

3.2.4 Sales or market rise risks

- Product pricing
- Product life cycle
- Buyer partnerships and collaboration
- Own partners, associates and alliances
- Brand or reputation
- Marketing

- Markets or market segments
- Quality of order fulfilment
- Assistance and support
- Customer relationships
- Customer base

3.2.5 Project execution risks

- Infrastructure and utilities
- Sole source to a specific engineering company
- One of a kind or first of a kind project
- Information or communications
- Contracting and procurement
- Project integration
- Scope
- Contractor
- Quality requirements or standards
- Cost
- Schedule

3.2.6 Financial or exchange rate risk

- Exchange control
- Taxation
- Transfer pricing
- Cash flow
- Credit and financial markets
- Fraud
- Integrity of reporting
- Budgeting
- Exchange rate
- Interest

3.2.7 People and skills risks

- Organisational
- Admin and processes
- Succession planning
- Demographics and psychographics
- Climate

- Skills and competencies
- Talent pool
- Change readiness
- Leadership

3.2.8 Legal risks

- Signing authorities
- Anti-trust
- Contracts
- Compliance

3.2.9 Safety and Health risk

- Governance
- Quality for systems and processes, quality assurance and control
- Security
- Health
- Safety of processes and occupational safety

3.2.10 Distribution risks

- Dealers and distributors
- Order processing
- Transport
- Outbound logistics
- Packaging
- Inventory management

3.2.11 Technology risks

- Intellectual property
- Relevance
- Technological development
- Product development
- Research and development
- Engineering
- Information technology and information management

3.2.12 Strategic risks

- Political and government

- Natural disasters
- Global and national economic trends
- Demographics
- Fashions and preference
- Industry characteristics
- Competitive environment
- Partnerships, rivalry, alliances, substitutes or new entrants

3.3 Prioritisation of Projects

During the Idea Generation Phase, the risk profile is defined for the project using the tier classification.

Risks are classified as levels A, B, C or D for the categories, based on the degree of uncertainty, where level D risks are known with some uncertainty as compared to a level A risk where uncertainty is severe due to the many risks which still remain unknown.

Each category is allocated a score which determines which company in the organization will execute the project. Also, based on the final score calculated for the project, (from the tier classification), the project list sheet for that specific company will be updated and projects prioritised according to the scored calculated.

The template for the tier classification is attached in Appendix 9.2.

3.4 Risk Management (at the various stages during the project life cycle)

Risk assessments are done at all stages of the project life cycle at the organisation.

Risks identified are classified as per the risk categories for the organisation, as included in Section 3.2 above. A description of the risk as well as the cause and the consequence of the risk is captured in a risk register.

The risk register template is attached in Appendix 9.3.

The risk event is determined by focusing on the probability and impact for each risk using the Risk Matrix. The probability is determined based on the likelihood of the risk occurring. The impact of the risk can be evaluated based on financial, capital earnings, safety and health, schedule, technical implications, environment, legal etc.

The rating tables for probability and impact are included in Appendix 9.4 and 9.5 respectively. The risk matrix is included in Appendix 9.6.

Initially with the identification of risks, they usually lie in the high risk areas of the risk matrix. Mitigation actions are then explored to strategically reduce the risks from high levels to tolerable levels. The proposed response to the risk is documented.

The risk response strategy can be seen in Appendix 9.7.

Each risk is allocated to a risk owner. The risk register is then signed by the relevant stakeholders.

The risk audit checklist which is used at the various stages of the project life cycle is included in Appendix 9.8.

3.6 Summary

Projects at the organisation are executed according to the BD&I Model. Within the Idea Generation, Front End Loading and the Implementation phases, there are stages. Once a stage is passed, a risk review is held to identify and evaluate risks. Risk assessments are therefore done at all stages of the project life cycle.

Project risks are identified according to the categories of production, supply or feedstock, maintenance, sales or market rise, project execution, financial or the exchange rate, people and skills, legal issues, safety and health, distribution, technology or strategies. Risks are thereafter assessed.

A description of the risk as well as the cause and the consequence of the risk is captured in a risk register. The risk event is determined by focusing on the probability and impact for each risk using the Risk Matrix. The probability is determined based on the likelihood of the risk occurring. The impact of the risk can be evaluated based

on financial, capital earnings, safety and health, schedule, technical implications, environment, legal etc.

Initially with the identification of risks, they usually lie in the high risk areas of the risk matrix. Mitigation actions are then explored to strategically reduce the risks from high levels to tolerable levels. The proposed response to the risk is documented. Each risk is allocated to a risk owner.

Chapter 4

4. Method of Approach for Research

It is very important to decide on which research approach best suits the research being worked on, to increase the efficiency of the research study.

Research may be categorised as quantitative or qualitative. Quantitative research is defined as a systematic investigation, which uses mathematical or statistical techniques. For quantitative analysis, the data is essentially numerical, expressed in the form of statistics, percentages, etc. Qualitative analysis is where the researcher investigates themes or observations and then describes the information as patterns, exclusively for that specific set of participants only.

Quantitative research is further described, in the article titled “Types of research, The four main approaches”, as the collection of data that follows a strict procedure which is then converted into a numerical form for statistical analysis to be done, from which conclusions can be drawn. Qualitative analysis, a methodical yet more flexible process uses recordings, observations, etc and attempts to uncover a deeper meaning or significance of behaviour, beliefs and emotions which will be generalised for a specific group of participants only.

It was mentioned that qualitative research uses the research methods of interviews and observations while quantitative research focuses more on questionnaires, surveys and trend analysis (Shuttleworth, 2008).

Following the definition of research as quantitative or qualitative, research may be further categorised as a deductive or inductive approach. While the deductive approach works from the general to the specific, inductive research works from specific observations to a broader generalisation (Skinner, no date).

During a deductive research, a variety of data is collected by the researcher to confirm or reject the hypothesis of interest, which is the tentative prediction on what the researcher expects will result from the study. Arguments are generally based on laws, rules and accepted principles (Burney, 2008). For the inductive study, the researcher uses specific observations to formulate a pattern to reach a hypothesis. This hypothesis then defines the research problem. Hence deductive would be more

classified as quantitative research and inductive would be classified as more qualitative research. (Hall, no date).

The comparison between deductive and inductive research is shown in Figure 9 below.

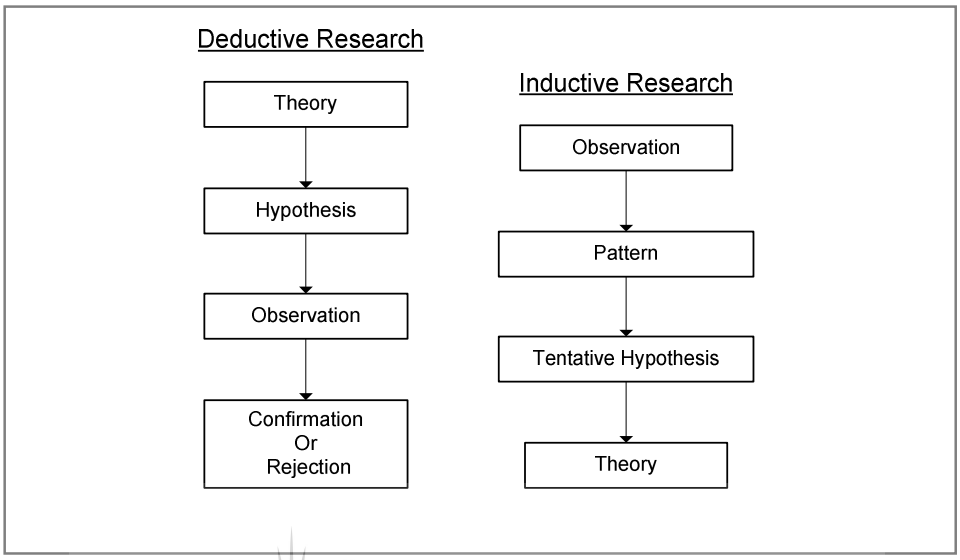

Figure 9: Research Technique
Source: (Burney, 2008, Inductive and Deductive Research Approach)

The comparison between quantitative and qualitative analysis is shown in Table 2.

Research may also be defined as primary or secondary. Data collected by the researcher will be primary research while research based on another researcher's work is referred to as secondary data. This is summarised in Table 3 below.

Usual distinctions between Quantitative and Qualitative Methods	
Concepts usually associated with Quantitative Methods	Concepts usually associated with Qualitative Methods
Type of Reasoning	
deduction	induction
objectivity	subjectivity
Causation	meaning
Type of Question	
pre-specified	open ended
outcome-orientated	process-orientated
Type of Analysis	
numerical estimation	narrative description
statistical inference	constant comparison
NB: the use of "usual" is meant to remind the reader that these distinctions are not entirely discrete. In fact, there is a spectrum that encompasses both methods, that in turn, crosses these traditional demarcations.	

Table 2: Usual distinctions between Quantitative and Qualitative Methods
Source: (Skinner, no date, Research-the-essential-guide, Ways to categorise research and methodology)

	Primary	Secondary
Definition	Actual research collected by the researcher	Research based on data collected by another researcher
Sources	The primary source is an original document containing first hand information about a topic	A secondary source interprets and analyses the information gathered by the primary sources.
Source examples	Diaries Interviews Letters Original works of art Photographs Works of literature	Biographies Dissertations Indexes, Abstracts, Bibliographies Journal Articles Newspapers

Table 3: Primary and Secondary Research Methods
Source: (Skinner, no date, Research-the-essential-guide, Ways to categorise research and methodology)

4.1 Preference for the Deductive Technique and Quantitative Research

The method of approach used to compile this dissertation was based on employing a deductive technique since there existed a theory that risk management contributed to the success of the project. A hypothesis was drawn up accordingly to test the theory of whether risk management contributed to project success at the organisation or not.

Another reason for choosing a deductive approach can be attributed to deductive research being associated with quantitative research (Hall, no date), where quantitative research follows a strict procedure which is then converted into a numerical form for statistical analysis to be done, from which conclusions can be drawn. For this research study it was proposed that an investigation be conducted which focussed on mathematical and statistical techniques.

During the observation phase, a questionnaire was distributed using email to selected participants based on the business unit at the organisation that the participant works at, the participants occupation and work experience. *The choice for using the questionnaire as the preferred method for data collection is included in Section 4.2.5.1.*

In the confirmation phase, the information from the questionnaire was compared to the theoretical understanding and the literature review that was completed during the study.

4.2 Research Process

The need for research is initiated when a problem or a theory is identified or if more information pertaining to a specific area of concern or belief is required.

The researcher's belief that risk is a major contributing factor to the success of a project and the need for the best available risk management process to be in place, initiated the research into what other researchers have found, as well as if active resources at the organisation believe that risk can have a major impact on a project's success.

The following process steps were followed to complete this study:

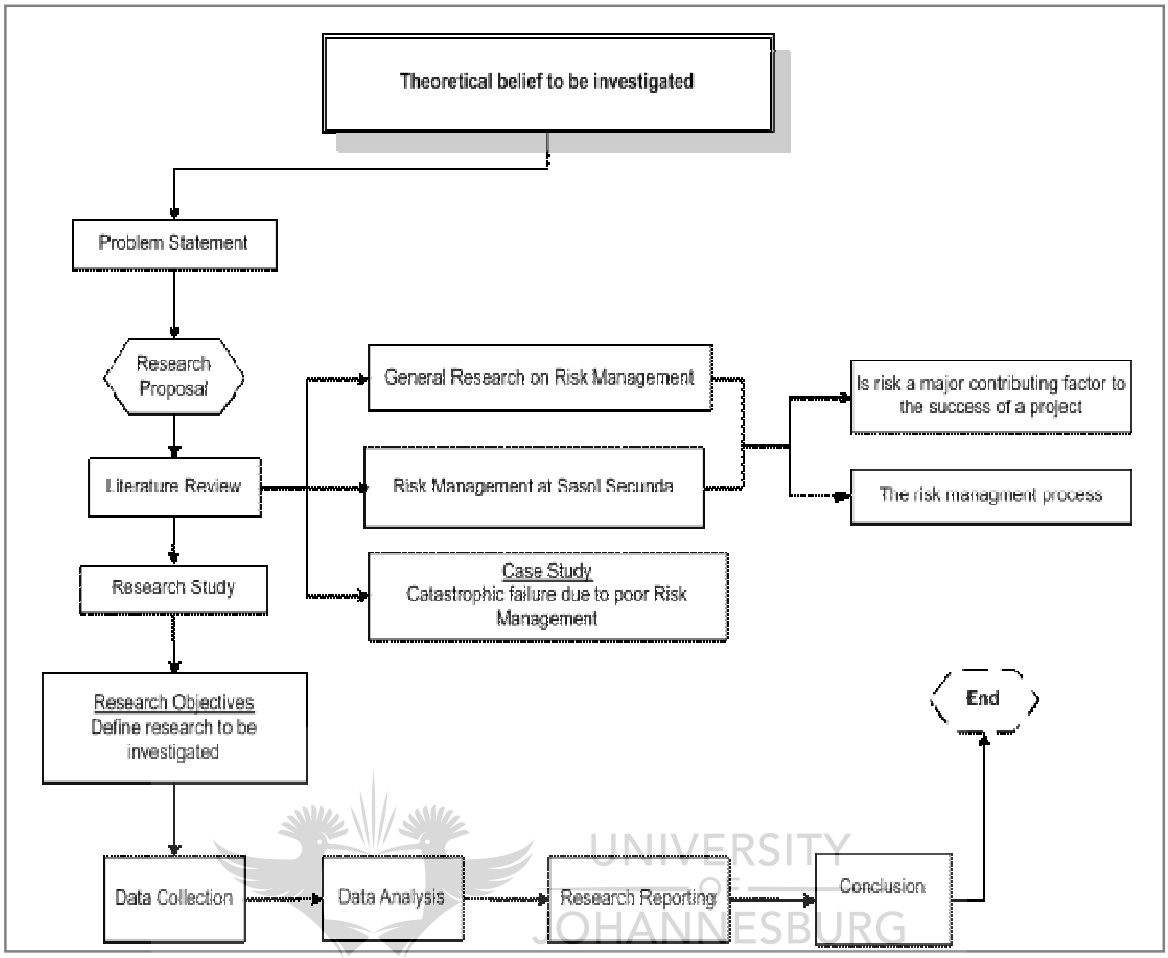

Figure 10:
Research Process Steps

4.2.1 Research Proposal

Following the choice of the topic for research, a research proposal was compiled, with the purpose to:

a) Obtain approval for the research topic from the Academic Institution
b) Present the specific area of concern where more information was required
c) Discuss the importance of the getting the acquired information and therefore the need to conduct the research

The research was approved by the Academic Institution allowing the researcher the opportunity to proceed with the research.

4.2.2 Literature Review

a) A general literature study on risk management was completed to determine what other researchers have already established on whether risk management is a contributing factor to the success of a project and the risk management process
b) The risk management process within the organisation was then investigated
c) An investigation into a case study where poor risk management had major impacts on a project was also investigated to illustrate the importance of risk management.
d) For the purpose of compiling this dissertation: textbooks, books, internet research novels, course as well as a questionnaire survey were used as sources of information

4.2.3 Research Study

A research study was required to gather the necessary information from the active resources at the organisation.

4.2.4 Research Objectives

It is important to determine the objectives of the research. This will define the data that will be required from the research, which will then be translated into the research questions. The objectives for the research is discussed in Section 1.6.

4.2.5 Data Collection

The opinions of personnel within the organisation were then investigated to determine the perception on the contribution of risk management to the project success and the risk management process.

It was then necessary to establish how data would be collected.
Information gathering could be done through many data collection options which includes questionnaires, personal or telephonic interviews, case studies, etc

A questionnaire is a research instrument which consists of a series of questions, that could be designed to propose a list of options, simple checklists or written responses if preferred by the respondent.

An interview is the method of gathering information by speaking directly, either personally or telephonically, to the person. Responses are open and uncontrolled. Information gathered may be abundant and analysis may become difficult with having to filter the information to get to the relevant information required for the study.

A case study is the in depth study of a particular situation as compared to a statistical study. It provides for a realistic result by focussing on evaluation in the real world (Shuttleworth, 2008).

According to Whitney (1972), an alternative to a questionnaire can be the personal or telephonic interviews. While the latter alternatives may have the advantages of clearing any misconceptions and the opportunity of follow up to responses in a personal interview as well as anonymity for a telephonic interview, a questionnaire may be specifically designed for the study.

As already mentioned, the characteristics of a successful questionnaire, is one that is simple and designed with a list of options, checklists, etc with the option of writing responses if preferred. It may be less expensive as there may be no costs associated with travelling or telephone costs and also reduces the influence as a result of the presence of the interviewer.

Further advantages to a questionnaire is that not much effort is required in a questionnaire as compared to a personal or telephonic interview, and the questionnaire may be accustomed to the research required. A questionnaire also receives standardised answers that enable the data compilation to be that much simpler.

With a questionnaire, data can be collected from a larger and more diverse group of people, and where responses can be collected with anonymity, it means that questions will be answered more truthfully (Caines, 2011). This process is also less intrusive since it can be completed by the participant in their own time (Jones, 2011).

According to Caines (2011), there are also disadvantages associated with a questionnaire. Participants can be non-responsive or they may misinterpret the questions.

The choice of open ended or closed ended questions also influences on the execution of the questionnaire.

Open ended questions enable the respondent to formulate their own answers while close ended questions prompts the response from a selection of given choices. Open ended questions yields in depth information as a result of no limit to the participants response. Closed ended questions are easier to complete and since the choices are finite and specified, respondents may be more willing to participate. Results are easier to analyse and interpret [(Gulnazahmad, no date), (Skinner, no date)].

Closed	Open
Easier to analyse	Can elicit a wide variety of responses
Good if questionnaire is long	Good for exploring a topic
Better if motivation of respondent is low	Does not superimpose answers and expectations
Quick and easy to answer	Can be difficult to summarise/analyse
Does not discriminate against the less articulate	Response has to be reported accurately
Can create false options and bias if sufficient options are not included	Unpopular if used in a self-completion questionnaire as can be time-consuming
Good design vital. Range should be exhaustive	
Loss of spontaneity and expressiveness	

Table 4: Closed and Open ended Questions in Questionnaires
Source: (Article titled Data Collection, no date)

4.2.5.1 The Questionnaire as the preferred choice for Data Collection

It was decided that a questionnaire be the preferred method of choice for the collection of data, since data could be collected from a larger and more diverse group of people. It would also be simpler, less expensive, doesn't require much effort. Data compilation would also be easier.

It was decided that the questionnaire be designed such that it included a list of options as well as written responses for where additional information was required for an elaborate understanding. A due date for the response was provided, which also allowed the participants to complete the questionnaire as time allowed them to.

Participants that were chosen to complete the questionnaire were selected based on their exposure to projects and therefore work experience, as well as the environment in which they are employed at the industry.

The questionnaire was then distributed to the selected participants, to acquire the information to address the research objectives.

4.2.6 Data Analysis

The data received from the questionnaire was evaluated and summarised.

This information was then compared to the information from the literature review to determine if there was a correlation between the literature study and the research findings.

4.2.7 Research Reporting

The original research findings, as well as the comparison between the research findings and the information from the literature review, was evaluated during the data analysis stage and then documented.

4.3 Summary

The choice of the research approach is dependent on the research being worked on. This is important to increase the efficiency of the research study.

The approach to research may be quantitative or qualitative, where the former uses mathematical or statistical techniques and the latter investigates themes or observations, from which patterns are derived for that specific set of participants only. While qualitative research uses the research methods of interviews and observations, quantitative research focuses more on questionnaires, surveys and trend analysis.

Research may be further categorised as a deductive or inductive approach. A deductive approach works from the general to the specific, where data is collected to confirm or reject the hypothesis of interest. An inductive research works from specific observations to a broader generalisation to formulate a pattern to reach a hypothesis. Deductive analysis is therefore associated with quantitative research and inductive would be classified as more qualitative research.

The method of approach used to compile this dissertation was based on employing a deductive technique since there existed a theory that risk management contributed to the success of the project. A hypothesis was then drawn up to test this theory. Also, since it was decided by the researcher that an investigation be conducted which focussed on mathematical and statistical techniques, it is a further indication of quantitative research which is associated with the deductive technique.

Research may also be defined as primary or secondary, where data collected by the researcher will be primary research and research based on another researcher's work is referred to as secondary data. In this dissertation, there is a combination of primary research, with a combination of open and closed ended questions for the actual findings *(based on the questionnaire feedback)* as well as secondary research used for the literature review and the investigation into the case study at NASA.

Due to the many benefits of a questionnaire namely, it is able to be distributed to a larger and more diverse group of people, simplicity, reduced associated costs, not requiring much effort and easy data compilation, it was chosen as the preferred option for data collection.

The findings from the questionnaire study were then compared to the information from the literature review to determine if there was a correlation between the literature study and the research findings. The original research findings, as well as the comparison between the research findings and the information from the literature review were then documented.

Chapter 5

5. Research Findings from the Questionnaire Investigation

Initially, it was decided to investigate whether risk management is an important factor to consider when working on a project and if risk management contributes to the success of the project.

It was decided to investigate what were the factors believed to define project success at the organisation. This could then be compared to the theoretical study.

In the following figures 11 to 26, the results as obtained from the actual questionnaire study and feedback are shown.

5.1 Is risk an important factor to consider

Based on the feedback received from the questionnaire, risk management is believed to have an impact on a successful project. It can therefore be concluded, that there exists a direct relationship between a successful project and risk management.

Risk is also believed to be an important factor to consider when working on a project. It is believed that risk identifies what can go wrong at an early phase in the project enabling more control over the project. This is clearly evident from the questionnaire feedback received, where all responses are in agreement with the researchers belief.

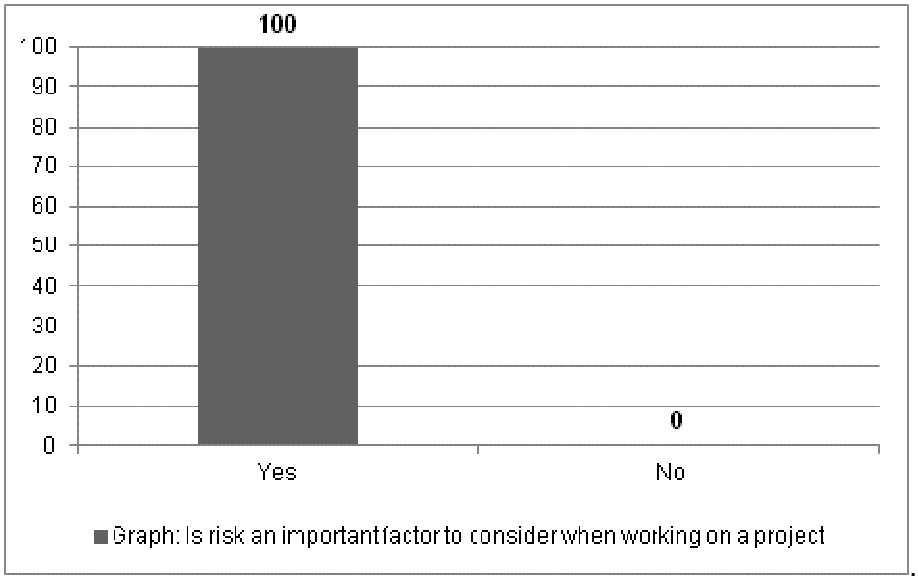

Figure 11:
Is risk an important factor to consider when working on a project
Source: Questionnaire for this research study and feedback from the organisation

5.2 A successful project

From the literature research study, a successful project is one where all risks are identified at an early stage of the project, and where all action steps to mitigate or reduce the impact of such risks are in place. When questioned further on which project management functions define project success, the following response was received.

5.3 Factors defining project success

Approximately 31 % of the responses received, believe that a successful project is defined by cost, time and quality. Therefore, the response of most of the questionnaire participants are in agreement to the traditional model that defines project success (de Bakker *et al*, 2010).

Approximately 15% of the responses received, believe that a successful project is defined by a project meeting all deliverables within the project mandate, where a project mandate is the official document that governs the scope of work for the project at the organisation.

Because safety is the number one priority at the organisation, major focus was also attributed to safety and incident prevention in conjunction with cost and time. This was equivalent to approximately 12%.

Responses were also received which considered adherence to the rules, regulations and procedures.

The responses are shown in Figure 12.

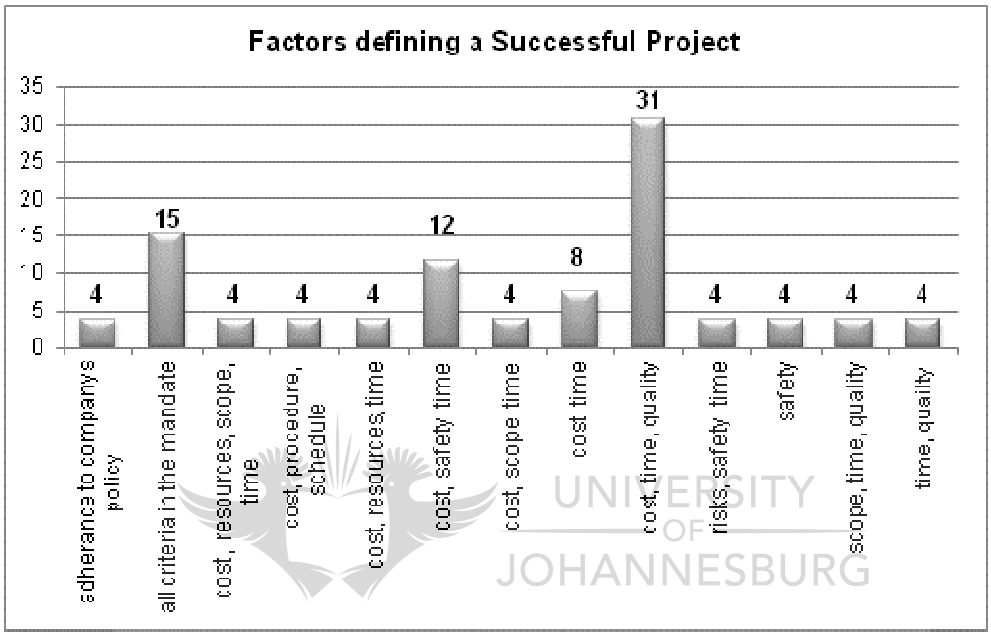

Figure 12:

Factors defining a successful project

Source: Questionnaire for this research study and feedback from the organisation

Every project will have risks attached to it, but properly managing risks will result in a successful project. It must be noted that serious risks may even result in the closure of a project.

Risks must be continuously monitored throughout the life cycle of a project, to ensure that the project adheres to the time and cost constraint by preventing any delays or cost escalation, or dependant on the risk impact, risk management may even enable for the appropriate contingency to be allowed for. This will be true for all project management functions that must be catered for.

The sooner risks are identified, the sooner they can be addressed.

Accurate risk management helps the project cope with unexpected hiccups. Its best to have risk management to determine what could go wrong and plan ahead rather than trying to deal with problems when it occurs without plans being in place to deal with it. Hence, being pro-active is better than trying to be reactive.

Risk management is also an important factor to ensure that no harm will come to the personnel of the organisation.

5.4 Prioritisation of the project management functions based on risk contribution

Risks are known to occur within every function of project management. *Refer to Sections 1.3 and 2.3*. Based on feedback received from the questionnaire, it is believed that the greatest risk occurs within the risk domain. This is elaborated as risk itself being the biggest risk, and therefore a threat to the project. This can be further explained as the risks associated with not knowing or identifying the risks and accounting for it.

At the organisation, it is believed that environmental and safety risks are the major threat to the projects, since the environment and safety are the major priorities for the organisation. Immense attention was focussed on these factors.

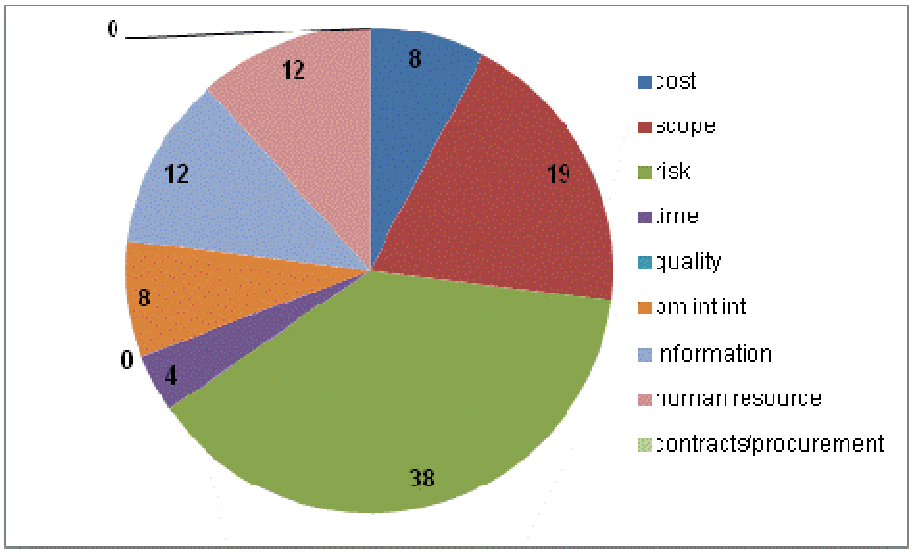

Figure 13:
Risk contribution to the Project Management Function
Source: Questionnaire for this research study and feedback from the organisation

The scope of a project was identified as the second highest to risk contribution. Scope changes, or scope creep, can drastically change the cost of a project and thus its feasibility as well as schedule.

Within the organisation, it was found that the third highest risk contribution to a project was as a result of lack of information as well as human resources. To begin a project all necessary information must be available as well as the resources to get the work done.

Approximately 12% of the participants believe that there is insufficient focus on information. This can be due to insufficient importance placed on information management, information not being updated or properly documented, negligence within the project group following the project implementation where information in the form of drawings or data sheets that are not updated, or carelessness resulting in loss of information.

Approximately 12% of the participants also believe that manpower for the design and execution of the project contributes to risk, especially where the project requires for a specialist field. It can affect project completion if this resource is not available. While an external consultant may be resourced for this function, the increase in cost will impact on the overall project.

From Figure 13, it can be seen that time or cost does not contribute as much risk to projects as much as the above mentioned factors. Perhaps this belief by participants can be attributed to:

- sufficient contingencies being included in the cost estimates, which are already based on accurate estimates from the companies data base
- sufficient planning allowed for in schedules, and
- due to the strict measures to ensure adherence of the product to Legislation requirements

Hence the factors of cost, time and quality are not believed by the participants to be major risks, since there factors are properly planned for.

As mentioned in the paragraph above, since the quality of the product must meet Legislation requirements, is not expected that there will be risks associated with quality. Therefore, quality, procurement and contracts is not believed to contribute much towards risk in a project. These factors are denoted as “0” in Figure 13.

5.5 Is risk management an important procedure for project execution

Based on feedback received, it was found that while the general belief within the organisation is that risk management is an important process of project management, this process is only done for big projects for some departments.

Risks can occur in small or big projects, and the outcomes can sometimes be worse in a smaller project than in a big project. Further attention must be focussed in this area of the organisation to change the perception that risk management must only be done for big projects.

This is indicated as other in Figure 14.

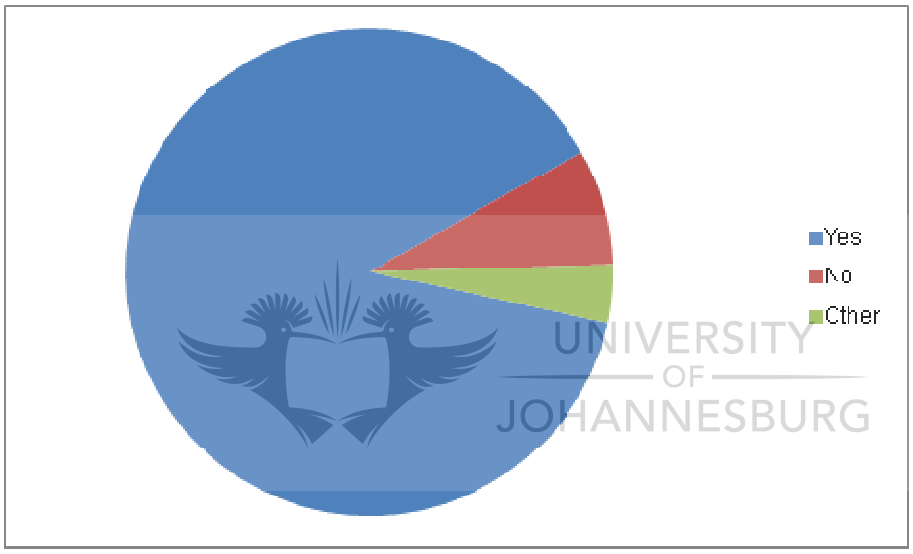

Figure 14:
Is risk management a part of Project Execution at the Organisation
Source: Questionnaire for this research study and feedback from the organisation

5.6 Risks identified during project execution

Based on feedback received on risks experienced during the process of project execution, the highest risk to the project was identified as time.

Following time as the major risk, other risks were also identified as a result of cost, quality and human resources.

The risks experienced during project execution are shown in Figure 15.

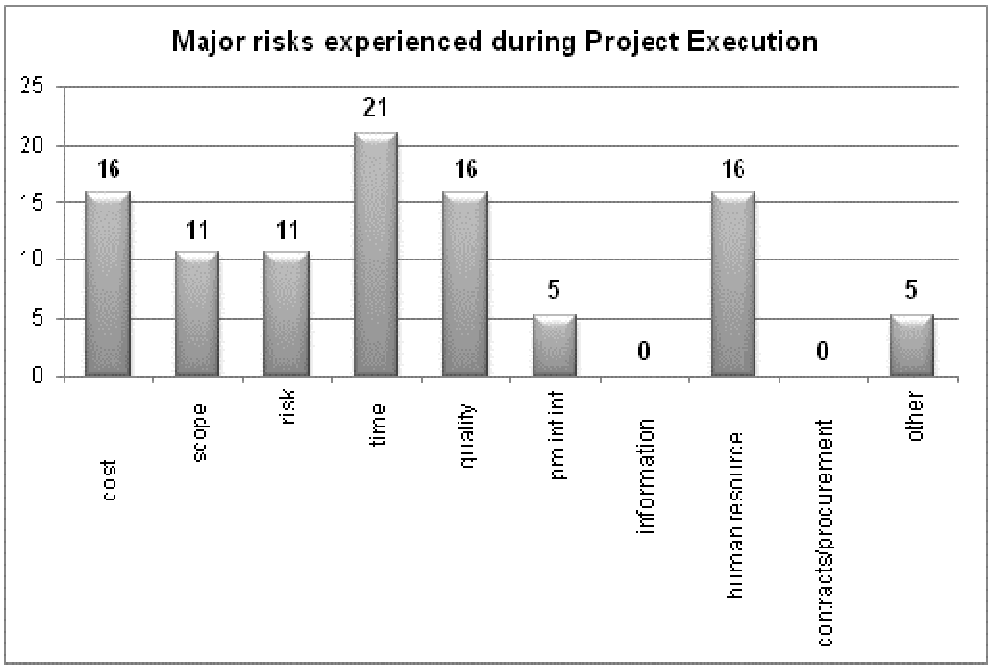

Figure 15:

Risks experienced during Project Execution

Source: Questionnaire for this research study and feedback from the organisation

Comparing the risks associated with the project management functions **actually experienced** during project execution, as shown in Figure 15 above, to the risks associated with the project management functions **perceived** to contribute the most risk to a project, as shown in Figure 13, there doesn't appear to be consistency.

Perhaps it is the scope, (second highest project management function with associated risk, Figure 13), which is believed to be a contributing risk factor that actually contributes to additional quality, cost and time during the actual project executions. More focus should be focused on time, cost, quality and human resources, since cost, time and quality define a successful project.

At the organisation, more effort must be focussed on the alignment between the project management functions perceived to have the most risk associated to it, as compared to the project management functions that actually contribute most risks during project execution.

5.7 Optimisation of the generic model of risk management, *the Risk Matrix Model*, at the Organisation

Since the generic model of risk management at the organisation was also investigated with the attempt of optimisation, the process as used by the different business units was further investigated.

The relevance of the following steps as a part of the risk management process and its influence on the results of a project was investigated further.

From the literature review, the following steps form the risk management process:

1. risk management planning
2. risk registration
3. risk identification
4. risk control
5. risk reporting
6. risk allocation
7. risk analysis - *impact and probability*

The feedback received, as shown in the following Figures 16 to 22, indicate the belief at the organisation as to whether these above mentioned steps are important to the risk management process.

Figure 16:

Risk management planning

Source: Questionnaire for this research study and feedback from the organisation

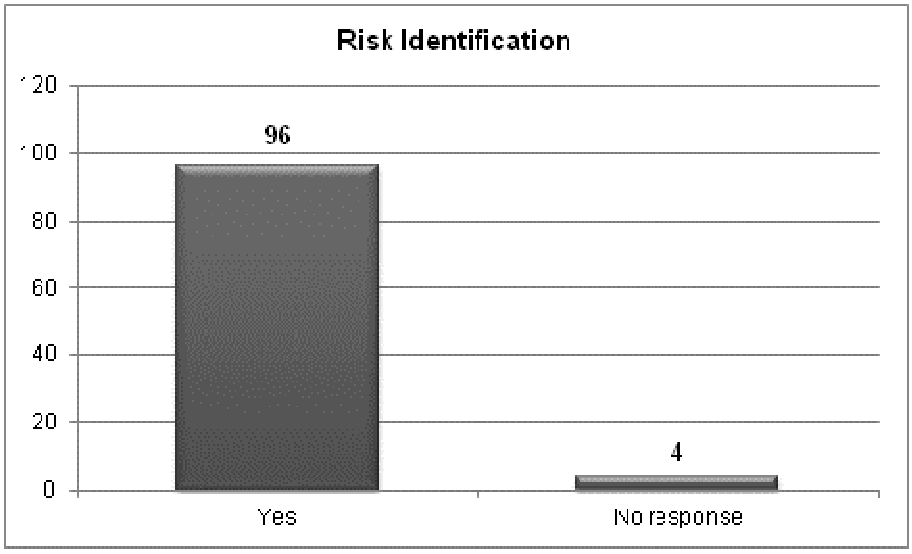

Figure 17:

Risk identification

Source: Questionnaire for this research study and feedback from the organisation

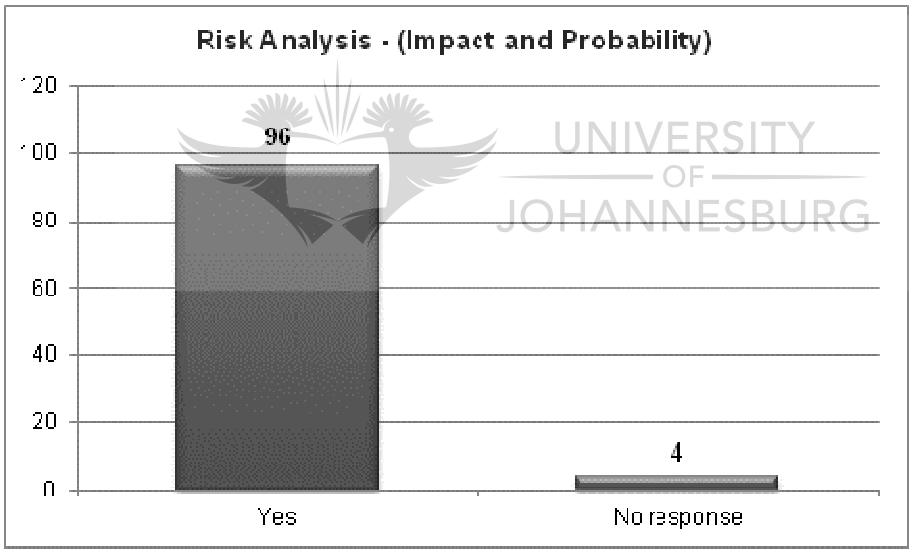

Figure 18:

Risk analysis

Source: Questionnaire for this research study and feedback from the organisation

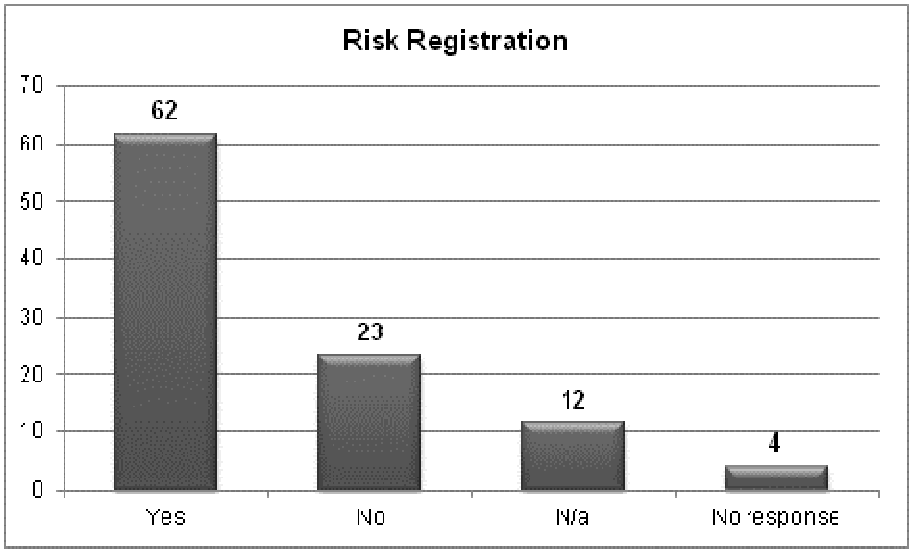

Figure 19:

Risk registration

Source: Questionnaire for this research study and feedback from the organisation

Risk management planning, risk identification and risk analysis are believed to be important steps in the risk management process.

There are some scattered opinions for the registration of risks.

From the perspective of the researcher, once the risks are identified, it would imply that the risks are then documented. This step of documentation is considered as the official step of risk recording. Having another step for risk registration will render this step as redundant. This is debatable and is recommended to be investigated further.

An interesting recommendation was made by one of the participants, which will be strongly recommended to the organisation. Following the identification of risks, risk analysis, risk allocating, risk mitigation and risk documentation, it was recommended that risk mitigation steps be further elaborated into activities which must be tracked in follow up risk review sessions.

Usually, risks are identified and mitigation plans are put in place, but the flaw to the process is, that activities to addess the mitigation step are not documented and tracked.

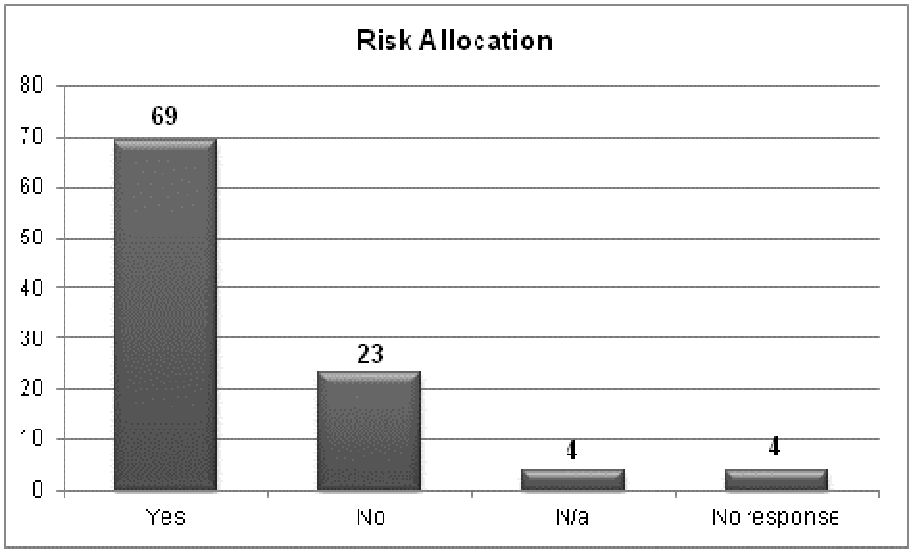

Figure 20:

Risk allocation

Source: Questionnaire for this research study and feedback from the organisation

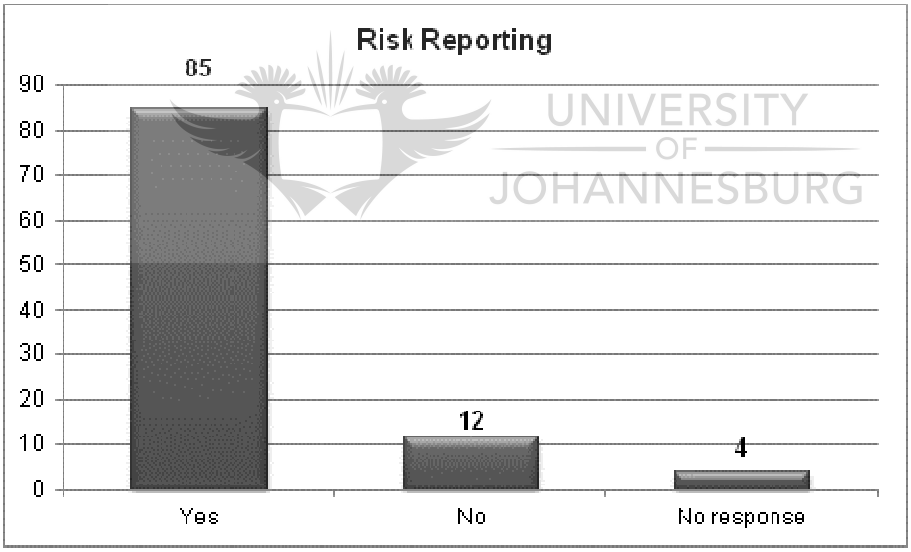

Figure 21:

Risk reporting

Source: Questionnaire for this research study and feedback from the organisation

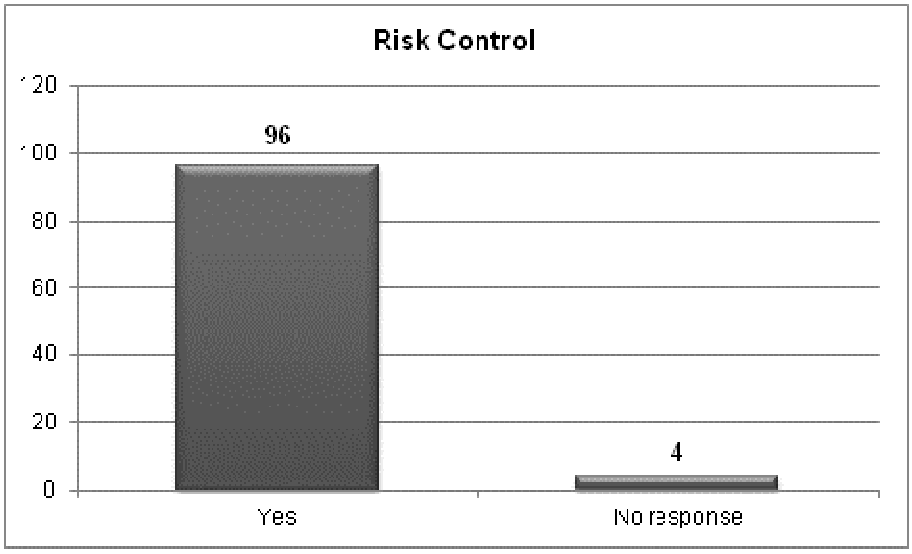

Figure 22:

Risk control

Source: Questionnaire for this research study and feedback from the organisation

It is believed that risk allocation, risk reporting and risk control are important steps for the risk management process.

It was further investigated if the above steps were sufficient for the risk management process.

Figure 23:

Process Steps

Source: Questionnaire for this research study and feedback from the organisation

From Figure 23, it can be seen that the process steps are sufficient. It was further commented that these process steps are sufficient provided that the correct resources with the appropriate experience and knowledge are involved in doing the risk assessment.

The risk management process must be performed pro-actively.

Where responses were indicated as no, it implied that the process was not sufficient.

From the feedback obtained, it was found that other process steps used to identify risks, include but is not limited to the following:

1. Hazard and Operational Analysis (Hazops)
2. Mechanical Flow Diagram (MFD) reviews
3. Environmental Impact Assessments (EIA)
4. Project kick off meetings
5. Potential Deviation Analysis (PDA)
6. Adherence to Occupational Health and Safety Acts, for safety related issues
7. Safety Integration Level Reviews (SIL)
8. Root Cause Analysis (RCA)

It was proposed that the above mentioned risk processes be a part of the risk management process to ensure integration and to prevent risks from being overlooked.

5.8 The influence of risk on the different environments in which the project is concerned

It is believed by the researcher that there is more risk associated with the utilities environment as compared to a production environment.

In a production environment, should there be a deviation, the losses can be easily predicted for that environment. In the utilities environment, since utilities are supplied to all business units in the factory, the impact may not be easy to quantify.

Based on the feedback, however, it is believed that the impact of risk is highest for the combination of both environments, with production ranked as the second highest impact, followed by the utilities environment, as shown in Figure 24 below.

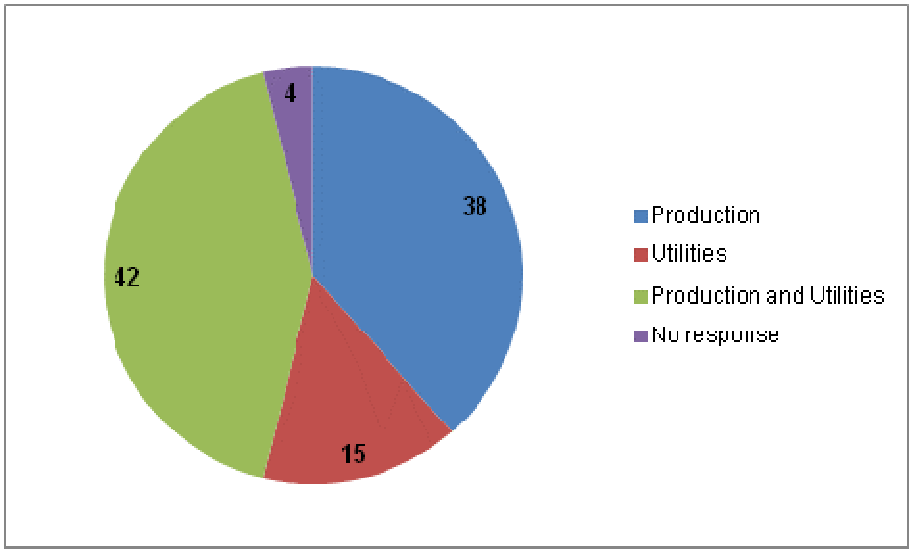

Figure 24:

Risk impacts on the production and utilities environments

Source: Questionnaire for this research study and feedback from the organisation

It was further investigated where in the engineering fraternity the most risks can be expected.

The results are shown in Figure 25 below.

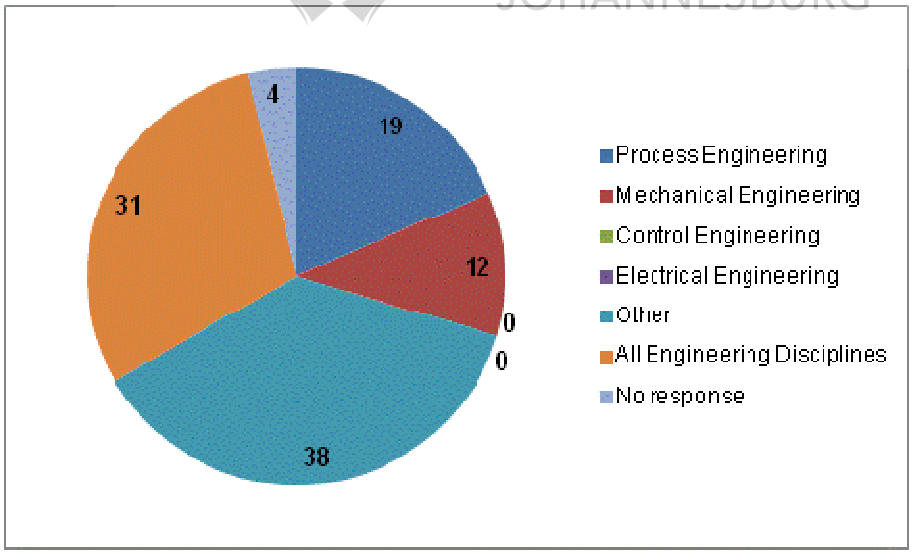

Figure 25:

Risk impacts on the engineering fraternity

Source: Questionnaire for this research study and feedback from the organisation

The selection list included:

1. process engineering
2. mechanical engineering
3. control engineering
4. electrical engineering
5. with all engineering disciplines, and
6. other

Based on the response, approximately thirty eight percent of participants believe that risks are present in the category titled other, where other includes

1. project management
2. procurement and commercial
3. environmental engineering

It is believed that improper project management practises increases the exposure of the project to risk. Good project management must be in place to bring together all disciplines for effective management.

Procurement and commercial can also be a major risk to the project, based on personal experiences during project execution for certain participants.

Weather factors, such as rain for example, can pose as a risk to the project. During project execution, rain can delay activities which are scheduled during a window of opportunity. If weather prevents these activities, it will impact on schedule and costs of the project. For more extreme weather conditions such as natural disaster situations (example earthquakes and floods etc) risks required for planned responses to be in place to reduce the vulnerability of the people as well as the measure to decrease the disaster impact.

Others believe that most risks are due to human resources.

Thirty one percent of the participants believe that risks are equally present in all engineering fraternities, with each project differing in the amount of risks identified per discipline. It was further elaborated that risks can occur from the actual design of the project (process engineering), mechanical equipment and material selection (mechanical engineering), placement of orders (procurement and contracts) as well as all other resources involved in the process such as consultants and project management (human resources) etc. This is further justified, since at the

organisation, most projects are multi-discipline. Hence, there is a potential that risks are present in all disciplines for the project.

Approximately nineteen percent of the participants believe that most risks are present in process engineering. This belief can be attributed:

1. Most risks are experienced during the process design.
2. The lead process engineer working on the project decides on the work that will be required. It is the process engineer who decides on the scope of the project and therefore the scope of work required of the discipline. The process engineer is also the link between and therefore should be effective in bringing together the right disciplines to get the work done effectively. If the process engineer fails to include the other disciplines early enough in time, it can affect the progression of the project which may impact o the quality, cost and schedule of the project.

Twelve percent of the participants believe that most risks are present in mechanical engineering. For those participants who believe that most risks are present in mechanical engineering argue this point, since mechanical systems are most pervasive, and therefore have the greatest impact if there is a failure. Since mechanical engineering is also associated with mechanical equipment and materials of construction it will impact greatly on schedule and cost impacts.

5.9 Other factors influencing the success of a project

An important factor influencing project success is communication.

The success of risk management is dependent on having the appropriate knowledge, guidance, expert experience and opinions available, to assist in the mitigation of risks. This is only possible if risks are communicated to the relevant role players. Apart from getting the assistance required to identify and mitigate risks, communication also creates awareness to relevant parties who will be impacted by the risk. Informed people will be more vigilant on how to react towards a known risk.

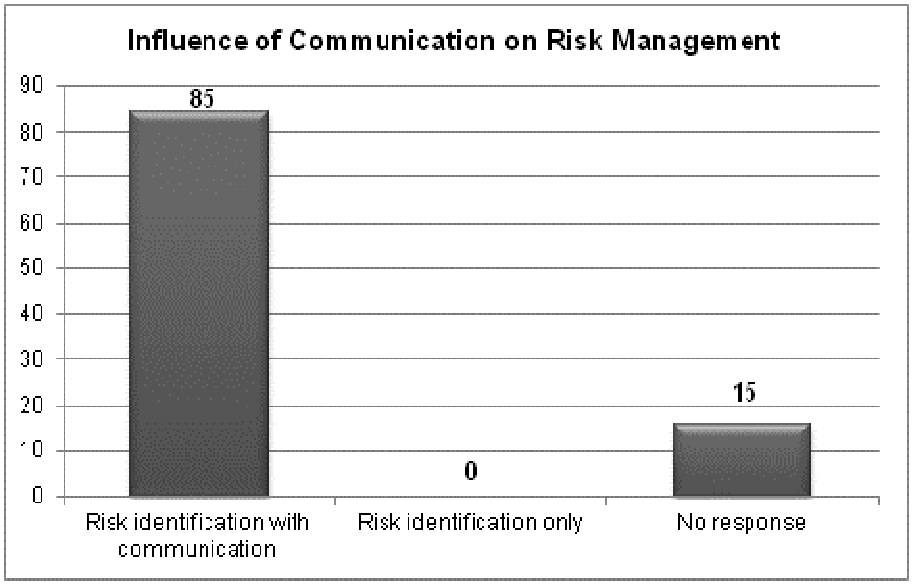

Figure 26:

Influence of Communication on Risk Management

Source: Questionnaire for this research study and feedback from the organisation

Therefore, communication enables control over next steps and mitigation actions for risks identified, by ensuring that each person understands their role. Sufficient communication is required to draw the focus on what is to be avoided and what is to be managed to ensure the execution of a successful project.

Chapter 6

6.1 Recommendations

Risk identification and risk mitigation have helped to prioritise and understand risks, but it is the execution or the risk response activities that add value to the project. At the organisation, risks are identified and mitigation plans are put in place, but a flaw identified, is that activities to addess the mitigation step are not documented and followed up on. An interesting recommendation, made by one of the participants which will be strongly recommended is that risk mitigation steps be further elaborated into activities, which must then be tracked in follow up risk review sessions. This will prove beneficial to the organisation.

A finding from failed projects, is that risks were identified but not communicated, and/or overlooked as a result of belief that the risk impact was negligible. In a situation as this, risks are either not communicated or risk owners are not made aware of their responsibilities. Risks must be assigned to a risk owner, who then becomes the responsible person to ensure that all activities associated with that risk are completed. Personnel who will be affected by these risks must also be made aware of the risks and its impacts, so they are in a position to know how to react to the risk. Learnings from failed projects as a result of poor communication must be communicated to the organisation to gain knowledge from it.

Also, a common error made is that all risks should be treated equally. This is not valid. Some risks have a higher impact than others, resulting in bigger losses. This must be communicated at the organisation to ensure that risks are prioritised and given the attention it requires.

At the organisation, it is believed that the most important project management function to focus on based on risk contribution are risk, scope, information and human resources, *as shown in Figure 13.* Based on the risks experienced during the actual project execution, most risk experienced are associated with time, followed by cost, quality and human resources, *as shown in Figure 15*. This indicates a misalignment between what is believed to the biggest risks as compared to the biggest risks actually encountered. More focus is recommended in this area of concern.

Another important area that requires much attention is for the high impact low probability risks. These risks are sometimes very easily overlooked due to the probability of occurrence being low. One fails to realise the effects if such a risk happens. Much care must be focussed on these types of risks.

It is believed by the researcher that there is more risk associated with a utility environment than a production environment. In a production environment, the losses are only associated with that specific business unit. In the utilities environment, a failure affects all business units that the utility is supplied to within the organisation. The magnitude of the losses are therefore difficult to estimate. The opinions of the questionnaire participants differ from that of the researcher. The participants believe that the risk is equal between a production and a utility environment. It is therefore recommended that this scope be further researched.

From the research study, while the Risk Matrix Model at the organisation appears to be the most optimised model, having all the relevant process steps, the process step of risk registration is still debatable. While risk registration is a formal step according to literature, it is not a formal step at the organisation. The relevance of the risk registration step must be investigated further.

Senior management support is also a highly influential factor contributing to successful risk management. This must be continuously communicated to ensure that the focus on this important aspect is not overlooked.

6.2 Conclusion

Risks are present in all projects.

While a risk has a negative connotation attached to it, that can potentially harm a project, mitigation actions can be put into place to reduce the impacts of the risk to support the project benefits for the organisation.

Risk management is a crucial function within all projects. The benefits of risk management in projects are huge, if risk events are treated with a proactive approach. (Chapman *et al.,* 1997)

Professional companies do not limit risk management to projects only, but further extends it to the daily operations to identify and assess risks to ensure that the operational objectives are met within the planned schedules and budgets, to ensure the efficient operation of the organisation.

While risk identification and risk mitigation have helped to prioritise and understand the risk, it is the execution or the risk response activities that add value to the project.

Risks can be avoided, minimised or accepted. Avoiding risks implies organising the project such that it doesn't encounter certain risks anymore. Acceptance of a risk should only be done, if the effects on the project are minimal. Minimising risks by influencing the negative effects is the approach usually followed to mitigate the risk event.

Another finding from failed projects, is that risks were identified but not communicated, and therefore overlooked as a result of belief that the risk impact was negligible.

Some project managers also believe that once risks are identified, the task is completed. They fail to realise that this is the starting point only. Each risk identified must be assigned to a risk owner, who then becomes the responsible person to ensure that all activities associated with that risk are completed.

Also, a common error made is that all risks should be treated equally. This is not valid. Some risks have a higher impact than others, resulting in bigger losses. Risks should be prioritised and be given the attention it requires Bart Jutte (2010). The nature of the risk is therefore a precondition for the response it requires. This finding is in agreement to Bart Jutte (2010), where he mentions that while treating all risks equally it may make the project really simple, but since some risks have higher impacts that other risks, it can the biggest losses.

Risk mitigation may also include a contingency. It should be enforced that mitigation strategies be the first step in being proactive to reduce risk. Contingencies should be in place as an alternative, if the mitigation action is unsuccessful. Contingency should not be the only choice.

Following the completion of this risk study and its effects on the success of a project, it was found that the perceived relationship between effective risk management and

its contribution to a successful project is clearly evident and in accordance to the literature review.

Risk management at the organisation is clearly concluded to be an important factor to consider when working on a project.

The definition of project success at the organisation is believed to be a project where all risks are identified at an early stage of the project where all steps to mitigate the risks are in place. This follows on to the most important project management functions that define project success. It was found that 31% of the responses received believe that cost, time and quality define a successful project (Figure 12), which agrees with the traditional project success model according to theory.

While these are the main factors that determine the success of a project, they are not the only factors that determine the success of a project. This statement is also in agreement to de Bakker Karel (2011).

At the organisation, it is believed that the most important project management function to focus on based on risk contribution are risk, scope, information and human resources as shown in Figure 13.

Based on the risks experienced during the actual project execution, most risk experienced are associated with time. The second highest risks experienced are associated with cost, quality and human resources, as shown in Figure 15.

This indicates a misalignment between what is believed to the biggest risks as compared to the biggest risks actually encountered.

Perhaps it is the scope which is believed to be a contributing risk factor, that actually contributes to additional cost, time and quality and human resources since resources are being used up during the actual project execution.

More focus should be based on time, cost, quality and human resources. Since time, cost, quality define the traditional project success model, these are critical factors to focus on.

Another important area that requires much attention must be on the high impact low probability risks. These risks are sometimes very easily overlooked due to the

probability of occurrence being low. One fails to realise the effects if such a risk happens. Much care must be focussed on these types of risks.

It is believed by the researcher that there is more risk associated with a utility environment than a production environment. While in a production environment, the losses are only associated with that specific business unit, a failure in the utilities environment affects all business units that the utility is supplied to within the organisation. The magnitude of the losses are therefore difficult to estimate.

This however, varies from the opinions of the questionnaire participants who believe that the risk is equal between a production and a utility environment. In fact, ranked second most important, is believed to be in a production environment, thereafter followed by the utilities environment. This is shown in Figure 24.

It is recommended that this scope be further researched. This investigation will be beneficial to the organisation, especially to support and justify the business cases for a project in a utilities environment. Currently at the organisation, based on experience, projects supporting production have a higher preference over projects supporting utilities, because it is perceived that profits are of more importance than reducing risks in areas where risk transgression is payable by fines and penalties.

It can be concluded that the Risk Matrix Model at the organisation is the most optimised model, having all the relevant process steps.

The process step of risk registration is still debatable. While based on the literature review, risk registration is a formal step, at the organisation, this is not a formal step. At the organisation, once risks are identified, it is documented in the risk register. The step of documentation is considered as the official step of recording the risks. Having another step for risk registration will render this step redundant. The relevance of the risk registration step must be investigated further.

At the organisation, risks are identified and mitigation plans are put in place. The flaw to the existing process however, is that activities to addess the mitigation step are not documented and followed up on. An interesting recommendation was made by one of the participants, which will be strongly recommended, as it will prove beneficial to the organisation. Following the identification of risks, risk analysis, risk allocation, risk mitigation and risk documentation, it was recommended that risk mitigation steps be

further elaborated into activities. These activites must then be tracked in follow up risk review sessions.

Another important factor influencing risk management is communication. Risks must be communicated to get the right knowledge from people with the right experience. Risk owners allocated to mitigate risks must also be made aware of their responsibilities. Personnel who will be affected by these risks must also be made aware of the risks and its impacts, to be able to know how to react to the risk. This detailed risk register can then be distributed to the risk owners as a communication tool. Based on the outcome of the study completed by de Bakker Karel (2011), it was also found that interaction between the project stakeholders during a risk management activity resulted in a positive effect on the effectiveness of the risk activity.

Senior management support is also a highly influential factor contributing to successful risk management. Their support is required for the proposed mitigation actions and/or contingencies when addressing risks (de Bakker Karel *et al.,* 2010)

This research study is fitting to the theoretical belief that effective risk management is an important influencing factor on the success of a project and that a successful project is defined as a project completed within the projected schedule, budget and meets all requirements.

It was important to the researcher to determine which of the project management functions should be focussed on to improve project success as well as having the most efficient risk management process in place.

Following the research, it can be concluded that the risk management model at the organisation is the most optimised model in accordance with that of literature.

The project management functions believed to have most risk attached to it, was compared to the actual project management functions with most risks attached to it during the actual project execution. This will be an opportunity to get an alignment on which project management functions should be the focus area.

Interesting next steps or ideas were provided by the questionnaire participants which has been included in the scope of Chapter 6.1. This will be proposed to be investigated further.

This research is concluded as being successful in meeting the research objectives that is to define the success of a project at the organisation, to determine if risk management is an important factor that contributes to project success, the prioritisation of the project management functions according to risk contribution at the organisation, and the optimisation of the risk management process.

Chapter 7

7. References

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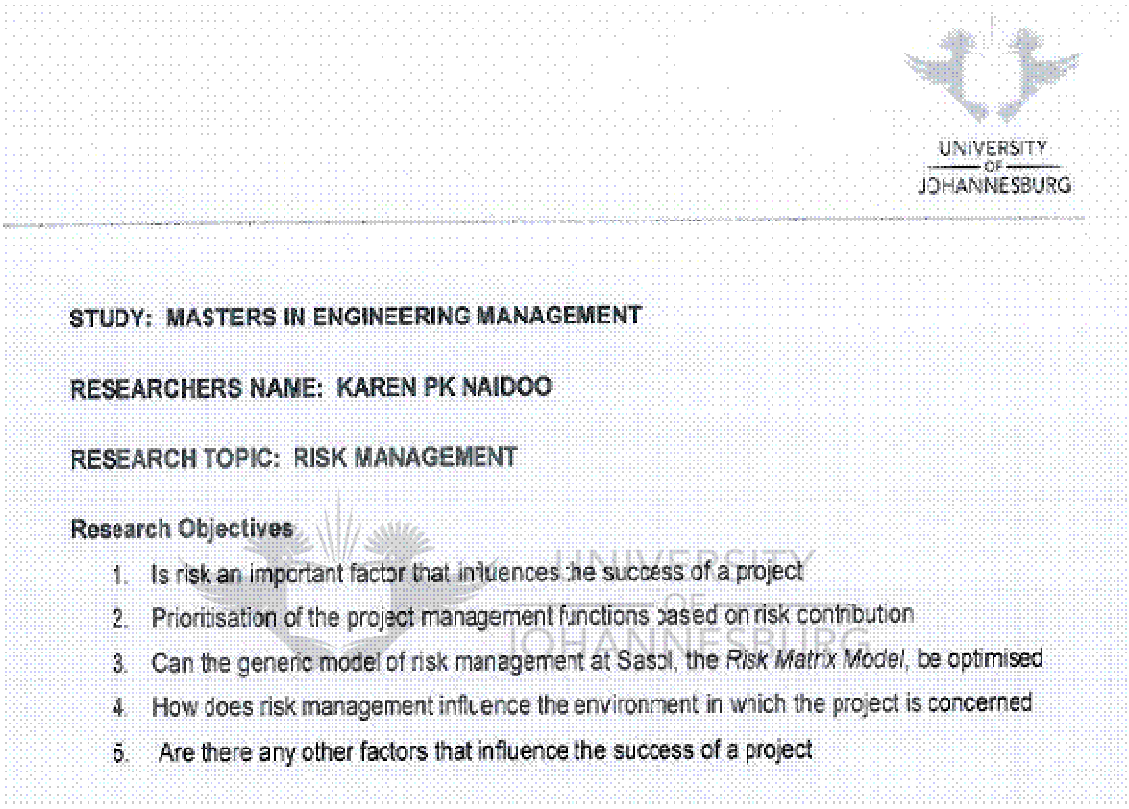
Chapter 9

9. Appendices

9.1 Research Questionnaire



UNIVERSITY OF JOHANNESBURG

STUDY: MASTERS IN ENGINEERING MANAGEMENT

RESEARCHERS NAME: KAREN PK NAIDOO

RESEARCH TOPIC: RISK MANAGEMENT

Research Objectives

1. Is risk an important factor that influences the success of a project
2. Prioritisation of the project management functions based on risk contribution
3. Can the generic model of risk management at Sasol, the *Risk Matrix Model*, be optimised
4. How does risk management influence the environment in which the project is concerned
5. Are there any other factors that influence the success of a project

Name	
Occupation	
Business Unit	
Date Completed	

GENERAL INFORMATION

No	Question and Response
1	How long have you been employed at the organisation
2	How long have you been employed at the current business unit
3	Indicate your knowledge rank on the business rules and regulations within the business unit a. Excellent b. Good c. Average d. Poor
	Elaborate on your selection
4	Indicate based on your opinion, the importance of acquiring the knowledge of the rules and regulations withir the business unit a. Very important b. Important c. Slightly important d. Not that important
	Elaborate on your selection

UNIVERSITY OF JOHANNESBURG

RESEARCH INFORMATION

No	Question and Response	
1	How would you describe a successful project	
2	In your opinion what is the relationship between a successful project and risk management	
3	Is risk an important factor to consider when working on a project - yes or no	
	Why	
4	Using the project management function table *(Table 1 below)* and based on your work experience, rank the following project management functions according to risk contribution 1.cost 2.quality 3.time 4.scope 5.project management integration 6.information 7.human resource 8.contracts/procurement 9.risk	
	1	6
	2	7
	3	8
	4	9
	5	
	Elaborate on your choice above	
5	Is risk management an important procedure in your project execution - yes or no	

			Risks Identified	Project management function mostly affected
6	List two projects that you have worked on and give examples of risks that were identified for these projects	Project 1	1	
			2	
			3	
			4	
			5	
		Project 2	1	
			2	
			3	
			4	
			5	

			Indicate in your opinion what would have happened if these risks were not identified
7		Project 1	1
			2
			3
			4
			5
		Project 2	1
			2
			3
			4
			5

No	Question and Response
8	What process steps did you follow to identify these risks

No	Question and Response				
9	In your opinion do the following activites influence the results of a project				Answer
	risk management planning	yes	no	n/a	
	risk identification	yes	no	n/a	
	risk registration	yes	no	n/a	
	risk analysis - impact and probability	yes	no	n/a	
	risk allocation	yes	no	n/a	
	risk reporting	yes	no	n/a	
	risk control	yes	no	n/a	

No	Question and Response
10	Based on the previous question, are the listed activities sufficient to identify, analyse and mitigate risk impacts
	Can you suggest additional steps that can optimise the process
11	Are most risks associated with the process engineering, mechanical engineering, control engineering, electrical engineering, other - please specify
	Elaborate on your choice
12	In your opinion where does risk impact more - in a production environment (where a saleable product is produced) or in a sustaining environment (utilities)

No	Question and Response
13	Have you worked on a project where risks were not identified
	a. How dic this impact the project success
	b. What would have been the outcome if these risks were identified
	c. What was the reason for these risks not being identified
14	How would you rank the success of a project according to the folowign scenarios
	a. Risk identification only b. Risk icentificatcn with communication
	Elaborate on your answer above

---- the end ----

Table 1: Project Management Functions Table

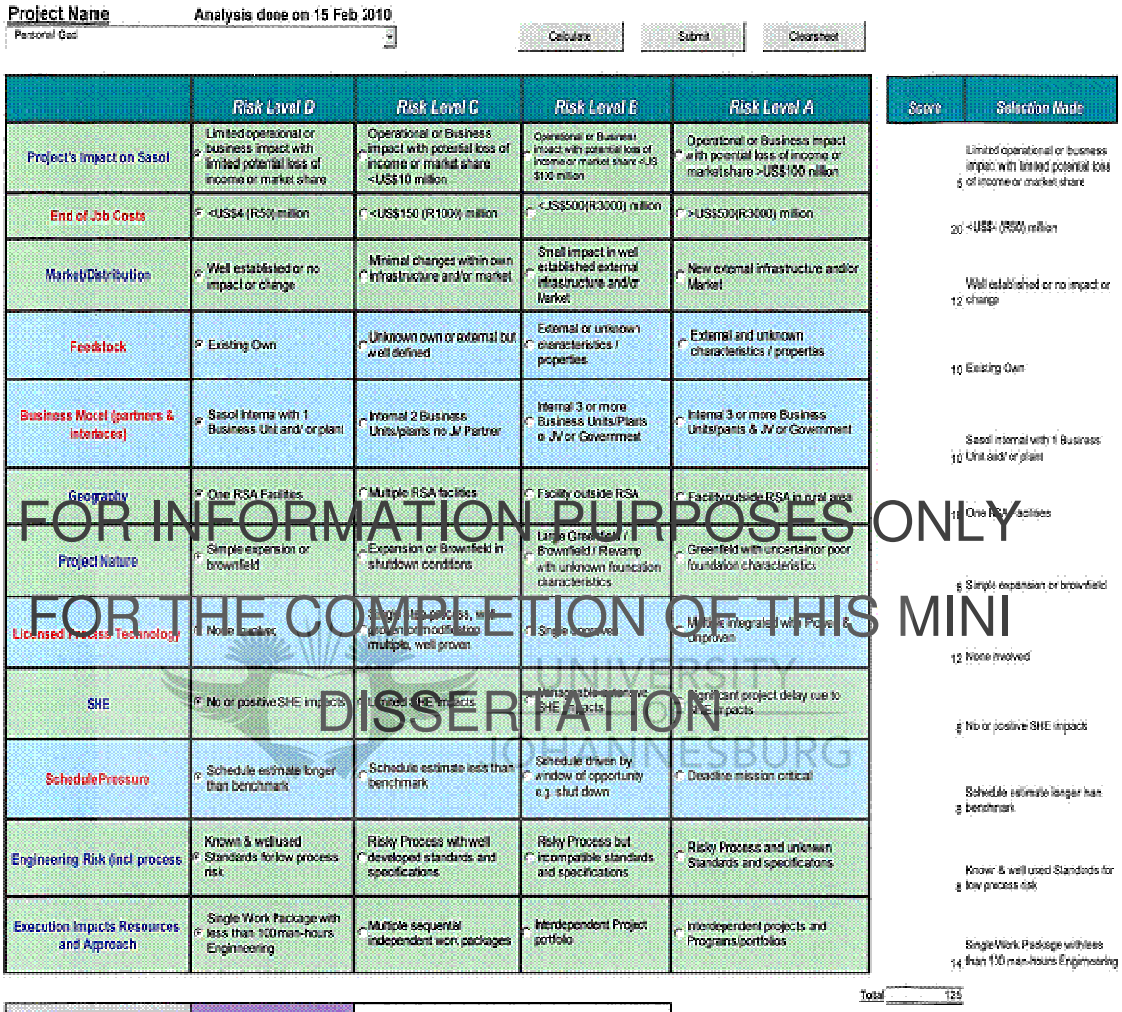
Project Management Function	Associated Risk Event
Scope	Changes in scope to meet project objectives, unclear scope definition, new technology, unfamiliar methods and tools
Quality	Value of performance, environmental impact, inaccurate metrics, extreme quality requirement
Time	Delays due to labour, material unavailability, weather Over optimism, omitted tasks, incorrect logic for dependencies, etc
Cost	Impact on cost due to an accident, fire, theft, price changes, supply shortages
Risk	Insufficient risk management or risks associated with overlooking risks
Contracts and Procurement	Contractor insolvency, claims settlement, etc
Human Resources	Strikes, termination of resources resulting in under staffing, incompetent resources resulting in resources mismatched to task, unique skill requirement, new resources
Communication	Incorrect communication resulting in incorrect actions
Project Management Integration	Incorrect start relative to the project life cycle.

9.2 Tier Classification

The following templates for the organisation can be found on the Sasol Intranet website:

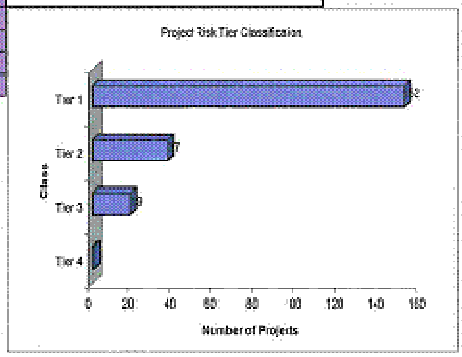
http://knowledge.sasol.com/livelink/livelink.exe?func=ll&objId=130228764&objAction=browse&viewType=1

[accessed on: 23/04/2011]



Class	Number of Projects
Tier 4	1
Tier 3	19
Tier 2	37
Tier 1	152
Total	209

Tier Classification: Tier 4



9.3 Risk Register

The following template for the organisation can be found on the Sasol Intranet website:
http://intwww.sasol.com/sastech/BDI/reference/risk%20management/RiskManGuideline.htm
[accessed on: 23/04/2011]

A	B	C	D	E	F	G	H	I	J	L	K	M	N	O
Risk No	Risk Category	Risk Description	Root cause Sourceof risk	Risk Consequence	Current Risk Assessment			Risk Owner	Response Plan (Preventive/Corrective)	Response Plan Implementation Status	Due Date	Residual Risk Assessment		
					Impact	Probability	Risk Level					Impact	Probability	Risk Level
1														
2														
3														
4														
5														

Note:

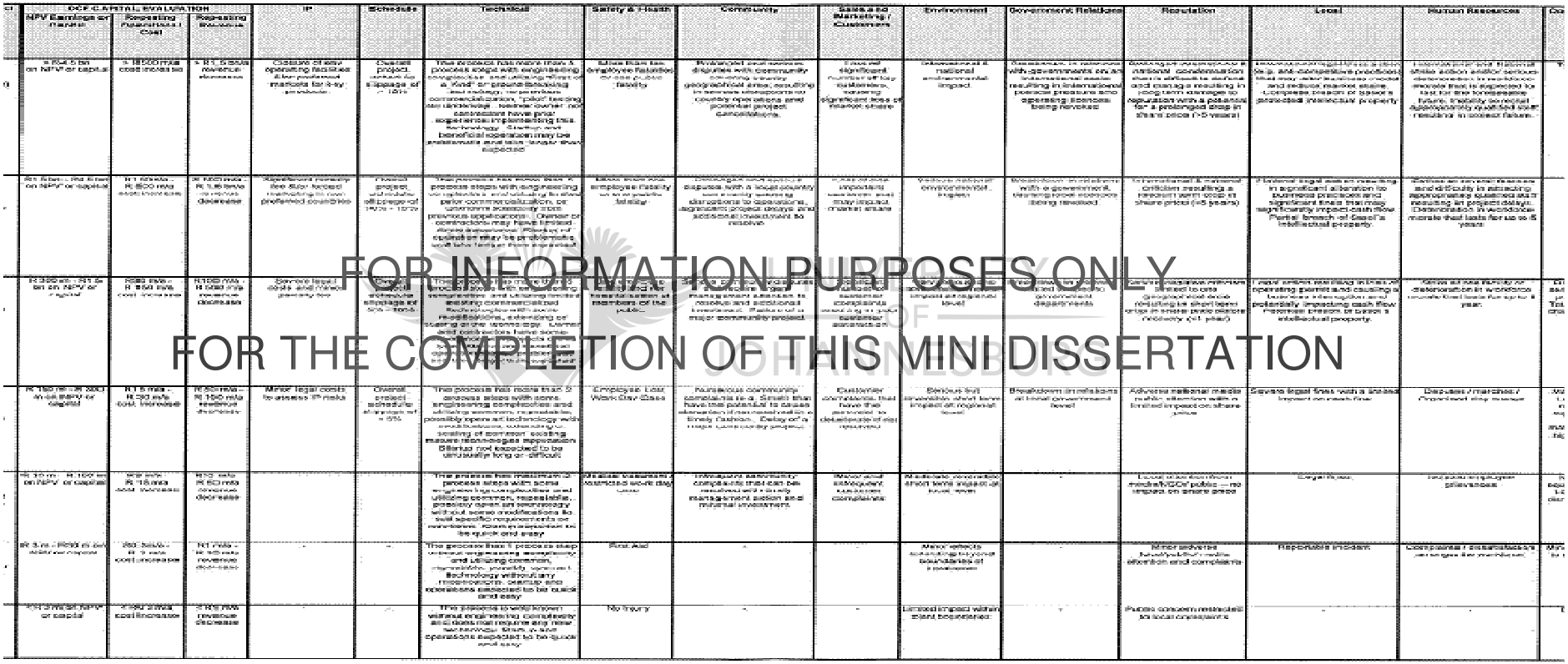
1. Columns not relevant to a particular project / BU should be marked N/A and not deleted
2. The register when printed is split over two pages to facilitate easier reading and photocopying
3. Risk items should be reported by category

9.4 Impact Classification

The following template for the organisation can be found on the Sasol Intranet website:

http://intwww.sasol.com/sastech/BDI/reference/risk%20management/RiskManGuideline.htm

[accessed on: 23/04/2011]



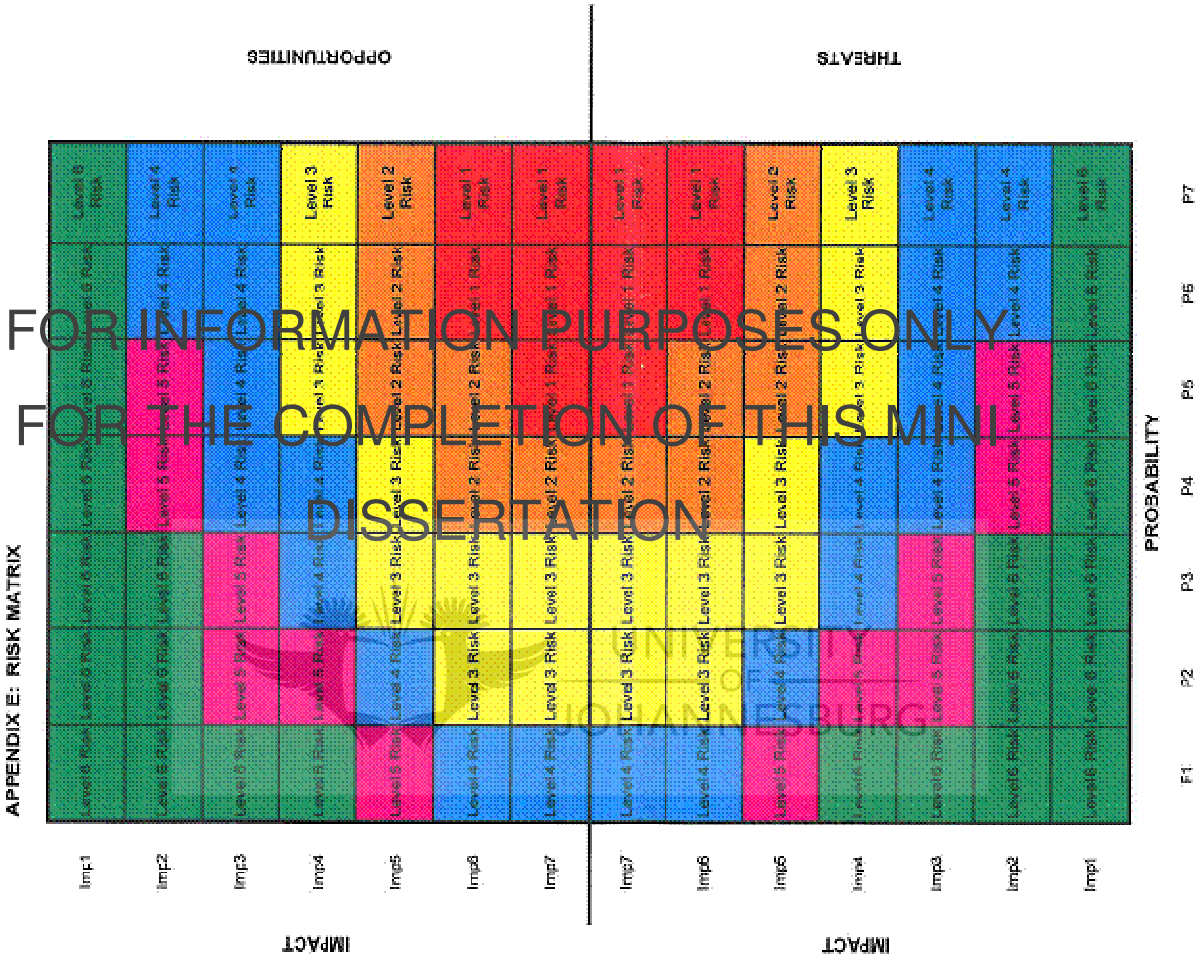
9.5 Probability Classification

The following template for the organisation can be found on the Sasol Intranet website:
http://intwww.sasol.com/sastech/BDI/reference/risk%20management/RiskManGuideline.htm
[accessed on: 23/04/2011]

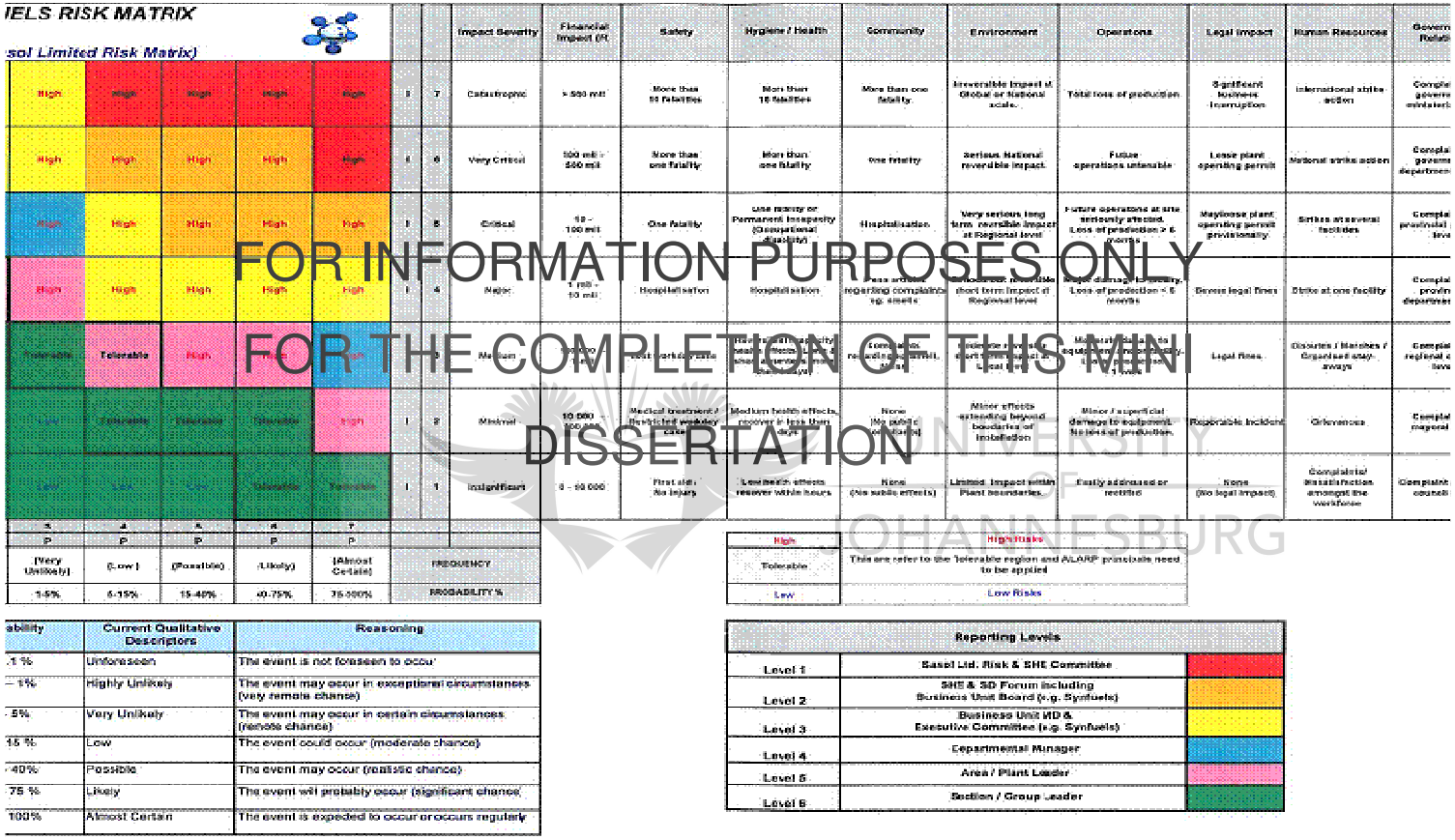
	P1	P2	P3	P4	P5	P6	P7
QUALITATIVE DESCRIPTORS	Unforseen	Highly unlikely	Very unlikely	Low	Possible	Likely	Almost Certain
PROBABILITY INTERVALS	0 - 1%	1 - 5%	5 - 10%	10 - 20%	20 - 50%	50 - 80%	> 80%
Likelihood Definitions	The event is not forseen to occur within the next 20 years	Smal chance of the event occuring once in every 20 years	The event may occur once in every 10 - 20 years	The event may occur once in every 5 - 10 years	The event may occur once in every 2 - 5 years	The event is expected to occur within the next 1 - 2 years	The event will almost definitely occur at least once or is already occuring.

9.6 Risk Matrix

The following template for the organisation can be found on the Sasol Intranet website:
http://intwww.sasol.com/sastech/BDI/reference/risk%20management/RiskManGuideline.htm
[accessed on: 23/04/2011]



The following template for the organisation was provided to the researcher by the Safety, Health and Environmental Department at the Organisation



IELS RISK MATRIX

sol Limited Risk Matrix)

							Impact Severity	Financial Impact (R	Safety	Hygiene / Health	Community	Environment	Operations	Legal Impact	Human Resources	Govern Relati
High	High	High	High	High	1	7	Catastrophic	> 500 mil	More than 10 fatalities	More than 10 fatalities	More than one fatality	Irreversible impact at Global or National scale.	Total loss of production	Significant business interruption	International strike action	Compla gover minister
High	High	High	High	High	1	6	Very Critical	100 mil - 500 mil	More than one fatality	More than one fatality	one fatality	Serious National reversible impact.	Future operations untenable	Loose plant operating permit	National strike action	Compla gover departmen
High	High	High	High	High	1	5	Critical	10 - 100 mil	One Fatality	Loss fatality or Permanent Incapacity (Occupational disability)	Hospitalisation	Very serious long term reversible impact at Regional level	Future operations at site seriously affected. Loss of production > 6 months	Mayibuye plant operating permit provisionally	Strikes at several facilities	Compla provincial leve
High	High	High	High	High	1	4	Major	1 mil - 10 mil	Hospitalisation	Hospitalisation	Press articles regarding complaints eg. smells	Considerable reversible short term impact at Regional level	Major damage to property. Loss of production > 6 months	Severe legal fines	Strike at one facility	Compla provin departmen
Tolerable	Tolerable	High	High	High	1	3	Medium	100 000 - 1 mil	Medical treatment / Restricted workday case	Medium health effects, recover in less than 1 day	Complaints received, permit	Minor effects extending beyond boundaries of Installation	Major damage to property. Loss of production < 6 months	Legal fines	Disputes / Marches / Organised stay-aways	Compla regional leve
Low	Tolerable	Tolerable	Tolerable	High	1	2	Minimal	10 000 - 100 000	Medical treatment / Restricted workday case	Medium health effects, recover in less than 1 day	None (No public effects)	Minor effects extending beyond boundaries of Installation	Minor / superficial damage to equipment. No loss of production.	Reportable incident	Grievances	Compla regional
Low	Low	Low	Tolerable	Tolerable	1	1	Insignificant	0 - 10 000	First aid / No injury	Low health effects, recover within hours	None (No public effects)	Limited impact within Plant boundaries	Easily addressed or rectified	None (No legal impact)	Complaints/ dissatisfaction amongst the workforce	Complaint counsel

5	4	3	2	1	
P	P	P	P	P	
(Very Unlikely)	(Low)	(Possible)	(Likely)	(Almost Certain)	FREQUENCY
1-5%	5-15%	15-40%	40-75%	75-100%	PROBABILITY %

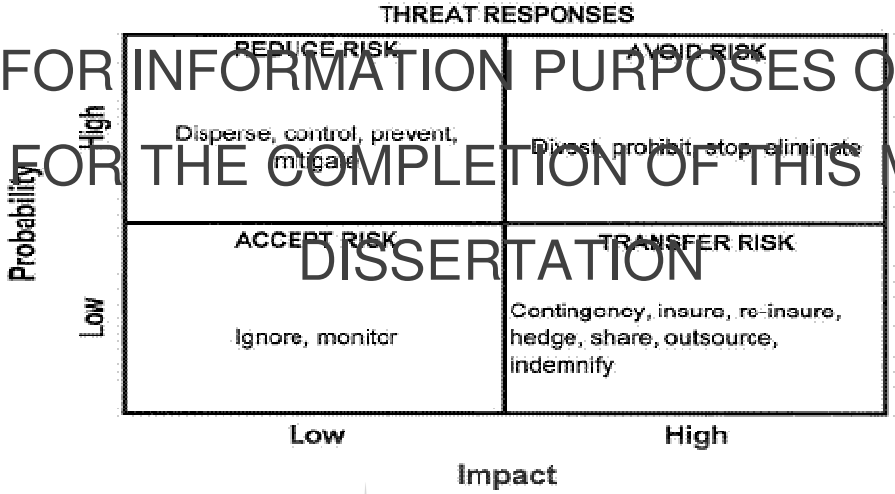
High	High Risks
Tolerable	This are refer to the Tolerable region and ALARP principle need to be applied
Low	Low Risks

ability	Current Qualitative Descriptors	Reasoning
.1 %	Unforeseen	The event is not foreseen to occu
– 1%	Highly Unlikely	The event may occur in exceptional circumstances (very remote chance)
5%	Very Unlikely	The event may occur in certain circumstances (remote chance)
15 %	Low	The event could occur (moderate chance)
40%	Possible	The event may occur (realistic chance)
75 %	Likely	The event will probably occur (significant chance)
100%	Almost Certain	The event is expected to occur orocours regularly

Reporting Levels	
Level 1	Sasol Ltd. Risk & SHE Committee
Level 2	SHE & 3D Forum including Business Unit Board (e.g. Synfuels)
Level 3	Business Unit MD & Executive Committee (e.g. Synfuels)
Level 4	Departmental Manager
Level 5	Area / Plant Leader
Level 6	Section / Group Leader

9.7 Risk Matrix response

The following template for the organisation can be found on the Sasol Intranet website:
http://intwww.sasol.com/sastech/BDI/reference/risk%20management/RiskManGuideline.htm
[accessed on: 23/04/2011]



9.8 Risk Audit Checklist Template

The following template for the organisation can be found on the Sasol Intranet website:
http://intwww.sasol.com/sastech/BDI/reference/risk%20management/RiskManGuideline.htm
[accessed on: 23/04/2011]

PROJECT: _____

PROJECT MANAGER: _____

NO	DESCRIPTION	Y	N
1	Was a risk assessment done for the project according to procedure QMS276P?		
1.1	Was a project risk management plan compiled?		
1.2	Was a qualitative risk assessment completed?		
1.3	Were the high impact risks identified and quantified?		
1.4	Was a response strategy identified and developed?		
1.6	Were the risks monitored and reviewed on an ongoing basis?		
1.7	Was the project risks communicated and reported to the		
1.7.1	Project Steering Committee?		
1.7.2	Divisional boards?		
1.7.3	GRMI?		
2	Was the risk register completed as per the agreed standard?		
2.1	Risk categories?		
2.2	Risk description?		
2.3	Root cause / source of risk?		
2.4	Risk consequence?		
2.5	Initial / previous assessment?		
2.6	Owner?		
2.7	Response plan?		
2.8	Due date?		
2.9	Response plan status?		
2.10	Current risk assessment?		
3	Was the Risk Response Plan (column K of register):		
3.1	Comprehensive, addressing both preventative and corrective solutions?		
3.2	Assigned to a responsible person?		
3.3	Reviewed and updated at least bi-monthly?		
3.4	Risks signed off when completed or removed from project by project manager or		

FORM F759/ Rev 1 QMS/273P

Page 1 of 2

NO	DESCRIPTION	Y	N
	steering committee?		
4	Quality of the Risk Process as per procedure QMS276P :		
4.1	Was the assessment credible (depth i.e. were credible independent sources/experts consulted when the risks were identified and rated)?		
4.2	Was the assessment exhaustive (breadth i.e. were all the potential risks identified and assessed on a continuous basis)?		
4.3	Was the assessment checked by an independent agent for bias / hidden agendas?		
5	Was the required control (i.e. approving or signing off risk items as they are completed or changed) exercised by the:		
5.1	Project Manager?		
5.2	Steering Committee?		

COMMENTS: _____

_____

_____

_____

_____

_____

_____

AUDITOR: _____ DATE: _____

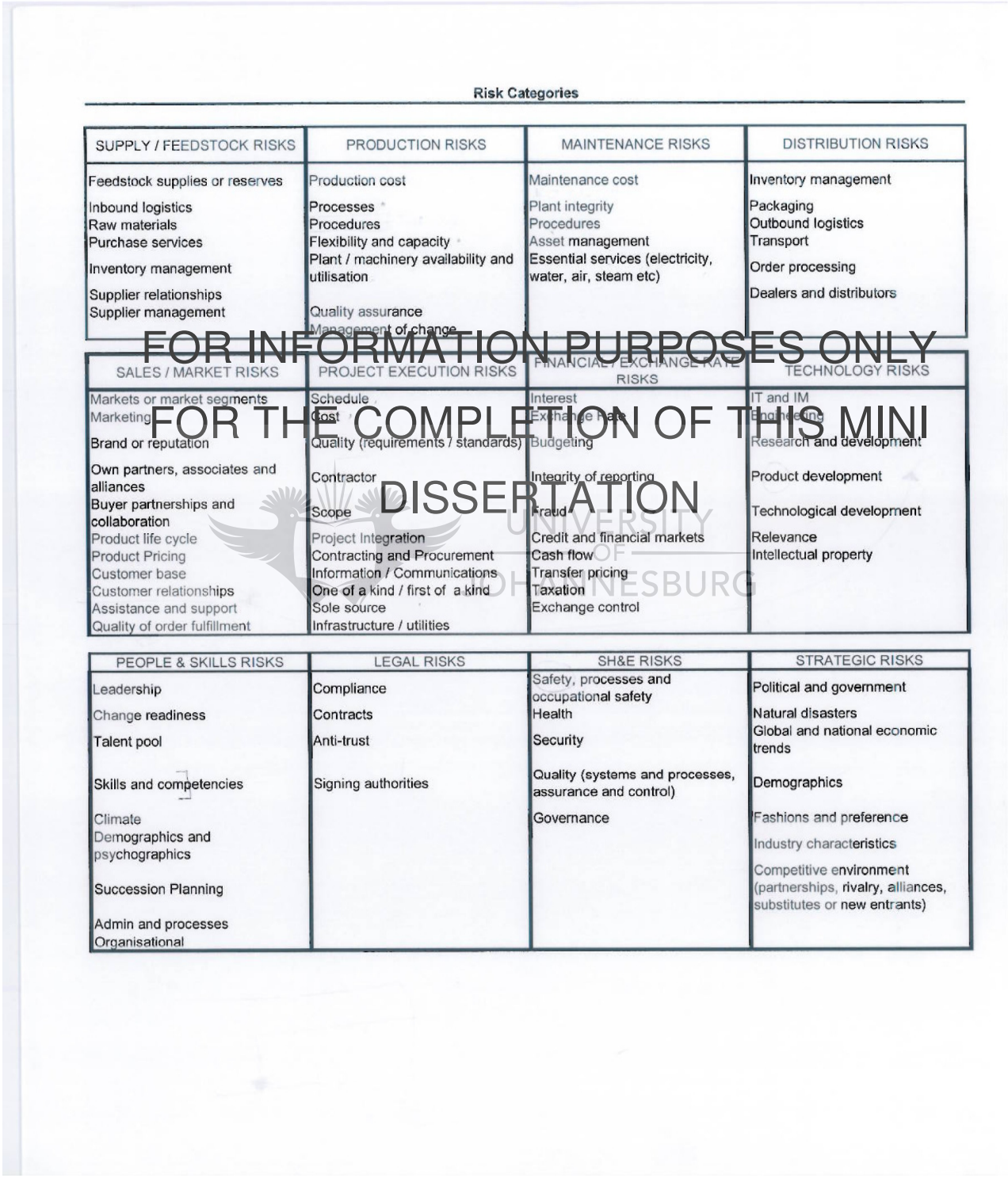
9.9 Risk Categories

The following template for the organisation can be found on the Sasol Intranet website:

http://intwww.sasol.com/sastech/BDI/2Feasibility/Project/OpsDocs/RiskManagement.htm

QMS276P Roadmap: Integrated Risk Management for capital projects

[accessed on: 23/04/2011]



Risk Categories

SUPPLY / FEEDSTOCK RISKS	PRODUCTION RISKS	MAINTENANCE RISKS	DISTRIBUTION RISKS
Feedstock supplies or reserves	Production cost	Maintenance cost	Inventory management
Inbound logistics Raw materials Purchase services	Processes Procedures Flexibility and capacity	Plant integrity Procedures Asset management	Packaging Outbound logistics Transport
Inventory management	Plant / machinery availability and utilisation	Essential services (electricity, water, air, steam etc)	Order processing
Supplier relationships Supplier management	Quality assurance Management of change		Dealers and distributors

SALES / MARKET RISKS	PROJECT EXECUTION RISKS	FINANCIAL / EXCHANGE RATE RISKS	TECHNOLOGY RISKS
Markets or market segments Marketing	Schedule Cost	Interest Exchange rate	IT and IM Engineering
Brand or reputation	Quality (requirements / standards)	Budgeting	Research and development
Own partners, associates and alliances Buyer partnerships and collaboration	Contractor	Integrity of reporting	Product development
Product life cycle Product Pricing Customer base Customer relationships Assistance and support Quality of order fulfillment	Scope Project Integration Contracting and Procurement Information / Communications One of a kind / first of a kind Sole source Infrastructure / utilities	Fraud Credit and financial markets Cash flow Transfer pricing Taxation Exchange control	Technological development Relevance Intellectual property

PEOPLE & SKILLS RISKS	LEGAL RISKS	SH&E RISKS	STRATEGIC RISKS
Leadership	Compliance	Safety, processes and occupational safety	Political and government
Change readiness	Contracts	Health	Natural disasters
Talent pool	Anti-trust	Security	Global and national economic trends
Skills and competencies	Signing authorities	Quality (systems and processes, assurance and control)	Demographics
Climate Demographics and psychographics		Governance	Fashions and preference Industry characteristics
Succession Planning			Competitive environment (partnerships, rivalry, alliances, substitutes or new entrants)
Admin and processes Organisational			

9.10 Case Study: NASA's Space Shuttle Challenger Disaster, 28 January 1986

Since a case study is an in depth evaluation of a particular situation in the real world as compared to a statistical study, (Shuttleworth, 2008), it was decided that a secondary research investigation into a case study be conducted to demonstrate the consequence of poor risk management and its impacts if not managed effectively. (Kerzner[7], 2003)

Introduction

The space shuttle Challenger, exploded resulting in the death of seven crew members and the complete destruction of equipment. The cause for this disaster was due to faulty seals on the mating segments of the solid rocket boosters, which consisted of a primary and secondary o-ring and putty.

Project Background

During the early 1960's, NASA's strategic space exploration system was based on three project legs.

Leg one was a re-usable space transport system, the Space Shuttle, leg two was a space station to serve as a launch platform for space research and exploration and leg three was planetary exploration to Mars.

Identified risks in the Case Study

1. Due to limited funding, the project scope was re-prioritised. The scope of the project was changed to leg one only and that was to build a re-usable space transport system. *This re-usable space transport system would be known as the Space Shuttle.*
2. Companies hoping to be contractors to NASA provided incorrect and unrealistically low cost estimates. *The impact of this incorrect cost estimates and miscommunication would impact, and therefore result in an increase in other costs at a later stage in the project.*
3. The main engine's thrust that was provided by contractors never achieved the 109% of thrust that was required by NASA. *This miscommunication would reduce quality of the project.*

[7] Project Management Case Studies

4. Research and Development (R&D) is a very important phase of any project where uncertainties are present. It is therefore a crucial step for new projects to ensure that the unexpected is detected at this early phase so that mitigation steps can be established prevent it from occurring during the full scale project. For this specific project, R&D was essential to produce a truly re-usable space shuttle. Due to a constrained budget the R&D phase was sacrificed with NASA accepting a design for a partially re-usable space shuttle. *The elimination of the R&D phase of the project as a result of reduced budget costs which would impact negatively on quality.*

5. Numerous other design modifications were made to the original design to reduce the R&D required for the project.

6. To increase influence and power to guarantee a customer base, NASA enlisted the support of the United States (US) Air Force. Further modifications to the original payload bay followed to meet the size and shape standards of the US Air Force. This implied a decrease in the total allowable vehicle weight. To achieve this allowable vehicle weight, the original design of the air breathing engines were eliminated. This limited safety and the landing versatility of the new vehicle. *Reduced costs for re-design would negatively impact on risk due to safety.*

7. The chain of negative impacts on the quality of the project is by this point clearly evident, as a result of the reduced budget costs. In the following statements, further negative impacts on the project will be noted due to this.

8. For an ideal system, the preferred fuel design is a liquid fuel design comprising of a three element liquid fuel engine system. The flow of liquid from storage tanks can be easily controlled and even shutdown in the case of an emergency; It is therefore a safer option. Since the three element liquid design engine was significantly more expensive to maintain as compared to the solid fuel system, NASA utilised a combination of liquid and solid propellants. NASA compromised on a one part liquid and two parts SRB. Apart from dangers associated with the solid propellant where it could not be easily throttled or shutdown, SRB would continue to burn till all the propellant was consumed. This would impact on safety at launch, since at launch the SRB are ignited and would have the maximum propellant loads.

9. The contract for the building of the shuttle was awarded to the contractor with the lowest bid. It must be noted that the contractor who was awarded the contract for the Apollo Project had also bid but was not considered although they had the appropriate experience. The award for the contract was based on the cost impact only. *The impact of cost continues to impact on risks associated contracts and procurement.*

10. The design, proposed by the contractor awarded the contract, had a major flaw as it did not accommodate for a launch escape system. NASA accepted this change of scope because a launch escape system would add additional weight and costs. *Risks associated with change of scope as well as the budget would negatively impact on quality and safety.*

11. Also, regarding contracts, the contract for the SRB was awarded to the lowest cost per flight bidder, although other bidders ranked higher in technical design and safety. It was later discovered that the design that was accepted from the lowest bidder, offered a thrust of more than 70% that was required for the launch.

12. Requirement for Sealing in the Design:

Background

Segments for the shuttle consisted of four solid rocket sections joined together using putty and o-rings at the mating segments. This putty sealant is required to prevent hot exhaust gases reaching the o-rings during launch. During ignition, joint rotation can occur due to misalignment as a result of expansion, hence stressing on the importance of proper sealing.

- During high pressure tests, holes were created in the putty before the o-rings could seal the gaps.

- It was found that for previous launches an asbestos based putty was used. Due to fear of lawsuits for using asbestos, production of this type of putty was stopped. A new type of putty was used for this project. At high temperatures, the hot exhaust gases penetrated the new type putty further due to its resiliency[8] properties, and eroded the o-rings. At low temperatures, tests showed that the new type putty lost its stickiness. *Risks associated with change of scope impacting on safety and quality.*

- An official team was requested to investigate the o-ring erosion problem. However, no records of this official team could be traced. *Risks associated with communication.*

13. The risk assessment process was based on qualitative analysis only and not quantitative analysis. Since the concern with the o-ring did not prevent launch, the risk was considered as acceptable and hence a low risk. *This act shows that the problems*

[8] Ability of the putty to go back to its original shape after heat expansion. In this case study it was found that after expansion of the putty, it did not return to its original shape. This implied that the thickness was reduced resulting in the hot exhaust gases coming into contact with the o-rings resulting in erosion. Initially engineers considered this as an acceptable risk.

associated with sealing was considered as an acceptable risk rather than a problem impacting on safety and quality.

14. The reason that quantitative data analysis was never implemented was because the process of data gathering to generate statistical models would be expensive and labour intensive.

15. Communication was done via teleconferencing due to location of NASA in respect to its contractors. All necessary documentation required was faxed. *Risk identified here are associated with communication.*

16. An increase in paperwork resulted resulting in a constraint. A request to waiver[9] the paperwork process was put into place. The waiver process became a normal operating procedure as time progressed. *Risks associated with communication.*

17. As flights continued, the o-ring problem became more pronounced. Apart from erosion only, black soot (blow-by) was seen on the o-rings depicting that the heat was more concentrated as a result of being completely penetrated through the putty. Further testing showed that with the joint rotation, the primary o-ring sealing was almost non-existent, putting strain on the secondary o-ring sealing. O-rings were continuously replaced to meet with the flight schedule demands instead of resolving the problem. *Risks associated with quality impacting on safety.*

18. As a safety measure, the contractor who constructed the space shuttle used two o-rings for additional sealing.

    - Due to the erosion problem, the purpose of the secondary o-ring changed from additional support to a necessity.

19. When the erosion and blow-by persisted on following flights, a launch constraint was imposed. This too was overseen with a waiver. *Risks associated with communication*

20. Another factor impacting on the performance of the putty was the temperature. As colder weather approached more problems were experienced as a result of the putty losing its stickiness. At temperature lower than 50ºF, it was found that the primary o-ring could also not establish contact concluding that the secondary sealing capability could not be guaranteed.

[9] An official process which allows an exception to a policy, rule or risk

Case Study Conclusion/Summary

The contributing factors to the Challenger Disaster included mechanical failure due to poor design of the joints and sealants, changes to design due to scope changes to minimise costs, and poor communication and poor decision making as a result of lack of proper information, amongst many other influencing factors.

NASA failed to realise the impacts of a failure.

The contractor did not realise and understand the implication of the tests, which showed that the design had an unacceptable flaw. The joint test and certification program was inadequate, and neither NASA nor the contractor fully understood the sealing mechanism by which the joint sealing took place. When it became evident that there were in fact problems, insufficient importance was allocated to the problems, due to lack of quantitative risk analysis, inadequate trend analysis and misinterpretation of criticality. At no time was a re-design of the joint recommended.
As the joint problem grew in number and severity, NASA did not accept that the risk was deemed unacceptable.

Neither NASA nor the contractor reacted to internal warnings about the faulty seals. No attempts were shown to rectify the seal after a defect was found with the original design. No corrective actions or solutions were explored to address the o-ring erosion and the blow-by issues although the problem became frequent and sufficient data became available.

Flights were not grounded till the problem was resolved. Risks were taken since they had “got away with it”. Based on the case study, resources were focused on meeting schedule deadlines instead of focusing on improving and optimising on the facilities to support the higher flight rates.

There was no safety staff or a safety organisation for support.

Insufficient emphasis was placed on proper communication between the contractor and NASA. Communication was done only via teleconferencing and faxes rather than meeting personally from time to time. NASA also minimised risks in reports and briefings with management, where problems weren’t expressed as urgent or dangerous as it really was.

Neither NASA nor the contractor conducted analysis to verify the relationship between temperature and the seals. Based on theory, putty would lose its stickiness at low temperatures.

On the day of the accident low temperatures persisted. Although compliance of the putty and the o-ring sealing could not guaranteed, management insisted on adhering to schedules. Decision making was rushed. Junior personnel were pressured into making a recommendation in the absence of senior personnel.