A quality management perspective of operations' Total Quality Management at OR Tambo International Airport

by

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ABSTRACT

The Problem: The research investigates the gaps in terms of Total Quality Management within the Project Management's PMI PMBOK guidelines.

Aim: The aim of this Minor Dissertation is to incisively inquire about the probability and possibility of improving Total Quality Management where there is lack, and to ensure the enforcement of the best standards where they exist. The process of inquiry pays a particular focus on Airfield Lighting Projects and General Maintenance.

Design and Methodology: A search for academic literature to substantiate and validate all the conclusions and recommendations of this minor dissertation has been conducted. A particular interest has been given to the Academic Literature on Project Management Knowledge Areas (as prescribed by the PMBOK), Total Quality Management, Industry and Regulatory Standards as well as General Academic Literature. All this information has been collated into this minor dissertation which may be used for future reference. Quantitative Research Tools have been used to draw up various inferences, conclusions and recommendations. A survey has been conducted in the form of questionnaires. The responses have been analysed and statistical methods have been used to verify Internal Consistency of Reliability, namely the Cronbach Alpha. The Ishikawa (Fishbone) Diagram was drawn up. Conclusions were then drawn from the above mentioned exercise.

Results and Discussion: A hypothesis is drawn from the research. Results showed that there is gap in terms of scope definition that may be as a result of differing stakeholder interests with the airport environment. Also that certain precepts of Total Quality Management may not be adhered to. And lastly, it was proven that changes in quality imply changes cost, time and budget.

Recommendations:. The research recommends the adoption of a Total Quality Management approach throughout the whole project life-cycle including for requirements of operations. The Total Quality Management approach includes Lean Six Sigma Method, Etcetera. Also, the research recommends ISO accreditation and adoption of ISO Quality standards as a minimum standard throughout the airport's value chain system.

DECLARATION

This minor dissertation is a presentation of my original research work. Wherever and/or whenever contributions and input of others is involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions. The research work was done under the supervision of Dr L. D. Erasmus and the co-supervision by Prof Jan-Harm C. Pretorius, who are both from the University of Johannesburg.

Name : Yanga Sapepa

Signature : _____

Date : 16 March 2018

DEDICATION

To my family – I want to thank you for the support and patience; thank you for your forbearing nature. The journey, the process of enquiry, has been rewarding at best and left one irascible at worst. This is dedicated to all those that seek knowledge because knowledge is power. A special word of gratitude to my supervisor Dr Louwrence D. Erasmus and Prof Jan-Harm C. Pretorius for the support and words of encouragement throughout the whole journey.

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List of Abbreviations

3BL	:	Triple-Bottom-Line
ACSA	:	Airports Company South Africa
AGL	:	Airfield Ground Lighting
BIM	:	Building Information Modelling
CII	:	Construction Industry Institute
CV	:	Contributed Value
DLA	:	Delegated Level of Authority
DM	:	Defect Management
DRM	:	Dynamic Reliability Management
ECSA	:	Engineering Council of South Africa
EM	:	Electro Migration
ICAO	:	International Civil Aviation Organisation
LoD	:	Level of Detail
OEM	:	Original Equipment Manufacturer
ORTIA	:	OR Tambo International Airport
OSH Act	:	Occupational Health and Safety Act Number 85 of 1993 of the Republic of South Africa
PDRI	:	Project Definition Rating Index
PM	:	Planned Maintenance
PMBOK	:	Project Management Book of Knowledge
PMI	:	The Project Management Institute
QI	:	Quality Inspection
QTO	:	Quantity Take-Off
QPMS	:	Quality Performance Management System
QS	:	Quantity Surveyor
RPV	:	Risk-Based Project Value
SABS	:	South African Bureau of Standards
SACAA	:	South African Civil Aviation Authority
SANS	:	SABS South African National Standards
SDC	:	UK Sustainable Development Commission
SEM	:	Structural Equation Modelling
SPC	:	Statistical Process Control
TPM	:	Total Productive Maintenance
TQM	:	Total Quality Management
UK EPSRC	:	United Kingdom (Britain) Engineering and Physical Sciences Research Council
WBS	:	Work Breakdown Structure

1. Introduction

Airports have lighting that helps guide aircraft, using the runways and taxiways during aircraft landing and take-off and especially during night-time operations or in rainy weather or when there is fog. Airfield Ground Lighting consists of lights that are spaced out on the runway, indicating the edge, centreline, holding areas, stop bars, runway approaches, and similar infrastructure. As with any other electrical infrastructure, this equipment deteriorates and needs replacement when it reaches its serviceable end-of-life. The requirements for the design and maintenance of the aerodrome are dictated to, by various regulations including the ICAO Standards with a particular focus on ICAO Annexure 14 and the imperative is to ensure maintainability and availability of the infrastructure. This is to ensure safety and compliance.

1.1. Problem Statement and Purpose

The OR Tambo International Airport has, in the past, delivered many Airfield Ground Lighting projects. The purpose of this enquiry is to assess the compliance of its activities in terms of Total Quality Management, as there may be non-compliances (gaps) in terms of application within its operations; namely maintenance and projects. This enquiry focuses on the Project Management Institute Knowledge Areas and compliance in terms of Quality Management. According to Burke (2006) the PMBOK… nine knowledge areas are:

- Scope
- Time
- Cost
- Quality
- Human Resource Management
- Communication
- Risk
- Procurement
- Integration

The following questions are posed in this mini-dissertation to support the focus of the enquiry to answer the following questions, regarding project successes and failures in OR Tambo International Airports' Airfield Ground Lighting Projects in terms of Total Quality Management:

- *What needs to be done to ensure Total Quality Management is implemented at OR Tambo International Airport in terms of the operations and the airport's projects?*

The objectives are closely linked to the aim, as mentioned above and it shall be demonstrated in the Discussion Section of this paper. The objective is to draw up conclusions and to make recommendations using the quantitative methods of research by applying statistical methods to analyse the empirical results sought from questionnaires. The results from questionnaires

were probed and tested for internal consistency of reliability by using the Cronbach's Alpha Test.

1.2. Research Methodology

Quantitative Research Tools have been used to reach various conclusions and recommendations. A survey has been conducted in the form of questionnaires. The responses have been analysed and statistical methods have been used to verify the Internal Consistency of Reliability, namely the Cronbach Alpha. The Ishikawa (Fishbone) Diagram was drawn up. Conclusions were then drawn from the above mentioned exercise.

The following activities will form the basis of the Research Methodology, as it can be seen on Figure 1:

- Literature reviews was conducted for gap determination.
- Initial Research Questions and Identification of Experts was done.
- Support and permissions to conduct research from the OR Tambo International Airport Senior Management was established.
- The Delphi Process of preparing Survey Questionnaires was done.
- Surveys were conducted (on an anonymous basis where necessary or by request); this enables us to do the concept design and measurement design.
- Interviews with the relevant stakeholders were conducted.
- Verification of the Survey Results by means of Statistical Methods, namely the Cronbach's Alpha Test Methods.
- The Survey Results were verified by using both the Cronbach Alpha.
- Conclusion and Recommendations were then drawn from the research.

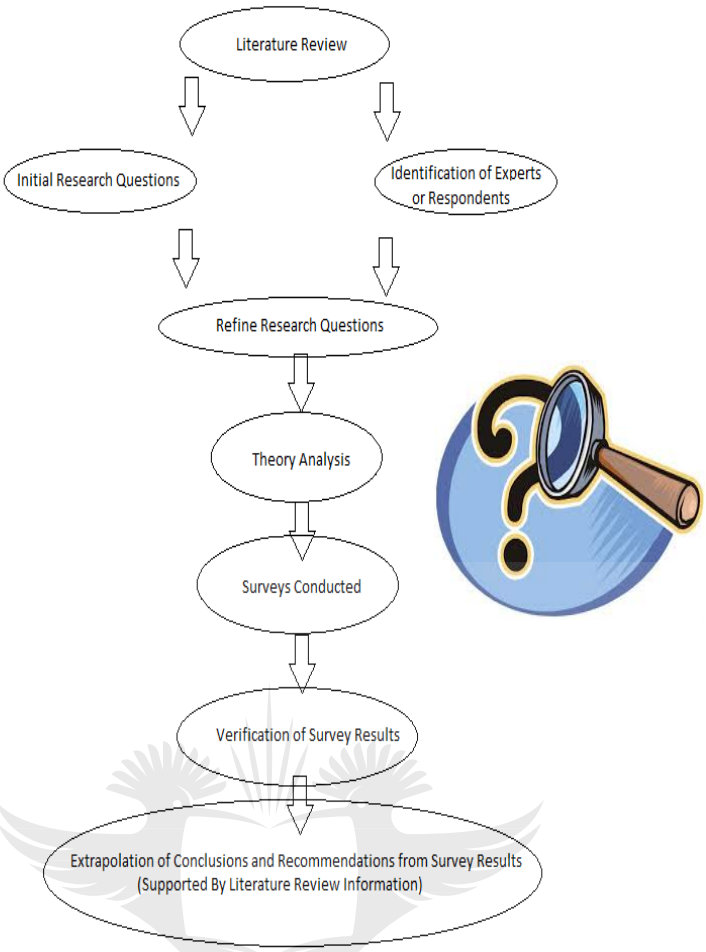


Figure 1:The Research Methodology Process that has been adopted

Ultimately, after the synthesis of the hypothesis, recommendations of best minimum practice must be recommended.

Chapter 1 offers an introduction and overview of the entire research paper for the reader to be acquainted with the intricacies of the research. While, chapter 2 purports to provide the theoretical basis for the Findings, Conclusions and Recommendations of the entire research and it is based on peer-reviewed material such as research journals, academic literature, interviews, etcetera. Chapter 3, then, outlines the Research Design inclusive of the Research Methodology, Limitations, Assumptions and Ethical Considerations that culminated into the Findings, Conclusions and Recommendations of the entire research process. The Findings and the Discussions are elaborated in chapter 4; and these are based on viewpoints extrapolated from the inputs of various research academics, experts and contributors through their peer-reviewed material – these includes the observations from the researcher of this research article. In addition, chapter 5 rounds of the research process by outlining the Conclusions and Recommendations, which are substantially, deduced from chapter 4

of this research article. For ease of reference, chapter 6 has been included and it tabulates all the material that was used throughout the research process.

2. Literature Review

2.1. Background

What is quality? According to Nicholas and Steyn (2012), quality has an implication of that more is required even if specifications or requirements are met. Even though the contractor may meet all the project specifications, ensuring that the customer is prevented from taking a contractor to court (for any dissatisfaction), the specifications, alone, cannot guarantee one that there will be customer-satisfaction with the end-result. Likewise, the contractor may receive appreciation of his or her work or that they will be granted repeat business (because of customer-satisfaction) – quality therefore implies that more than just a met project specification is required.

Nicholas and Steyn (2012) further state that a measure of project success is in how satisfactorily a project is executed on budget, on schedule, and also how the performance requirements are met and that performance specifications generally relate to project stakeholders' requirements and anticipations about the function and how the product performs or project deliverables or goals . Nicholas and Steyn (2012) then further explain that a high-quality project is one that performs according to the project requirements, gratifies all its project participants and civilisation at large, and causes no damage to the surroundings.

From the above it can be deduced that quality is a function of Cost (or Budget), Time and Scope; and that if any one of those factors is compromised then project's quality is also compromised.

Figure 2: The relationship between Quality, Budget, Scope and Time [Source: Erasmus (2017)]

Figure 2, above shows the relationship between Quality, Budget, Scope and Time as agreed with Erasmus (2017).

Klakegg and Lichtenberg (2016) state that cost control is a very important task in project management and that it allows the project team and the user (or client or sponsor) to be aware of cost movements and forms a basis for well-timed corrective and remedial actions whenever unfavourable (adverse) variances too frequent delays and severe budget overruns are found. Usually, the cost of an entry of work is equated with a known standard cost or budget. Klakegg and Lichtenberg (2016) further argue that promoters (or project leads) planners quite often deliberately understate risks and costs overestate the chances of success in order to increase the chances that their project gets a go-ahead from the sponsors and hence receive the project funding.

Hillman and Willis (1996) and further re-affirmed by Sanz-Calcedoa, Gonzáleza, Lópeza, Salgadob, Camberob and Herrerab (2015) say that regarding Total Quality Management (TQM), it is a systematic tool that integrates all efforts within the spectrum of engineering projects. And those efforts being: to define, design, fabricate and install a product or service; that in turns costs the cheapest in terms of possible costing strategies but in the meanwhile that product provides or brings about total customer satisfaction. Sanz-Calcedoa et al. (2015) further say that competitiveness and business results can be improved by the use of ISO standards and the certification process based on the ISO standards. In summary, Sanz-Calcedoa et al. (2015) say that if organizations need to make improvements of their effectiveness and, subsequently, their business outputs, they can make an impartial and genuine application of a system of quality management within their operations and projects.

Hillman et al. (1996) and reaffirmed by Sanz-Calcedoa et al. (2015) and Lin, Chang, and Su (2016) say that some of the main concerns of management of quality control are addressed by QPMS as follows:

- the funds that are expended to assure quality; and
- performance factors as a result of quality.

Table 1: QPMS Project Life-Cycle Good Quality (Success) and Bad Quality (Failure) Aspects Abdul-Rahman (1993)

Aspects of design or project information	**Aspects of workmanship and site management**
Lack of co-ordination of design	Lack of skill
Difficult to build	Lack of care
Design will not work	Lack of knowledge
Low quality design	Poor planning by tradesmen
Unclear/missing project information	Contractor's organization problem
Designer does not understand material	Lack of protection to completed work

Lin, Chang and Su (2016) agree with the Table 1 when they say that the chief strategy, that is put to use by general service providers, is to enhance of building projects management of construction in terms of Defect Management (DM) for Quality Inspection (QI). Lin et al (2016) then say that important matters in construction DM in the generally accepted practice may be affected by quality inspection, including prolonged processes, misunderstanding, information management that is not efficient, and data entry redundancies.

2.2. Scope

The Merriam Webster Dictionary, (n.d.) defines scope as "the intention, object; space or opportunity for unhampered motion, activity, or thought; extent of treatment, activity, or influence; range of operation". Also, the Oxford English Dictionary, (n.d.) defines scope as "the extent of the area or subject matter that something deals with or to which it is relevant".

To define the scope Mirza, Pourzolfaghar and Shahnazari (2013) say that the scope of the product identifies the boundaries or confines of the solution. The decision on the product scope is concerned with defining which of the business requirements (bearing in mind the limitations or confines) could be carried out by the solution. From what Mirza et al. (2013) said, it can be deduced that scope can be defined as the limits at which a planned project or activity is to be accomplished without compromising its initial design and yet all its objectives being fulfilled.

Mirza et al. (2013) say that many projects begin with good ideas, enormous investments and a lot of effort. However, most of them do not succeed because of the lack and deficiency in understanding or defining project and product scope from the beginning of the project; throughout the project's existance and until the end of the project. A scope that defined in a correct manner and that is managed well leads to a quality product which meets the obligations and intentions of the user, and also that the project is completed within approved cost and within specified timelines (schedules) to the end-user and stake-holders.

The above statement is in agreement with Fageha and Aibinu (2013) when they say that the definition of the scope of a project is the systematic process wherein a project is well-defined and made ready for implementation. And that if the project is well scoped then it becomes easier to make a determination to continue with the project or to abandon the endeavour completely. A scope that is lacking definition at the initial stages of a project's life-cycle is a usual cause of problems during the execution phase and during the construction.

Fageha and Aibinu (2013) continue to say that defining project scope by means of input from all stakeholders is a vital mission. Fageha and Aibinu (2013) then say that the input needs to be sufficient at the initial stage of the project. Scoping makes available acceptable data that is a prerequisite to ascertain the activities that are to be accomplished in order to sidestep major variance may hinder how the project performs.

Fageha and Aibinu (2013) emphasise that a high level of pre-project planning determination can save up to a lot in terms of cost (and Fageha and Aibinu (2013) claim that up to 20% from cost and 39% from schedule) in amenities projects. Thus, a more reliable rating tool needs to consider stakeholders' importance to a project in order to identify the stakeholders' influence in the decision making to ensure their influence to the different project definition components. Fageha and Aibinu (2013) state that conflicts (differences) and polemics about the execution of a project can be triggered if the stakeholders are ineffectually involved and their apprehensions and anticipations are not well taken care of. As a solution, the project managers have to involve all stakeholders when deciding on project definition. They must accept the apprehensions of all stakeholders and mitigate conflicting interests. Any negative sentiment from stakeholders when defining the project can have an influence on the job.

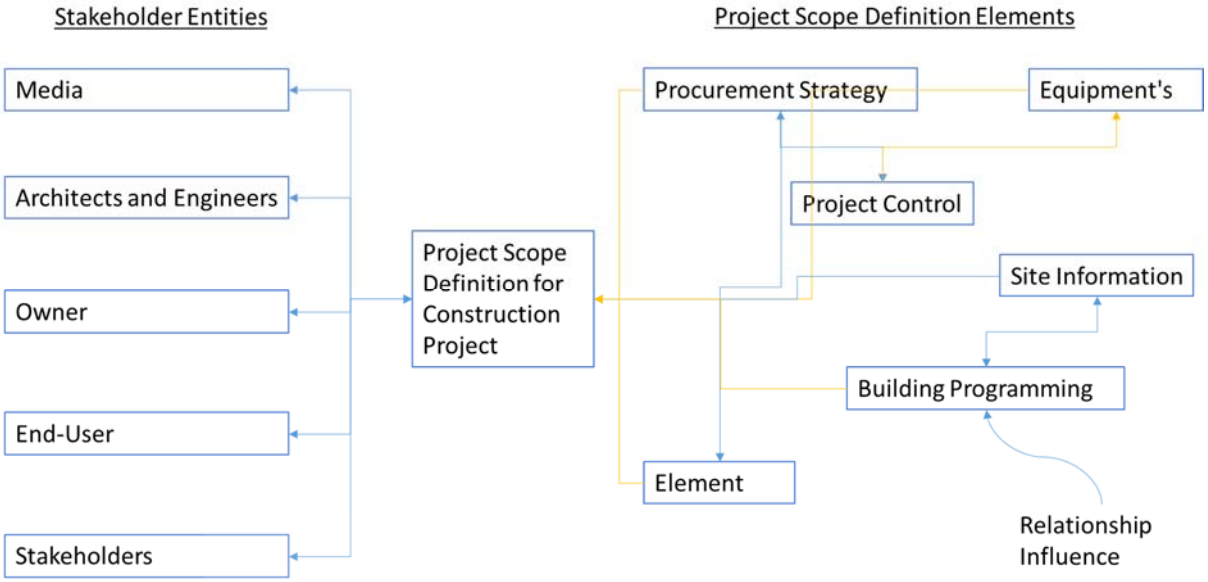


Figure 3: Formation of Scope Definition [Source: Fageha., and Aibinu (2013)]

Figure 3 shows the tasks that are done when the project scope definition is done. Each project has a project scope definition manuscript, which must be conjured up in the pre-planning period. For the project to have a project scope that is defined well, some fundamentals must be defined in a manner that is sufficient in the project scope definition manuscript right-hand side of Figure 3. These elements have different contributions to the completeness and inclusiveness of the definition of the scope of the project. At the same time, there are associations and interactions among the elements. On another hand (left-hand side of Figure 3) there are stakeholders who are driven with necessities and requests. These stakeholders could affect or be affected by certain elements; therefore, they must partake in outlining these elements. However, Fageha and Aibinu (2013) say that in truth, not all stakeholders' hopes can be satisfied. Hence, some stakeholders' apprehensions and involvement can dominate at the expense of other stakeholders' requirements, apprehensions and participation. Therefore, the hard task for project managers and the decision makers is to create a well-defined scope of a project in a way that gratifies stakeholders' prospects and apprehensions, and accrues the paybacks of their contributions.

Further, Fageha and Aibinu (2013), show the formulation of the Theoretical Framework for a good scope definition when they say that, as presented in Figure 3, on the one hand, some tools have been established for enabling the project scope definition with perhaps the most important (significant) tool is the PDRI developed by CII. Meanwhile, researchers have highlighted various ways to classify stakeholders in order to manage them well. For instance, stakeholders are categorised according to their supremacy, acceptability and the urgency with a resolve for their differing interests. In addition, Bourne (2005) developed the Stakeholder Circle, which is a tool that uses visual feedback, which offers an effective mechanism to assess and evaluate the importance of the interests of the stakeholder relative

to the project, taking to cognisance the stakeholders expected results and define suitable platforms to engage them for the success of the project.

According to Fageha and Aibinu (2013) the scope definition is susceptible to fault because of because of different interests from different stakeholders.

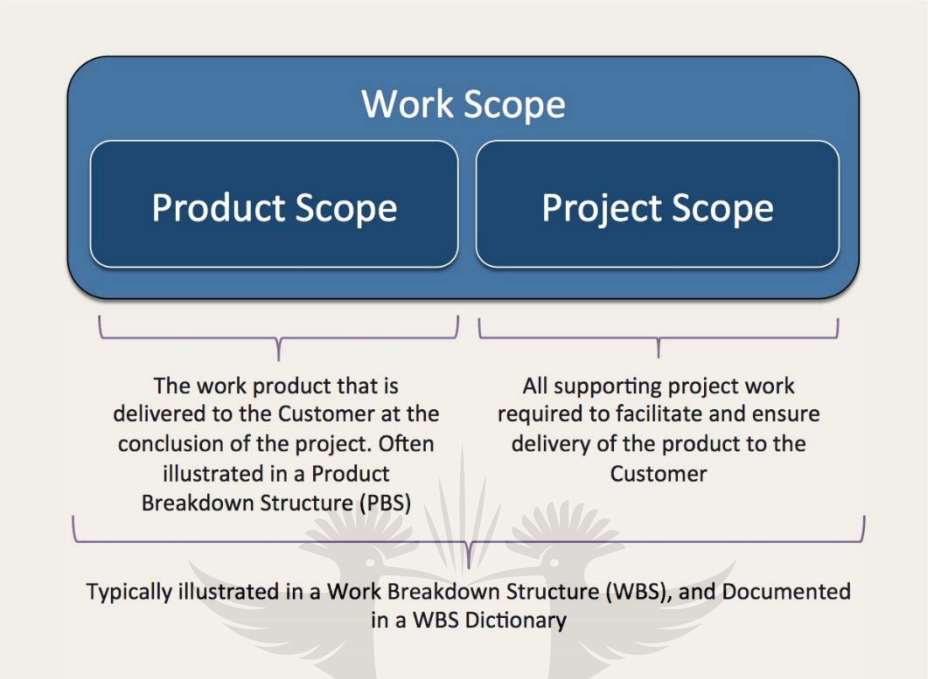


Figure 4: Formation of Scope Definition

From the above statement Fageha and Aibinu (2013), then say that according to the theories mentioned above, stakeholders would agree with the outcomes of a process in which they have been sufficiently involved in, regardless of the nature of the result (favourable, less favourable or unfavourable).

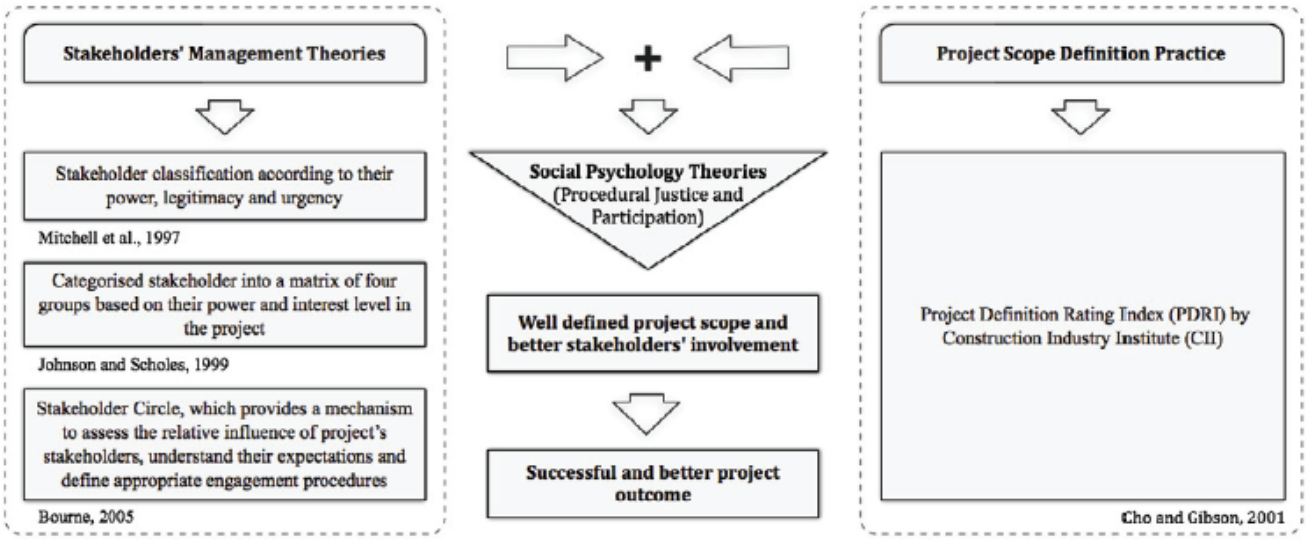


Figure 5: Theoretical Framework for Scope Definition involving Stakeholder Management Theories [Source: Fageha M. K. et al (2013)]

Fageha and Aibinu (2013), continue to emphasise the importance of the procedures that are used when decision-making as concurred by Aibinu, Ofori and Ling (2011). People feel better treatment if they are given the chance to participate in making decisions relating to their concerns. And even if their contribution has slight or no effect in the choice that is done, stakeholders still appreciate the opportunity to voice their viewpoints.

Still on the subject of scope definition, Mirza et al. (2013) continue to say that, for a project to be successful there must be a documented common vision which must be agreed upon by various stakeholders.

Martinsuo and Hoverfält (2017) reasoned that a strategy must be implemented to satisfy the scope objectives and that it ensures efficiency and effectiveness during portfolio management. This is in line with what Martinsuo and Hoverfält (2017) then also mentioned program management can be considered one form of a multi-project organization, over and above project portfolio management, for project-based and line management firms. The Project Management Institute, (2013) observes that projects, programs, and portfolios are forms that are different of organizational project management, each with unique profiles regarding planning, change management, success, and monitoring and scope.

Fageha and Aibinu (2013) conclude by saying that, project managers and decision makers must establish a project that is defined properly in a way that meets stakeholders' expectations and concerns, and increases the benefits of their inputs, while not compromising the reason for the existence and resolve of the project. Thus, all stakeholders must be granted sufficient prospects to have their viewpoints acknowledged.

2.3. Time

Scheduling for resources over time is a product of both proper planning together with understanding the task ahead, such that several activities or tasks can be completed in parallel (where resources and means, machines, are available) or in a staggered fashion if parallel completion is not achievable as agreed by Leung and Li (2016).

With regard to scheduling, Allahverdi (2015) concludes that the firms are forced by the global economy to be competitive in order to be successful and thrive. This suggests that organisations have to upsurge production throughput, reduce the nuisance surplus that is as a result of setup times/costs when doing scheduling.

Leung and Li (2016) have explored various scheduling problems with set restrictions of processing:

- Models with batch processing
- Models with resource constraints
- Models with coordination mechanisms
- Models with uncertainty
- Models with other structures or requirements

And from their paper Leung and Li (2016) supported by Allahverdi (2015) found that the above-mentioned models show either the inclusive processing set, nested processing set, interval processing set, and tree-hierarchical processing set restrictions. And that, setup times are unpredictable because of the randomness of factors such as crew skillset, availability and viability of tools and their setup teams, and unforeseen failure of equipment, auxiliary supplies and mechanisms and implements.

Refer to Figure 2, which elaborates on the relationship between Quality, Budget, Scope and Time as agreed with Erasmus (2017).

2.4. Cost

Cost is a vital component of all the "Knowledge Areas" as envisaged by the PMBOK, Project Management Institute, Inc. (PMI). (2013). The PMBOK also infers that cost is related to risk. Therefore cost reduction measures are linked with greater risks as mentioned by Sato (2009) and re-affirmed by Galve, Cevasco, Brandolini, Piacentini, Azañón, Notti and Soldati (2016).

To re-emphasise the relationship between Quality, Cost, Time and Budget refer to Figure 2.

Sato (2009) and re-affirmed by Galve et al. (2016) continues to say that, risk is the likelihood of events that may impede on the success of the project objective/performance. They mention that there is also a likelihood on positive risk, that is the chances that may cause positive bearing on reaching the objectives of the project. In other words, a good project manager play the pivotal role of balancing the act between" good" and "bad" risk.

Further, Sato (2014) and re-affirmed by Galve et al. (2016) says that the standard process of creating a project plan includes the creation of a work breakdown structure (WBS) and the definition of the WBS, the activity network is also defined, the activity cost and time estimation is done, and also the risk analysis is performed.

And according to Sato (2009) and also re-affirmed by Sato (2014) and re-affirmed by Galve et al. (2016) risk analysis includes:

- listing of probable events of risk and their causes,
- valuation of probability (likelihood) and the bearing and influence of each risk event,
- the classification of each risk event,
- the prioritization of each risk event, and
- creation of a risk response plan.

Sato (2009) further says that after the risk analysis then, the budget of the project is revised and confirmed; and the trade-off problem transpires from the risk analysis.

Sato (2014) then says that the strategies to respond to risk may be placed into two kinds of categories:

- Planned or pre-emptive risk and
- Ad-hoc risk.

These risk response strategies are dependent on the type of risk causes and influences. Some risk causes may be alleviated with extra funds that must be expended and they are named 'cost-dependent' risk drivers. The finds that are expended upfront to alleviate or prevent these risks is allocated appropriately for cost-dependent risk drivers, and they initiate of the trade-off problems according to Sato (2014) and re-affirmed by Galve et al. (2016). They say that sometimes as a trade-off lower cost materials or resource are used and this may lead to poor quality and in turn increase critical risks.

The PMBOK Guide, PMI (2008) suggests, among others, two approaches of quantitative analysis of risk:

- The Monte-Carlo Simulation and
- The Decision Tree Analysis.

The Monte-Carlo simulation technique uses each activity's cost probability distribution to predict entire project cost together with related probability that can be achieved. Meanwhile the decision tree analysis analyses single decision problems. However, the decision tree analysis does not suffice when solving the decision-types that are require continuous analysis of the problems. When the decision tree analysis is applied to a great amount of activities, the branches of the tree will rapidly develop to an unpractical point of complexity.

Sato (2009) and re-affirmed by Sato (2014) and Sato, and Hirao (2013) have proposed the risk-based project value (RPV) as solution where there is a deficiency of measurable metrics to assess or optimize the whole cost of the project that has critical risks.

Sato (2014) explain risk-based project value (RPV) as follows:

- RPV is how the projects are evaluated.
- RPV is tabulated on the basis of risk probabilities and project cash-inflows and cash-outflows of the project undertakings that are included in the project network diagram.

RPV explicitly comprises the risk probability of individual activities in their deterministic calculation process and their cost. Thus, it allows for the theoretical examination of the trade-off relationships without the need for arbitrary number simulations and sensitivity analysis, because the randomness does not always render results that are reproducible. And RPV signifies the total value of the entire project. RPV is thus measurable at any point in the project's life-cycle. The RPV is equivalent to the anticipated financial worth of the project's cash-flows.

By definition RPV is the sum or difference of cash flows that are attained (incomes less costs) of historical activities and anticipated ongoing activities' cash flows. These ongoing activities' cash flows are discounted by the likelihoods of closure or termination according to Sato (2014) and that the initial cost C must be expended on the activity, and income S will be gained when the activity has been completed successfully. There is a risk probability r for the likelihood of unsuccessful termination at implementation.

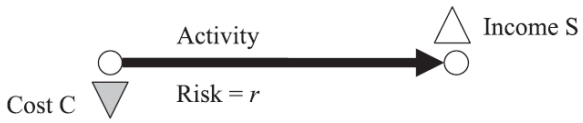


Figure 6: [Source Sato et al (2013)]

The definition of the RPV of a simple-type project is as follows:
Before project start:

$$RPV = (1 - \mathrm{r})\mathrm{S} - \mathrm{C}$$ Equation 1

After project completion:

$$RPV = \mathrm{S} - \mathrm{C}$$ Equation 2

Where:

r is Risk Probability
C is Cost
S is Income

For "'serial-type' projects containing a sequence of undertakings that start from 1 and end at N (Figure 6: [Source Sato et al (2013)]).

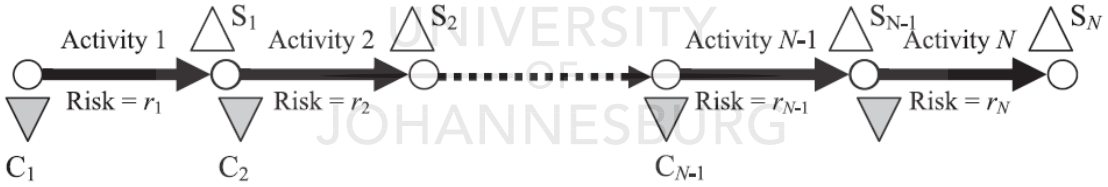


Figure 7: [Source Sato T. et al(2013)]

Sato T. et al continue saying that, C_i, S_i, and r_i are the initial expense, final income, and risk probability (probability of termination) of activity number i, respectively. Risk probability r_i is projected at all the activity levels and it is presumed to be independent for all the activities. The Income term S_i is linked to all the project activities, but it can also be zero.

For RPV Calculation Equations refer to Appendix 1: RPV Calculation Equations.

Again refer to Figure 2, which expounds on the relationship between Quality, Budget, Scope and Time as agreed with Erasmus (2017).

2.5. Quality

On quality in project management, Kılıc, Ulusoy and Serifoglu (2008) and re-affirmed by Pfeifer, Barker, Ramirez-Marquez and Morshedlou (2015) say that the quality of a project is quantified by the number of flaws and defects; and time is quantified (or measured) by the project duration and cost is quantified (or measured) by the total cost of time expended. Underlying the management of such projects is the risk of failure from several perspectives: time, cost, and operational performance (refer to Figure 2). And often the failure of these projects, when large-scale in nature, can have significant economic and social consequences.

Again to re-emphasise the relationship between Quality, Cost, Time and Budget refer to Figure 2: The relationship between Quality, Budget, Scope and Time.

Nicholas and Steyn (2012) mention that quality infers the fit for its purpose nature of a product. They further explain that quality implies the appropriateness for application and purpose. To them, a product of best quality is that which meets and sometimes exceeds the requirements and specifications, both in terms of reliability and price.

Kılıc, Ulusoy and Serifoglu (2008) and later re-affirmed by Pfeifer et al. (2015) continue to say that the impartial aim of quality maximization is to define quality quantitatively in such a way that different interested parties or stakeholders reach agreement on the resulting definition. On the while, the objective of cost minimization is employed when the aim is to minimize costs that are a result of the realization of an activity or resource usage.

Nicholas and Steyn (2012) continue to say that quality also suggests an lack of defects and that a good quality product is a product that is defect-free. That that expectation relates to non-conformity in that a customer accepts a product as good quality if it meets the anticipations. One approach to succeed in getting quality is to ascertain (and categorise) and correct as many defects as possible, and to categorise them as soon as practically possible. In general, the lengthier the time that is taken to remedy, or correct, or remove a nonconformity before it is revealed, the expensive it becomes to correct, or remove it. It might be comparatively cheaper to repair a defect in a part, but it is commonly more expensive to fix it after the part has been put into an assembly, and it even costs more after the assembly has been embedded inside a system. The defect (flaw) costs more when it causes a product or system to malfunction or fail while in use by the customer.

Nicholas and Steyn (2012) further mention the following Processes of Project Quality Management:

- ***Quality planning*** guides activities of quality of the future and it sets the standards that are to be met and the targets that are necessary for those standards to be met.
  Quality planning has the following two aspects:
  - To establish project quality management processes and policies for the entire organization, as well as applicable procedures; and
  - To establish a quality plan as an integral portion of the project master-plan for each individual project.

  The quality manager is responsible for setting up the procedures or standards that are to be met for the organisation. Quality standards that are already in existence in the

organization, such as the ISO 9001 standard, are often employed by projects in a quality management system.
For design and development projects, the following are the expected standard prescriptions and procedures for an organization:

- the design and development stages;
- the necessary reviews, verifications, and validations appropriate to each of the stages; and
- the responsibilities and authorities for the stages.

- ***Quality assurance*** ensures the project optimally utilizes processes that are a requirement to ensure that the quality standards are met and end-item specifications are satisfied. It also ensures that the project performs the planned quality activities.

- ***Quality control*** ensures that requirements and standards are being met. Also quality control ensures that quality assurance undertakings are done in accordance with quality plans. Quality control involves corrective action so as to attain the planned quality outcomes and the ongoing process of monitoring and appraising work. The process also verifies that project specifications are satisfied, and that quality assurance undertakings are done in accordance with the quality plan. Whenever defects are discovered, the causes are investigated and they are eliminated. Quality control must be integrated with:
  - how the organisation controls project scope,
  - how the organisation controls cost,
  - how the organisation controls progress, and
  - how the organisation controls risk.

2.6. Human Resource Management

According to Suwandej (2015) the move towards globalization has moulded management in the 21st Century, in that there is a more sophisticated complication in its existing boundless and seemingly borderless terrain and that the advancement in information technology and communication technology has drastically influenced all the activities the world-over. higher competitiveness is the main goal of most public and private organizations.

Management Excellence is a modern strategy that allows an institution to achieve growth and development and survive. Today, Management Excellence generally accepted by many public administrations as a framework for a strategy-to-success regulation.

Figure 8: Kutaya Organised Industrial Zone Study Model [Source: Cetindere A., et al (2015)]

According to Cetindere, Duran and Yetisen (2015) six different hypotheses were formed:

- Hypothesis 1: There is a substantial and optimistic correlation between training and performance of the business.
- Hypothesis 2: There is a substantial and optimistic correlation between leadership and performance of the business.
- Hypothesis 3: There is a substantial and optimistic correlation between continuous improvement and performance of the business.
- Hypothesis 4: There is a substantial and optimistic correlation between the degree of importance given to internal customers and performance of the business.
- Hypothesis 5: There is a substantial and optimistic correlation between the degree of importance given to external customers and performance of the business.
- Hypothesis 6: There is a substantial and optimistic correlation between training, continuous improvement, leadership, internal customer and external customer and performance of the business.

Suwandej (2015) revealed that high performing individuals of high responsibility needed to be rewarded and compensated for, accordingly; and how valuable the individual staff development and improvement of such staff is for an organisation. However, Suwandej (2015) emphasised that a design for the appropriate rewards or incentives program and improvement must be designed. And the design must be based on assessment, measurements and evaluation stimulated the staff to develop themselves and enhance the capability of the organization. The on assessment, measurements and evaluation must be informed by the findings of the metrics and evaluation principles. And also that the people who give measurements and assessment (evaluation) should have the appropriate knowledge and the evaluation system's understanding, in terms of the characteristics and appropriateness of the metrics and evaluation of the organisation as said by Suwandej (2015).

And according to Cetindere, Duran and Yetisen (2015) to reply to cumulative customer demands with high quality products ensures leverage on their competitiveness within the contemporary increasing competition conditions for a business. Both external and external customers require a thorough understanding of quality within the organisation. They see the

target group being the external customer, while they perceive the organisation's staff as the internal customer. They further mention that customer loyalty and satisfaction comes as a result of supply of high quality products. And also that demand elasticity is reduced by customer loyalty and satisfaction which can then result in the organisation being capable of selling more highly priced products and services and hence higher profits. They performed a regression analysis which showed that the performance variable was affected by the Total Quality Management characteristics like continuous improvement, training, both internal and external customer focus; in terms of performance. Likewise, they interpreted the analysis as such that an increase or decrease on the emphasis of TQM by a business results in an increase or decrease of performance by the business; as such, the outcomes a business that adopts and appropriately practices the TQM concept is headed towards perfection with its business plan.

Cetindere, Duran and Yetisen (2015) emphasise that organisational leaders should be well-informed, goal-oriented, strong-minded, determined, and decisive in terms of product and service improvement for the business to thrive in the competitive global business environment. Also, they say that training of the staff at the appropriate time and at the right circumstances proves effective for the desired operational outcomes as an example of the HPC Professional Training.

2.7. Communication and Integration Management

Corporate sustainability encompasses the integration of environmental, economical, and social dimensions, which are also called the triple-bottom-line (3BL), into the company procedures. Hassini, Surti and Searcy (2012) show that there is an accumulative interest in sustainable logistics systems. On the other hand, there is a need to have a bigger emphasis on the connections and trade-offs between the 3BL elements, together with calculating the different aspects of sustainability.

Walker et al (2012) and Suwandej (2015) confirm that in any project Communication and Integration Management is of utmost importance. We shall explore Communication and Integration Management in the following few lines; the importance Relationship of Business Performance with Mediators of Statistical Process Control (SPC) and Total Quality Management (TQM), Total Productive Maintenance (TPM) and Lean Production.

According to Ahmad, Zakuan, Jusoh and Takala (2012) intense global competition resulted in the establishment and improvement of the concept of Total Quality Management (TQM). Organisations that do international trade in global world-wide competitive markets have emphasise on TQM philosophy, tools, methods and procedures and methods to compete at international level. And that to compete at international level, an organisation necessitates increased quality realization to meet (and exceed) the customer approval.

TQM is a management concept and philosophical viewpoint that assists organisations to manage its aim to improve the performance and efficacy to attain world class competitiveness according to Konecny and Thun (2011).

Konecny and Thun (2011) answer the question about the relations amongst the following four concepts with the performance of the business namely:

- Total Quality Management (TQM),
- Lean Production,
- Total Productive Maintenance (TPM) and
- Statistical Process Control (SPC)

Konecny and Thun (2011) and Teeravaraprug, Kitiwanwong, and Saetong (2011) claim that the relations among the above-mentioned four concepts with business performance that render the following results:

- incremental continuous improvement,
- cost cutting (waste reduction) and
- ramping up of performance (again related to incremental continuous improvement)

Teeravaraprug, Kitiwanwong and Saetong (2011) also say that these practices and concepts are a comprehensive, complete set of manufacturing enhancement concepts aimed at ramping up of the organisations' performance. TPM helps get the most out of equipment performance and reduces downtime by reducing break-down as according to Breja, Banwet and Iyer (2011) and TQM objects to sustain and advance business performance improvement and product and service quality. Lean Production eradicates waste by enforcing a tight or adequate inventory control and reduction of the time delays and deferment of process hence reducing cost. Furthermore, SPC is a observation process that ensures, safeguards and guarantees that process is under control and that the process is running in a stable manner as said by Juran (1998) and re-affirmed by Madanhire and Mbohwa (2016).

Ahmad et al. (2012) continue saying that the benefits of TQM are as follows:

- improved communication through better co-operation,
- improved employee participation,
- improved quality,
- improved team-work,
- improved customer satisfaction,
- improved working relationships,
- improved employees' satisfaction,
- improved productivity (higher output), and
- improved market share.

There is a positive connection between TQM practices and the performance of the business as claimed Gunday, Ulusoy, Kilic and Alpkan (2011); and Miyagawa and Yoshida (2010).

Now let us consider the 10 Hypothesis regarding the relations among Total Quality Management, Total Productive Maintenance, Statistical Process Control, Lean production and business performance (as mentioned earlier by Konecny and Thun (2011)):

H1: Relationship between TQM and Mediators (Lean Production, TPM and SPC):

The TQM practices have a direct, positive effect to the Mediators and leads to improved Business' performance as mentioned by Corredor and Goñi (2011).

H2: Relationship TQM between Lean Production (TQM practices are positively correlated with Lean Production):

Juran (1998) and re-affirmed by which in turn Hofer, Eroglu, Rossiter and Hofer (2012) state that TQM is the fundamental support for effecting Lean production means of production and that the it is an conglomerate of a diversity of concepts, procedures and tools of production. Lean production will improve financial performance by cost cutting by enforcing better operational performance, such as adequate stock keeping through optimal inventory, higher quality products and services and shorter processing times.

H3: Relationship between TQM and TPM (TQM practice are positively correlated with TPM):

Konecny and Thun (2011) mentions that the TQM significantly supports TPM for improving business performance.

Teeravaraprug, Kitiwanwong and Saetong (2011) did a study that shows that before implementing Lean production, TQM and TPM should be effected and applied first. The two following are sets of factors and issues which are crucial for the effectiveness of TQM and TPM:

- focus on customer satisfaction
- and universally significant

Teeravaraprug et al. (2011) then says that TPM is a comprehensive improvement and it originate from the concept of zero defects and it hinges on the following:

- leadership (management),
- process management and strategic planning, and
- approach-specific elements such as the production tools.

H4: Relationship between TQM and SPC (TQM practices are positively correlated with SPC):

A stable process can be assumed by statistical process control, but till the process is entirely defined and controlled, predictions cannot be made as mentioned by Juran (1998) and re-affirmed by Madanhire and Mbohwa (2016). TQM makes available an infrastructure or opportunity such as employee participation, senior management buy-in and improvement to use other practices, thus, execution of SPC and TPM must be preceded by TQM Juran (1998) and re-affirmed by Madanhire and Mbohwa (2016). SPC reduces the changes in the process or process variance, and this improves performance of the process, customer satisfaction and cost cutting as said by Taj and Morosan (2011).

H5: Relationship between TPM and Lean Production (TPM practices are positively correlated with Lean production):

Bakri, A. Hj., Rahim, A.R.A., Yusof, N. M., Ahmad R., (2012) say in today's competitive nature of business, Q (quality), C (cost) and (D) delivery are becoming a vital business strategy leading to success and growth in most organizations. Further, Bakri et al. (2012) further show that there is a link between cost and waste and as such Lean Production reduces cost by reducing waste.

H6: Relationship between TPM and SPC (TPM practices are positively correlated with SPC):

To avert the reduction of performance due to factors outside the control; TPM advances the peak performance of the equipment by predicting the right time for the use of new machines and thus averts failure and hence the improvement of quality of products and services as mentioned by Mehrafrooz and Noorossana (2011). Stable processes are a requirement for SPC to eliminate irregularities such as incompetent unable workers and machine distortion. TPM provides consistent and stable output to control variability of equipment in the process as said by Juran (1998) and re-affirmed by Madanhire and Mbohwa (2016) and they mention that the TPM' implementation should precede SPC.

H7: Relationship between TPM and business performance (TPM practices are positively correlated with business performance):

Ahuja and Khamba (2008) notes that business performance in Indian industry is enhanced by the following critical success factors of TPM:

- top management leadership of organisation and its involvement,
- the maintenance procedures and practices and
- the initiatives of TPM viewed holistically.

Konecny and Thun (2011) conducted a study that shows that TPM and TQM, when supported by Human Resources practices, improve performance of the business significantly.

H8: Relationship between Lean Production and SPC (Lean Production practices are positively correlated with SPC):

Stable and consistent production is required for Lean Production implementation. The statistical technique to observe and forecast the stability of the process of production is SPC as claimed by Besterfield (2009). Also, Schonberger (2007) notes that because there is a risk of triggering impairment in the production process. And also that this impairment will cause delay in production, some businesses have struggle to implement lean production. Thus, Lean production should be implemented after implementing SPC.

H9: Relationship between Lean Production and business performance (Lean Production practices are positively correlated with Performance):

Demeter and Matyusz (2011) confirm that there is a positive link between financial performance indicators and Lean Production practices in that firms that impliment

Lean production have keep lower stock levels (keep lower stock levels – locked-up capital – higher inventories) than firms that abstain from implementing Lean production practices Demeter and Matyusz (2011). Furthermore, environmental management practices are also positively correlated to Lean production practice as said by Yang, Hong and Modi (2011).

H10: Relationship between SPC and business performance (SPC practices are positively correlated with Performance):

Rohani, Yusof and Mohamad (2009) claim that the results from the survey that was conducted within the Malaysian automotive industry display a positive correlation between SPC and the performance of an organisation. The SPC Information improves the ability of leadership of the organisation to make correct decisions based on the same SPC information. Therefore, SPC leads to higher levels of production (and efficiency) by decreasing waste and ensure higher levels of quality for both the short and the long term.

In conclusion to a study conducted by Ahmad et al. (2012) a conceptual model has been proposed to understand the relationships and Figure 9 shows the Structural Equation Modelling (SEM) techniques that are employed to analyse and study the relationships between TQM, TPM, SPC, Lean Production, and Business Performance.

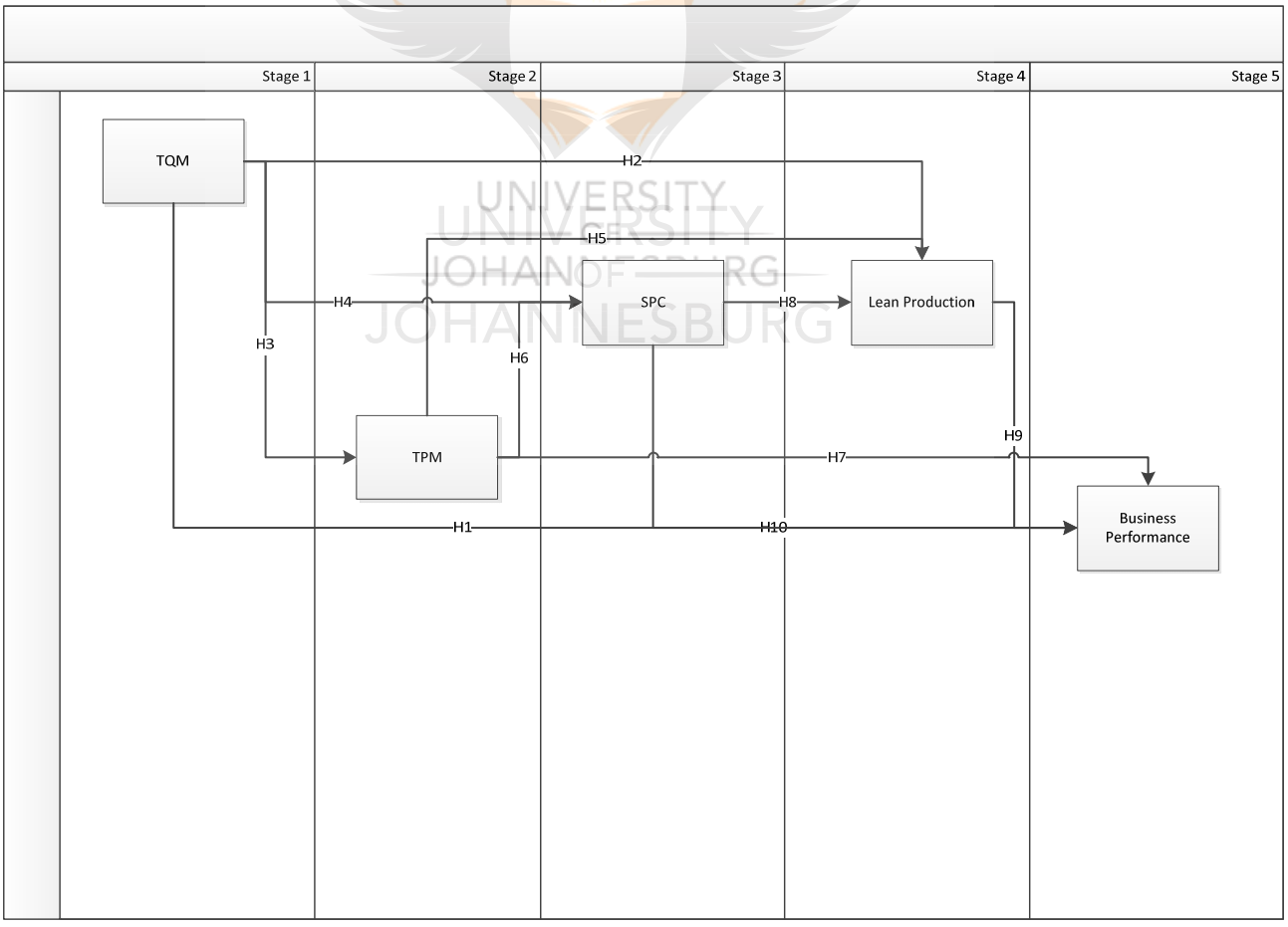


Figure 9: Structural Equation Modelling (SEM) [Source: Ahmad, M.F., et al. (2012)]

2.8. Risk

In any project, cost is a vital component of all the “Knowledge Areas” as envisaged by the PMBOK, and cost is related to risk in that the efforts to reduce costs, meanwhile, are at times linked to increased levels of risks according to Sato and Hirao (2013).

Sato et al, (2009) and re-affirmed by Sato and Hirao (2013) continue to say that risk is typically considered to be the likelihood of happenings that may cause bad effects on project objective or the performance of the project and its end result, the end product or service. There are risks that are positive, or simply, opportunities (as opposed to risks) as well, that may have a positive influence on attaining project objectives or end result. In other words a good project manager play the pivotal role of balancing the act between ”good” and “bad” risk.

McManners (2016) makes a link bewteen risk with sustanabilty at the levels social, environmental factors and economic. McManners (2016) claims that the **aviation sector** can be singled out as the most problematic segment of the industry to introduce the concept of sustainable development as a concept to be adopted. The UK was chosen for a study of sustainability within its aviation sector. This was because the UK aviation sector had already made attempts in trying to apply sustainability within its operations. The UK Sustainable Development Commission (SDC), which ran operations from 2000 until 2011, performed a research and analysis of the UK aviation sector. The results of the study showed that there are various stakeholder within many different intersts which are very much polarised. The polarisation of the stakeholder interests proved a barrier for sustainability in that country.

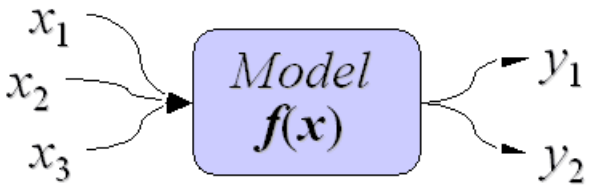
McManners (2016) says sustainability can be incorporated into policy by following understandings as prescripts:

- first, it is essential that there exists a structured long-term thinking and planning in terms of strategies;
- second, stakeholders dialogues must be well facilitated;
- third, both technological and business model innovation must be supported by all;
- fourth, the general public must be coerced, by means of information dissemination, to have a buy-in to support all the necessary changes.

Regarding Monte Carlo Methods on Risk:

Dubi (2006) says that optimizing the inventory management, resources, and maintenance teams, in a complex and complicated system of logistics is problematic to the extreme. Inventory management, resources, and maintenance teams are a regular difficulty in almost every huge capital investment industry or organization.

Dubi (2006) further says that the Monte Carlo method renders the performance function of systems that are realistic but the Monte Carlo is very hard to use as a tool for optimization because of the excessively high calculation time that is expended. Dubi (2006) then says that an analytic approximation for the “surface” of the performance function in the resources space must be used for analysis. The approximation (estimate) is based on parameters “learned” from a small number of Monte Carlo calculations. The process of optimization is then done methodically by marginal analysis over a projected, estimated analytic surface.

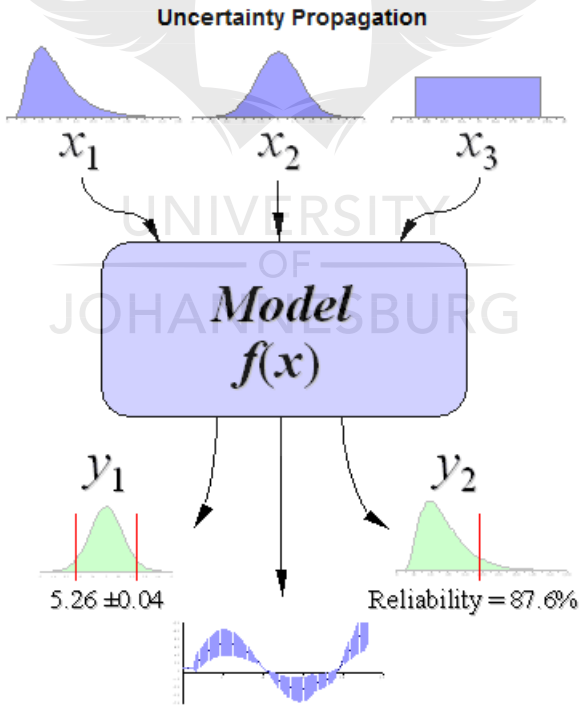


A parametric deterministic model maps a set of input variables to a set of output variables.

Figure 10: A Parametric Deterministic Model [Source: Dubi, A. (2006)]

For the equation to tabulate the performance of the scheme as function of the resources maintaining that performance refer to Appendix 3: Equation to calculate the performance of the system.

However, Rudoy and Wolfe (2006) and re-affirmed by Boulange, Watanabe and Akai (2017) say that the Monte Carlo methods have become recognised as a practical method to model appropriate for statistical optimization problems and inference. And Rudoy and Wolfe (2006) and re-affirmed by Boulange et al. (2017) mention that Monte Carlo functionals of interest are estimated by generating many random variants according to some target probability distribution. And that typically, such Monte Carlo methods are required when nonlinear associations among random variables comprising the model under consideration render the resultant distributions analytically intractable.



Schematic showing the principal of stochastic uncertainty propagation. (The basic principle behind Monte Carlo simulation.)

Figure 11: Stochastic Uncertainty Propagation Principle [Source: Dubi (2006)]

Reliability, Availability, Maintainability (RAM):

Regarding plant availability, Corvaro, Giacchetta, Marchetti and Recanati (2017) processing plant use reliability programs to maximise plant safety while ensuring a high plant availability. The size and complexity of these programs can differ and vary significantly. Reliability information or data is used to model reliability programs, like a preventive maintenance (PM) programs. The actual effective implementation and application of these reliability programs is greatly dependent on the correctness and exactness of the reliability models and the availability of data that is accurate, or at least the highly probable information.

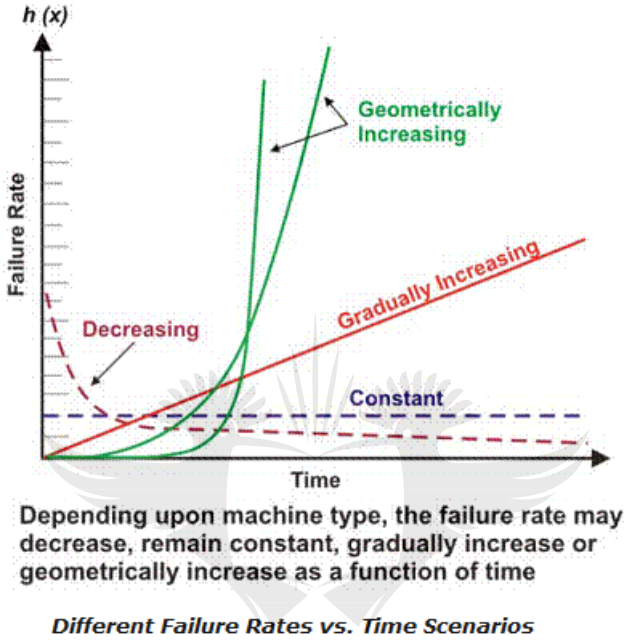


Figure 12: Source Houtermans, M., Al-Ghumgham M., Vande-Capelle, T., (2007)

Corvaro, Giacchetta, Marchetti and Recanati (2017) say that reliability engineering profoundly is dependent of probabilistic methods. Whether we speak of the reliability of an equipment component or an entire processing plant; a reliability model must first be created in order to predict the end result. The following are the techniques and methods that have been conjured up for the purpose of prediction – or forecast for reliability within the logistics management environment:

- Fault Trees
- Reliability Block Diagrams
- Monte Carlo Simulation
- Markov Models

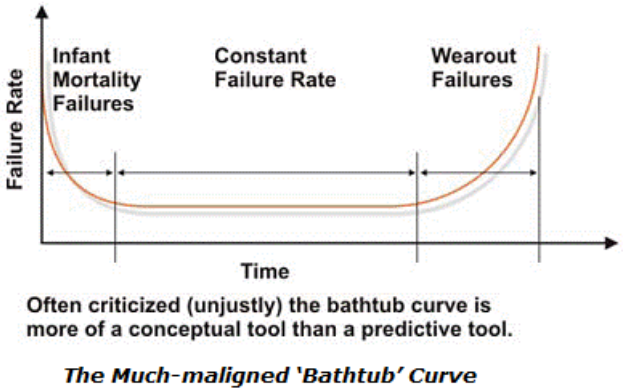


Figure 13: Source: Houtermans, M., Al-Ghumgham M., Vande-Capelle, T., (2007)

Houtermans, Al-Ghumgham and Vande-Capelle (2007) and re-affirmed by Corvaro, Giacchetta , Marchetti and Recanati (2017) further say that factories (plant operators) have over time developed a system or method and procedure to respond to equipment failure – repair or replace. They have noted that the failures happen in a random manner; so a database of failures was created such that failures in their nature are known. That then enables us to predict future events based on the history. The ability to follow up or to create a follow up system is one of the best traits of this procedure as suggested by Houtermans et al. (2007) and later re-affirmed by Corvaro et al. (2017).

Houtermans et al. (2007) have suggested the following steps to improve on reliability:

- The failure of a component that occurs in a system "X", shall be secluded and decommissioned. If the failure has triggered a equipment shutdown, then a new certified equipment component shall be fitted to bring about and speedup plant start-up activities. The Original Equipment Manufacturer (OEM) shall issue the new equipment component certificate.
- The failed equipment part shall be clearly marked by using a tag. The maintenance engineer shall keep a record of the failed equipment component.
- The maintenance department shall create and give out a copy of the examination report to the operations, and engineering departments.
- Operations shall spell recommendations based on consultation.
- A list of the 2 years' operations failures must be tabulated.
- Operations must ensure that preventative maintenance is done.

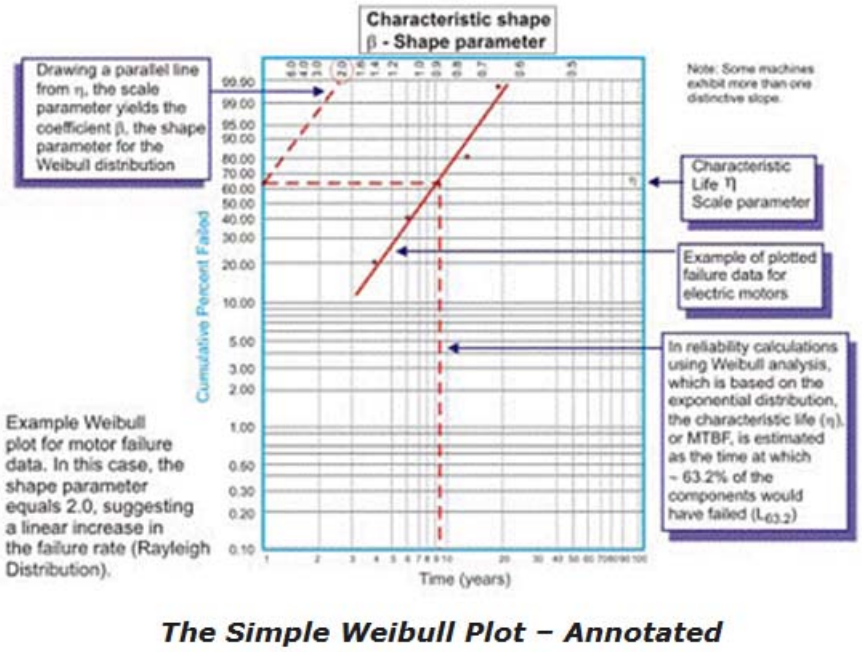


Figure 14: Source: Houtermans, M., Al-Ghumgham M., Vande-Capelle, T., (2007)

Reliability Management:

Karl, Blaauw, Sylvester and Mudge (2008) and re-affirmed by Lukinskiy and Lukinskiy (2017) say that for one to apply a scheme of real-time dynamic reliability management, there has to be accurate and precise simulations that can understand dynamic stress behaviour with minimal (marginal) computational expenditure. The simulations are adapted (adjusted to suite) from state-of-the-art science of failure work and used in real-time DRM (Dynamic Reliability Management). They suggest that all reliability models must be well-defined such that they show wear-out as a result of an accrued damage or portion of lifetime expended on each component. This approach is key to the effective calculation of total failure likelihood, which drives the suggested DRM control method and permits simple forecasts of the failure rate at the anticipated and anticipated lifespan of the component. This approach also permits the usage of degradation dependent simulations for individual reliability mechanism, a ability that is nowhere to be found when dealing straight with probabilities.

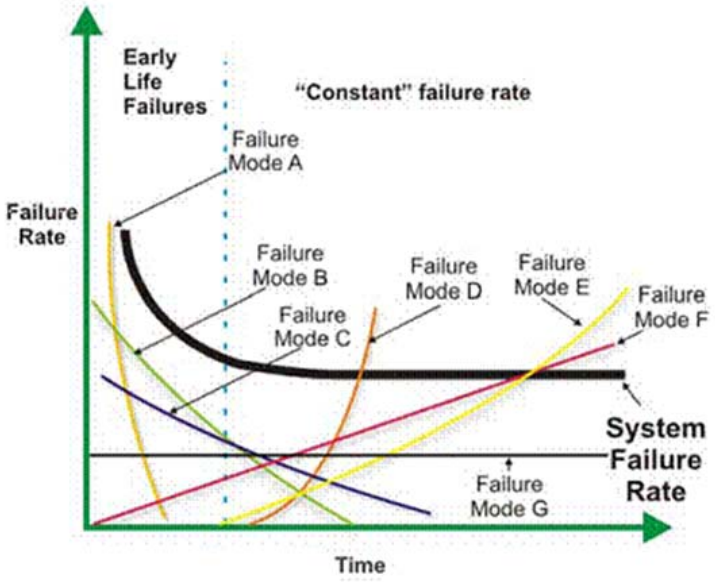


Figure 15: Source: Karl, E., Blaauw, D., Sylvester, D., and Mudge, T., (2008)

On System Level Modelling, Karl et al. (2008) and re-affirmed by Lukinskiy and Lukinskiy (2017) say that an efficient custom-made approach for calculating system-level probability of failure that can be created to the anticipated level and detail degree. However, this supposition will not be ominously altered by the conclusions that are reached. As now described, using probabilistic independence and greatly simplifies the mathematical formulation can lead to the correlation between the failure mechanisms and thus permit system-level probability calculations.

On Reliability Mathematics Lukinskiy and Lukinskiy (2017) say to achieve a higher processed accuracy of experimental information, a larger sample size (and with increasing sample consumption and amount of measure working) must be used. Thus the minimum sample size under the premise of meeting data processing accuracy is the appropriate sample size. In the process of reliability experiment, the sample size of every performance detection is calculated by Appendix 4: Equation for calculating Performance Detection: Fei, Haibin, Chengguang and Sihao (2007)

Fei L et al. (2007); re-affirmed by Lukinskiy and Lukinskiy (2017) concludes that a mathematical modelling, a method of calculating storage life of a sample (example: the rocket projectile) is specified and that a method of keeping the right inventory is defined in terms of dependant demand. It is proved that the Reliability Mathematics Methods can be adopted, which provides allusions to detection approaches. Levels of stocks management at dependent demand can be achieved without the wastage that is associated with high inventory stock.

2.9. Procurement

On procurement Lu, Won and Cheng (2016) say that substantial research on analysing the cash-inflows and cash-outflows of projects has been done. Detailed information is required, such that one can accurately and precisely estimate cash-inflows and cash-outflows. Detailed information that is necessary includes the following:

- cost estimation,
- resources,
- schedule,
- pricing schedule including materials,
- and data about subcontractors,
- contract data concerning the project owners and subcontracting companies, and
- general project information.

Lu et al. (2016) continue to mention that the integration methods between the schedule and cash flow assist to analyse the cash-flows of a project with detailed data or information.

The model for cash flow forecasting during the planning phase of a project is done by integrating the cost items and schedule in a manual manner. Lu et al. (2016) continue a technique to integrate the cost items and schedule in a manual manner for cash flow analysis takes time. And to avert the time consuming manner, each of the cost items is allocated as a ratio of the total cost calculated for the period the project's lifecycle. For example, they suggest that the forecast of the cash flow, which is based on detailed methods of cost-flows, and shared by the direct cost into the following divisions:

- materials,
- labour, and
- equipment costs,

However, since cost items are not premeditated based on the accurate amount of each resource, cash flow analysis cannot be done accurately and time dependant costing is affected because there is no linkage between cost and disbursement.

Lu et al. (2016) continue to say that many various approaches were suggested for more accurate and precise cash flow forecasting established a linear programming model by dealing with the following:

- characteristic monetary transactions,
- use of available credit lines,
- possible delays on payments,
- budget constraints and
- the effect of fluctuating interest rates.

Because of the unpredictability and irregularity in cash inflows and outflows; a stochastic system has been proposed (a randomly determined system) that can do calculations by the discovery of the best-fit probability distribution function and by assimilating project financing and randomly determined simulation-based scheduling into the only structure.

From their work Lu et al. (2016), propose the 5D BIM framework that help with taking decision that are of financial importance. The arrangement of the 5D BIM framework for project-level currency inflows and outflows and financial decision making is described in Figure 16. And the framework of the 5D BIM framework consists of four modules:

- 5D model is prepared,
- cash inflow is calculated,
- cash outflow is calculated, and
- project funding.

Further Lu et al. (2016) describe the "5D model preparation" as shown in Figure 16, in order to prepare a 5D BIM model, four main steps are needed. They are:

- generate the BIM model,
- extract the Quantity take-off (QTO),
- amalgamate the programme information and QTO list, and
- integrate the Cost information and programme loaded QTO list.

According to Lu et al. (2016) a BIM model covers the full geometric and semantic information and can be transferred to a 5D software platform to produce a QTO list, which can be used to generate a cost-loaded timeline and create a 5D BIM model and conduct 5D simulation. The BIM is a digital demonstration of the tangible and practical features of the tool, which contains Geometric, and Semantic Data as the basis of 5D simulation. While Geometric Data (information) delivers precise QTO of substances, Semantic Data delivers material data. Consequently, as more information is available, the accuracy of cash inflow and outflow analysis can be increased, as the job continues.

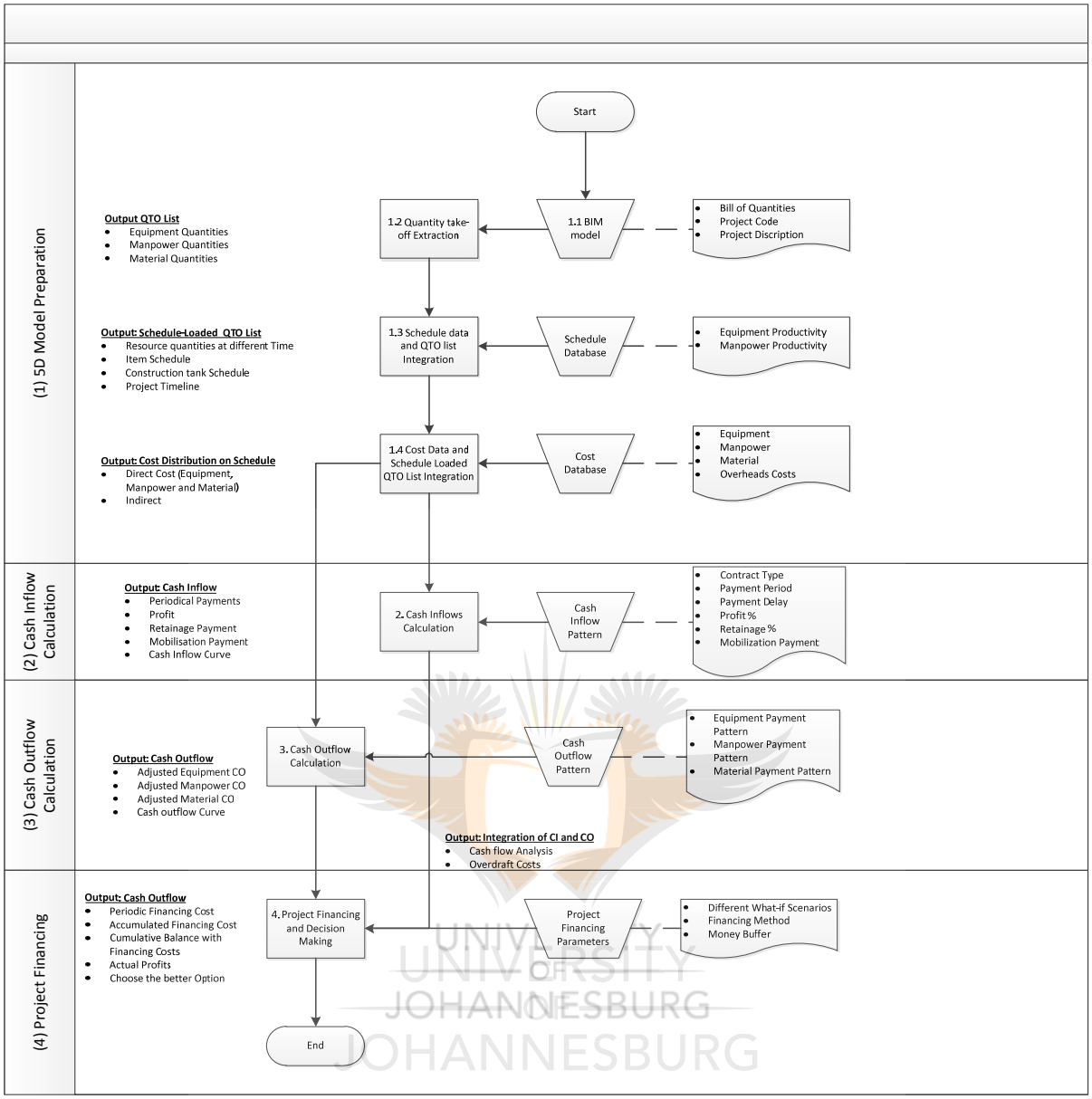


Figure 16: A 5 BIM Framework for Cash-Flow Analysis and Financial Decision Making: Source: [Lu, Q., Won, J., and Cheng, J.C.P., (2016)]

As for Quantity Take-Off (QTO) extraction, Lu et al. (2016) say that, many software tools such as Autodesk Quantity Take-off, Autodesk Navisworks, Vico Office, etc. make a provision for mining out object magnitude take-offs. Figure 16: A 5 BIM Framework for Cash-Flow Analysis and Financial Decision Making: Source: shows the workflow to calculate QTO of a project. The framework can be used by existing software applications to estimate many dimensions of each piece of equipment such as the following:

- extent,
- magnitudes,
- thinness,
- length
- breadth, and

- capacity.

The desired number of elements for all the pieces of equipment and resources, including the schedule database and cost database, are well-defined by the corporation's standard, and they can be stored in the Quantity Surveyor (QS) records.
Following the QS records and adding resources into each element, the following can be calculated:

- amounts of the resource,
- supplies,
- amount of labour, and
- tools.

Lu et al. (2016) further explain that the QTO list with all the resource's data got from the BIM model can then be connected to the outside schedule database to compute the project schedule. Figure 17: The Workflow of Quantity Take-Off: Source: Lu Q. et al. (2016) shows an example of BIM-based scheduling and clarifies the associated expressions. The schedule database comprises of tools, material and labour productivity, which permits approximating the period that is needed for execution for each work item. Some work items can form a construction task. A schedule-loaded QTO list is produced by totalling in a manual manner the logistic sequence amongst the tasks that differ. The project timeline, which only covers the period that is needed for execution of each task, can also be computed by doing away with unused data, such as item and resource measures and schedule.

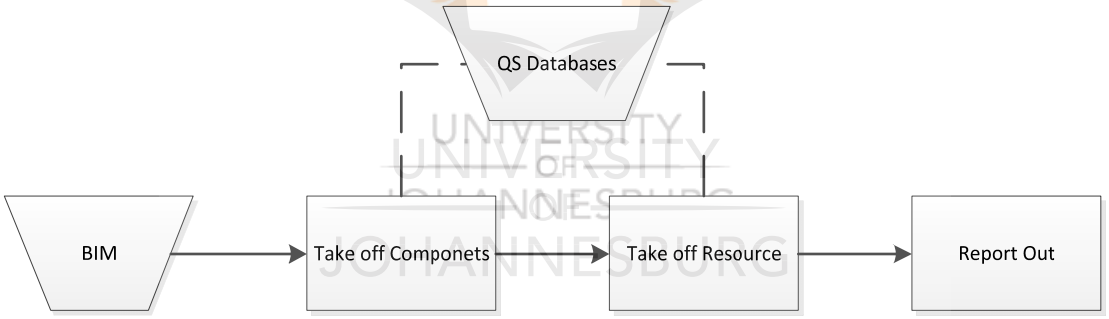


Figure 17: The Workflow of Quantity Take-Off: Source: Lu Q. et al. (2016)

Lu et al. (2016) then mention that the direct cost distribution on the project timetable can be projected by associating the costs that are in the schedule-loaded QTO list with the external database, for the following costs:

- tools,
- amount of labour, and
- costing of the material.

Include the costs for cost line-items such as the tower cranes, material hoists, and scaffolding, which cannot be related in a direct manner to each construction element. Also include the costs that are not direct like

- supervision,
- bonds or insurance,
- clean-up fees,

- etc.

The timeline dossier can then be loaded into the 5D software platform to make the 5D BIM model and by so doing finish 5D simulation. Cash outflow and cash inflow arrays should be well thought-out to allow for precise analysis of the cash inflow and outflow of the entire project.

Items	From Quantity Take Out (QTO) List					From Schedule Database		Calculate Schedule			
	Task ID	Work Item ID	Work Activity ID	Title	Resource Category	Primary Quantity (A)	Productivity (B)	Working Days (=A/B)	Predecessor ID	Predecessor Start	Expected End
Task-----	4			Level 1: Columns (Concrete)				9	3	04/04/2011 8:00	04/15/2011 17:00
Work Item---		4.1		Level 1: Columns (Concrete) - 10X10				3		04/04/2011 8:00	04/07/2011 17:00
Resource--			4.1.1	Rebar #3	Material	2000pd		1		04/04/2011 8:00	04/04/2011 17:00
Resource--				Rodman	Manpower		2000pd/day				
Resource--			4.1.2	Formwork	Material	500sf		1		04/06/2011 8:00	04/06/2011 17:00
Resource--				Formwork Carpenter	Manpower		500sf/day		4.1.1		
Resource--			4.1.3	Concrete 300 psi	Material	5cy		1		04/07/2011 8:00	04/07/2011 17:00
Resource--				Concrete Pourer	Material		5cy/day		4.1.2		
Resource--				Concrete Pumping Equipment	Equipment						
Work Item---		4.2		Level 1: Columns (Concrete) - 18X18	Manpower			6	4.1	04/08/2011 8:00	04/15/2011 17:00
Resource--			4.2.1	Rebar #4	Material	4000pd				04/08/2011 8:00	04/11/2011 17:00
Resource--				Rodman	Manpower		2000pd/day	2			
Resource--			4.2.2	Formwork	Material	1000sf				04/12/2011 8:00	04/13/2011 17:00
Resource--				Formwork Carpenter	Manpower		500sf/day	2	4.2.1		
Resource--			4.2.3	Concrete 350 psi	Material	10cy				04/14/2011 8:00	04/15/2011 17:00
Resource--				Concrete Pourer	Equipment		5cy/day	2	4.2.2		
Resource--				Concrete Pumping Equipment	Manpower						

Note: 04/05/2011 Public Holiday; 04/09/2011 Weekends

Figure 18: Example of BIM Based Scheduling [Source: Lu, Q., Won, J., and Cheng, J.C.P., (2016)]

Lu et al. (2016) then explain the Cash inflow calculation by stating that, the contract type and disbursement scheme can have an effect on the currency inflow. Further kinds of contracts can be assimilated by altering the currency inflow payment arrays in the framework. A contract price per unit contains a quantified set of calculable works' items. A guide amount of works' items is often produced for contractors to estimate the costs.

About decision making for conducting what-if scenarios; Lu et al. (2016) mention that, for a single project can have frame work changes as a result of contract conditions and state of the service providers or customers. Examples of influence factors are as follows:

- 5D preparation
  - changes in design;
  - changes in equipment or labour productivity;
  - changes because different building procedures;
  - changes in resource unit cost;
  - etc.
- Cash-Inflow:
  - Changes because of longer times of payment;
  - Changes because of payment delays;
  - Changes because of retainage percentage;
  - Changes because of the "with or without" mobilization disbursement;
  - etc.

- Cash-Outflow:
  - Changes in lead times for material;
  - Changes in buffer period;
  - etc.
- Project financing:
  - Changes in the financing instrument;
  - Changes in the interest rates;
  - etc.

The service providers or suppliers have different options that are produced by the influence factors, mentioned above, in funding the overdraft facility. A more profitable option must be selected, as mentioned by Lu et al. (2016).

2.10. Total Quality Management

According to Rouse (2017) Total Quality Management (TQM) is defined as a structured and comprehensive method and outlook to the organisation of the organization that wants to increase the quality levels of the products and services. The improvement of the quality of products and services is achieved through constant improvements as an answer to ongoing feedback from the end user. TQM prescripts may be referred to disjointedly for a specific business or may be in observance to the recognized standards and procedures, such as the International Organization for Standardization's ISO 9000 series (refer to ISO 9000 (2005)) and others. It started in the industrial sector and has since been modified for use in nearly all types of businesses or sectors conceivable; these include education sector, hotel management sector, public road maintenance sector, and religious sector. TQM can be applied to any kind of business. Total Quality Management is centered around quality management from the client's view-point, as a current focus of e-business.

Benavides-Velasco, Quintana-García and Marchante-Lara (2014) define Total Quality Management as a extensively acknowledged management philosophy that puts emphasis on constant process improvement in the organizations to deliver higher customer value and satisfy the needs of the customers. And that TQM is bringing about increased profitability and productivity.

Todorut (2012) mentions that Total Quality Management infers the version of standards from ISO 9000 series (refer to ISO 9000 (2005)), which, for the quality system, in ISO 9004 standard, sanctions were offered to organizations that effected quality system and make the next goal to develop it further.

In summary, Total Quality Management can be defined as a organizational leadership method for a customer-focused business that involves all personnel in constant enhancement and upgrading. TQM employs data, strategy, effective communications and strategy to incorporate the quality discipline into the goings-on and ethos of the business.

Among the recommendations of ISO 9004 standard to be met in order to achieve the sustainable success, we can exemplify the following:

- The stakeholders requirements and expectations identification;
- Identification of the organization's results for the achievement of the long-term satisfaction of stakeholders;
- Anticipation of the resources, including skills and technologies to meet the the objectives;
- Decisions that are to be made at the organizational level to effect changes that are necessary to ensure a proper framework for the setting out of operating processes;
- Policy development that is needed for the organization's vision and values to be acknowledged and supported by all participants within that organisation (internally and externally);
- Establish the organizational objectives taking into account both the requirements and expectations of stakeholders and the observing and assessment results and feedback of the external environment of the business and its strategically planned capability assessment;
- Develop and implement the processes for continuous improvement, including benchmarking studies, knowledge and innovation;
- Risk identification.

Todorut (2012) then maintains that some of the organisational management procedures that are precisely linked to the model of sustainable development and the interventions between those organisational management procedures must have a multifaceted management system; which is grounded on TQM codes. Todorut (2012) then says that those organisational management procedures effect in the acceptance of a sustainable development methodology.

Izvercian, Radu, Ivascu and Ardelean (2014) say that TQM is both a viewpoint and a organisational management platform. In applying TQM procedures in a business, the Human Resources Department is vital. The Human Resources Department is vital for the development and the communication of the TQM vision. About the TQM the Human Resources Department is responsible for the following:

- prepares the organizational specifics for the application of TQM processes,
- the actual application and
- supplying the needed support to conserve the interest and fervour.
- act as a swivel and critical go-between in the change-processes with relative analyses of the requirements of the enterprise

- may also improve and convey training plans that reverberate the long-term planned responsibility, mission and vision of the corporation.

In conclusion, the Literature Review shows the following gaps in terms of Total Quality Management within the PMI PMBOK Knowledge Areas' perspective:

1. As mentioned earlier during in this Chapter, in terms of Scope Management Fageha and Aibinu (2013) say that defining project scope by means of contribution from all stakeholders is a vital mission that must be sufficiently done at the initial stage of the project. The purpose of project definition is to make available acceptable data that is required to ascertain the work to be done in order to sidestep main and foremost changes that may affect project performance in a negative manner.
   1.1. Within the Airport Environment, the stakeholders may range from Airport Tenants, Airline Operators, Government Regulatory Bodies (South African Civil Aviation Authority), Airports Company South Africa, Airlines Passengers, Ground Staff, Air Traffic Control and so on.
   1.2. The nature of the wide variety of different stakeholders within the Airport Environment makes it hard to clearly define the scope because of the differing interests; and that is a gap.
2. On time, (regarding scheduling for resources over time) Leung and Li (2016) have clearly shown that scheduling is a product of both proper planning together with understanding the task ahead, such that several activities or tasks can be completed in parallel (where resources and means, machines, are available) or in a staggered fashion as mentioned earlier.
   2.1. This hinges on scope definition; if the scope is not well-defined, as a result of the gap pointed above, proper scheduling may be compromised.
3. As mentioned earlier on Cost, Sato (2009) and also re-affirmed by Sato (2014) cost is related to risk in that cost reduction measures are from time to time linked with greater risks. It is also mentioned that the efforts to reduce costs can be an additional source of the trade-off issues. Using cheaper supplies or resources with inferior qualities may add to critical risks.
   3.1. Again, the point above leads on from bad scoping because of differing interests. This may lead to cost reduction measures which may ultimately lead to increased levels of risk or in turn, concisely, poor quality.
4. As mentioned earlier, regarding quality in project management, Kılıc, Ulusoy and Serifoglu (2008) and supported by Mejía, Niño, Montoya, Sánchez, Palacios and Amodeo (2016) say that the quality of a project is quantified by the quantity of defects. Nicholas and Steyn (2012) mention that quality infers the fit for its purpose nature of a product. They further explain that quality implies the appropriateness for application and purpose. To them, a product of best quality is that which meets and sometimes exceeds the requirements and specifications, both in terms of reliability and price.
   4.1. Again the point above re-emphasises the relationship between Quality, Cost, Time and Budget refer to Figure 2: The relationship between Quality, Budget, Scope and Time.

4.2. This may prove a gap, as it has ventilated that, from the Literature Review that has been conducted, there are gaps identified in terms of Scope Management, Time Management and Cost (or Budget Management).

4.3. On risk, Sato (2009) and also re-affirmed by Sato (2014) say that risk is typically considered to be the likelihood of events that may cause bad effects on project objective or the performance of the project and its end result, the end product or service. There are risks that are positive, or, in other words, opportunities (as opposed to risks) as well, that may have an influence that is positive on achieving project objectives or end result. In other words a good project manager play the pivotal role of balancing the act between ”good” and “bad” risk.. And according to McManners (2016), makes a link bewteen risk with sustanabilty at the levels social, environmental factors and economic. McManners (2016) claims that the **aviation sector** (my emphasis) stands out as the most problematic sector to incoporate sustainability as a concept to be adopted. The UK was chosen for a study of sustainability within its aviation sector. This was because the UK aviation sector had already made attempts in trying to apply sustainability within its operations. The UK Sustainable Development Commission (SDC), which ran operations from 2000 until 2011, carried out an research and analysis of the UK aviation sector. The results of the study showed that there are various stakeholder within many different intersts which are very much polarised. The polarisation of the stakeholder interests proved a barrier for sustainability in that country.

4.3.1. The gap as revealed by the Literature Review is that according to the relationship between Quality, Cost, Time and Budget; risk may be increased as pointed above because of the following:

4.3.1.1. Bad scoping because of differing interests… may lead to cost reduction measures which may in turn lead to increased levels of risk or in turn, concisely, poor quality;

4.3.1.2. Refer to Figure 2, which elaborates on the relationship between Quality, Budget, Scope and Time as agreed with Erasmus (2017).

4.3.2. Gaps identified in terms of Scope Management, Time Management and Cost (or Budget Management).

4.3.3. Poor quality may compromise sustainability.

5. As mentioned earlier, Todorut (2012) maintains that those organisational management procedures effect in the acceptance of a sustainable development methodology.. Izvercian et al. (2014) say that TQM is both a viewpoint and a organisational management platform. In applying TQM procedures in a business, the Human Resources Department is vital.

5.1. From point no. 4.3 above, the gap identified is sustainability (or sustainable development) that may be compromised by increased risk.

5.2. Point No. 4.3 above, points out the relationship Quality, Cost, Time and Budget… and hence an established relationship with risk; this in turn shows a gap in terms of sustainable development.

3. Research Design

3.1. Introduction

This chapter attempts to illustrate the methods that were used in the attempt to answer the questions that were asked in the first chapter.

It is envisaged that the Lean Six Sigma (LSS) Methodology will be used for the purposes of seeking the answers to answer the questions posed on the first chapter.

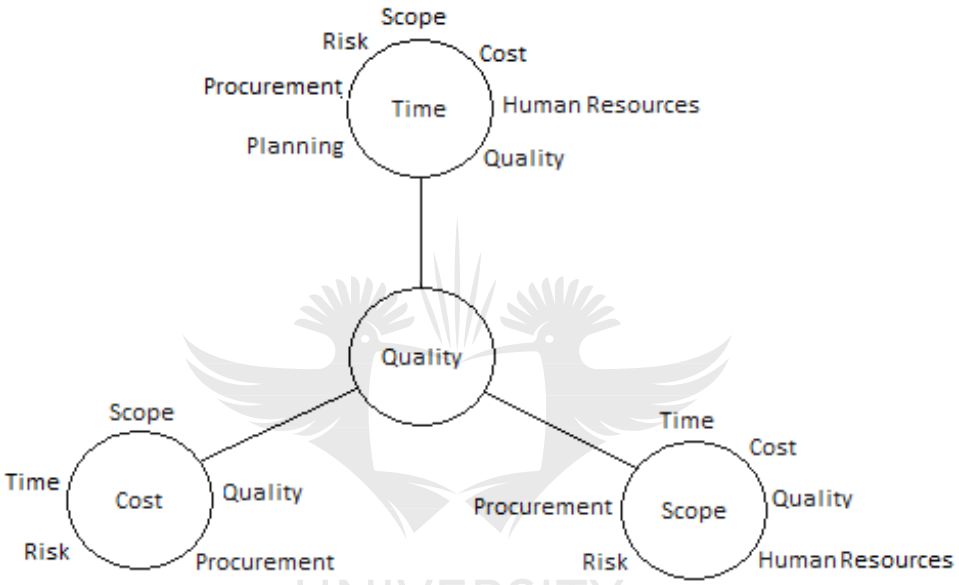


Figure 19: How Quality is affected by the PMBOK's Knowledge Areas

From Figure 19: How Quality is affected by the PMBOK's Knowledge Areas above one can then deduce the following:

Scope (Time, Cost) ≠ Cost (Scope, Time) ≠ Time (Cost, Scope)

This means that any changes in either Scope, Cost and/or Time affects Quality.

The Survey Questionnaire questions ware based on the DANAIC Methodology for the analysis. Moreover, the Ishikawa conclusions were drawn from the same methodology.

According to Radnor (2010) typical tools and techniques associated with Business Process Improvement Methodology (BPIM) include process mapping, Kaizen events, '5S', 2 visual management, 1 value stream mapping and the Define, Measure, Analyse, Improve and

Control (DMAIC) methodology for Six Sigma. For this study DMAIC is envisaged as the preferred method of analysis.

To define the DMAIC Methodology as proposed by De Mast and Lokkerbol (2012) mentions that:

Define: The processes of problem selection and benefit-analysis:

D1. The identification and mapping of relevant processes.

D2. The identification of all the stakeholders.

D3. The determination and prioritization of the needs of the customer and the customer's specification.

D4. The creation of a business case for the project.

Measure: The translation of the problematic issue into a quantifiable manner, and measurement of the present state of things; refined description of the goals:

M1. The selection of one or more (Critical To Quality Trees) CTQs.

M2. The Determination of the operational definitions for CTQs and the specifications.

M3. The validation of the measurement schemes of the CTQs.

M4. The assessment of the present process fitness to deliver on quality.

M5. The definition of the objectives.

Analyse: The identification of influence factors and causes that define the CTQs' behaviour:

A1. The identification of the possible influence factors.

A2. The selection of the vital few influence factors (vital few Xs).

Improve: The design and application of alterations to the process to increase the performance of the CTQs:

I1. The quantification of the relationships between vital few Xs and CTQs.

I2. The design actions that are needed to transform the process or settings of influence factors such that the CTQs are optimized.

I3. The implementation of a pilot test of improvement activities.

Control: The empirical confirmation of the project's outcomes and alteration of the process' management and control system in order that enhancements are sustainable:

C1. The determination of the new process ability.

C2. The implementation of the control strategies.

The DMAIC (Define, Measure, Analyse, Improve and Control) Methodology as proposed by De Mast and Lokkerbol (2012) has been used to assess quality for this research, in the form of Questionnaires.

The Research Design is the logic that links the information that has been collected during a research to the question of the research and in the process help to answer the research question.

Quantitative Research Methods are used. Quantitative Research Methods are used in the form of Statistical Interpretation of the Survey Results. And also, the Qualitative Research Methods are used to interpret the results that are sought through Interviews and it seeks to answer the "*why and how*" of the research question.

Tsai, Kohrt, Matthews, Betancourt, Lee, Papachristos, Weiser and Dworkin (2016) say Qualitative Studies are based on information that is essentially dissimilar to the information that has been gathered in other observational study designs. The varied viewpoints of study participants along pre-set continua (example: categorical or continuous) are tightened by the homogeneous measures that are used in quantitative studies. The prearranged continua can be statistically accrued, collected and amassed. Quantitative data analysis plans and study protocols can be prespecified, dispersed and disseminated. The gathered data can be treated as anonymous and it can be uploaded to protected data depositories in a confidential manner. The statistical code used to process the data can just as be shared with ease and it can be simulated. In addition, the process through which the output is interpreted into the manuscript text and tables. The researchers that are external can then investigate and analyse the electronic paper trail to confirm the published findings. Information-sharing or data-sharing, in effect, is "a threat that might keep potential cheaters honest". In contrast, the information compiled through qualitative studies is typically obtained through the following means:

- in-depth interviews,
- direct observation,
- focus groups,
- audio recording reviews and
- document reviews.

Tsai et al. (2016) continue to mention that the information lends itself to generating new theoretical discernments and understanding about certain occurrences better than it is likely by quantitative designs, while that identical information is typically not meant for the establishment of a generalization. While corresponding to other ways of social measurement, this info is also neither gathered nor analysed in as linearly, and it has been contended that the idea of reliability does not directly translate from the following:

- measurability to the qualitative (naturalistic) paradigm,
- nor being quantitative (rationalistic) to the qualitative (naturalistic) paradigm.

3.2. Research Methodology

To satisfy the needs of a Quantitative Research Methodology, a set of survey questionnaires has been drawn and distributed to a sample of research participants. The Survey Questionnaires on the Appendix 7: Sample Survey Questionnaire, 9, 10, 11, 12, 13 and 14 were distributed to the following groups of respondents, both within ACSA and also ACSA Contractors, who are directly involved in the Project Life Cycle:

- ACSA Procurement Department
- ACSA Finance Department
- ACSA Project Management Department
- ACSA Maintenance Department
- ACSA Safety and Compliance Department
- ACSA Contractors
- ACSA Senior Management
- TQM Criteria (Distributed to all respondents)

The following is the statistical outcomes of the survey:

- *A Consolidated Results' Report*
- *"Yes or No Selection" Results*
- *Cronbach's Alpha Test*

The Survey Questions with Option1 to Option 5 were put through the Cronbach's Alpha Test. The Cronbach's Alpha Test tests for Internal Consistency of Reliability of the Data Sample and renders a coefficient of 0,00 to 1,00.

The Ishikawa Model has been used to assess the effectiveness and efficiency to answer the question "*What needs to be done to ensure Total Quality Management is implemented at OR Tambo International Airport in terms of the operations and the airport's projects?".*

3.3. Limitations

The research is focused on Total Quality Management within the Project Management sphere and Airside Projects to be particular, hence the questionnaires excluded the general Project Management Knowledge Areas as spelt out in the PMI's PMBOK.

Also, the sample is limited to only those respondents who were willing to disclose the views about how the projects are managed in terms of the TQM, based on the survey questionnaires.

Another limitation is the time factor; given the duration of this research time is a very much limited resource.

The scarcity of peer-reviewed literature about the Airport Airside Project Management proves a major limitation.

3.4. Assumptions

It is assumed that the respondents who responded to the survey questionnaires have adequate experience within their fields of expertise as they are appointed professionals.

And that all the respondents who responded to the survey questionnaires were in a rational state of mind when responding to the Questionnaires.

Also, given the time limitation stated above; it is assumed that the sample of respondents to the survey questionnaires is enough to get conclusive results that will enable the research to answer the research question which is stated in the beginning on this dissertation.

3.5. Ethical Considerations

A permission to carry out this research has been sought and received from the ACSA Senior Management.

The research seeks to answer the research question which is stated in the beginning on this dissertation and thus also not to impugn the judgement and experiences of the research survey questionnaire – hence where and when the respondents request to be anonymous; their identities are treated anonymous.

No minors, in terms of “age of consent”, have been interviewed or participated in the research survey questionnaires.

4. Findings and Discussion

The following are the consolidated results from the Questionnaire Survey that has been conducted at the OR Tambo International Airport during the January and February 2017 period. DMAIC is used as the basis for the Survey Questionnaires as stated by De Mast and Lokkerbol (2012)*.

It shows that even though the airport has adopted some form of Quality Management; it relies mainly subjective feedback methods. The airport has adopted the ASQ Survey System which relies mainly on subjective, anonymous and random feedback.

General

"**Define**: Problem selection and benefit analysis*	No. of 1	No. of 2	No. of 3	No. of 4	No. of 5	Highest Response	
D1. Are all the Total Quality Management (TQM) processes identified and mapped?	6	11	7	4		2	Disagree
D2. Are all the Project management Stakeholders easily identifiable?	1	4	3	16	3	4	Agree
D3. How easy is it to identify and prioritise the End-User's needs and requirements?	1	5	7	10	1	4	Agree
D4. Do all ACSA Projects have a Business Case for the project?	1	1	3	9	12	5	Strongly Agree

Measure: Translation of the problem into a measurable form, and measurement of the current situation; refined definition of objectives*

M1. Is a selection one or more Critical-To-Quality Trees (CTQs) done for every Project?	8	7	10	2		3	I Do Not Know
M2. Are all the operational definitions for CTQs and requirements determined?	6	8	9	5		3	I Do Not Know
M3. For every Project we validate measurement systems of the CTQs.	6	10	7	3	1	2	Disagree
M4. For every Project we assess the current process capability.	4	8	7	6	2	2	Disagree
M5. For every Project objectives are defined.	3		3	13	7	4	Agree

Analyse: Identification of influence factors and causes that determine the CTQs' behaviour*

A1. For every Project we identify potential influence factors.	3	4	6	11	3	4	Agree
A2. We then select the vital few influence factors.	3	5	7	9	2	4	Agree

Improve: Design and implementation of adjustments to the process to improve the performance of the CTQs*

I1. For every Project we quantify CTQs.	4	9	7	7		2	Disagree
I2. For every Project we design actions to modify the process	4	9	4	7	1	2	Disagree
Or settings of influence factors in such a way that the CTQs are optimized.	1	8	6	2		2	Disagree
I3. For every Project we conduct pilot test of improvement actions.	2	10	7	2		2	Disagree

Control: Empirical verification of the project's results and adjustment of the process management* and control system in order that improvements are sustainable

C1. For every Project we determine the new process capability.	3	9	8	6	2	2	Disagree
C2. For every Project we implement control plans.	2	9	9	4	3	3	Both the "I Do Not Know" and "Disagree"

Does the Organisation's Maintenance Plan incorporate the TQM Framework?

Scale 1 - 5

	4	7	6	8	1	4	Agree

Does the Senior Management demonstrate an ability to manage the changes that needed to improve the quality, in terms of TQM?

Scale 1 - 5	3	8	5	11	1	4	Agree

Does the Senior Management maintain an environment that enables and promote quality improvement?

Scale 1 - 5	3	10	5	8	2	2	Disagree

Does the Senior Management take part in activities to improve the quality on a regular basis?

Scale 1 - 5	4	12	3	8	1	2	Disagree

Is the CEO and Senior Management are a primary driving force behind quality improvement efforts?

Scale 1 - 5	1	9	8	9	1	4	Both "Agree" and "Disagree"

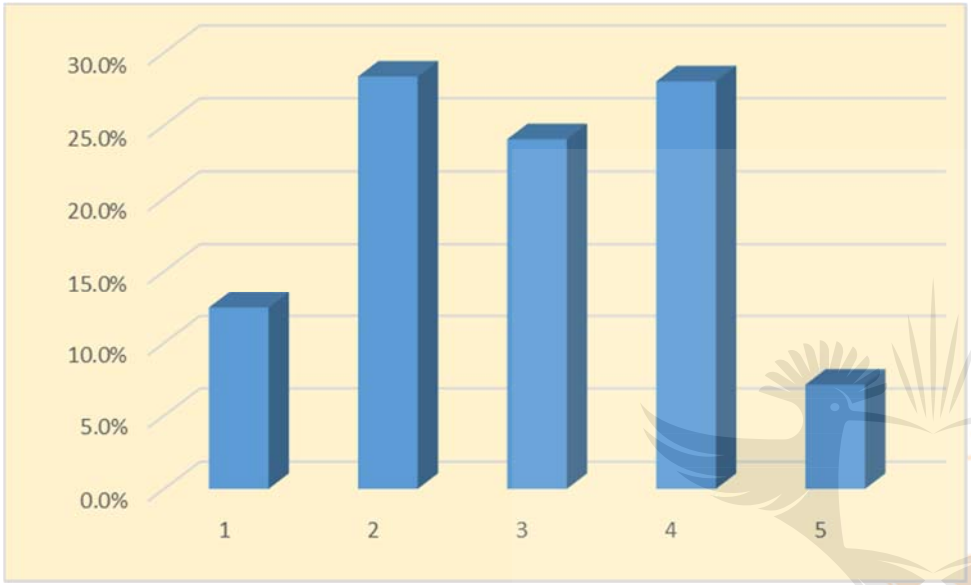
Does Senior Management have the information on needs and suggestions for quality improvement directly for Project Management?

Scale 1 - 5	2	8	8	9		4	Agree

Does the Senior Management encourage quality improvement by showing confidence in quality improvement initiatives?

Scale 1 - 5							
	75	**171**	**145**	**169**	**43**		
	12.4%	**28.4%**	**24.0%**	**28.0%**	**7.1%**		

Consolidated Survey Results (Graphical)



Does the Company have Quality Management Strategy, Implementation, Assurance, Accreditation, Etc.?

1 is Strongly Disagree

2 is Disagree

3 is I do not know

4 is Agree

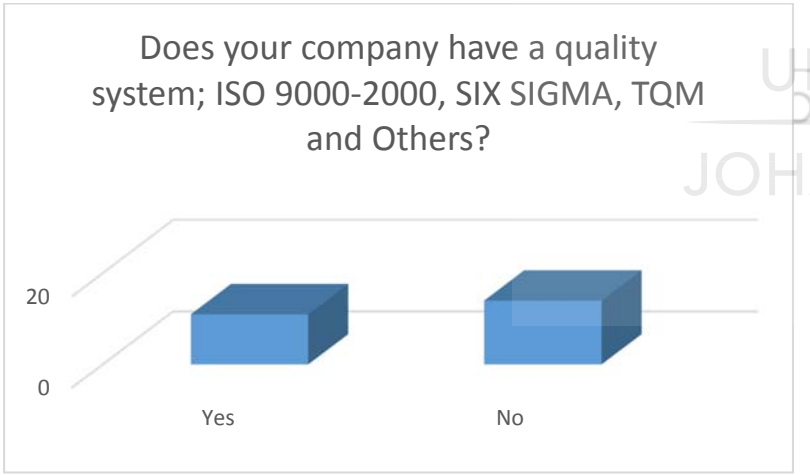
5 is Strongly Agree

The following are the consolidated results of the "Yes" or "No" Answers:

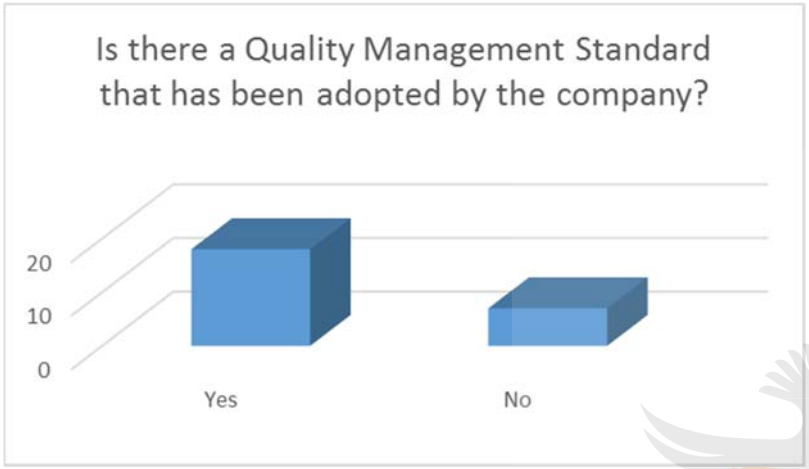
	Yes	**No**
Is your company accredited?	10	12
Does your company have a quality system; ISO 9000-2000, SIX SIGMA, TQM and Others?	11	14
Is there a Quality Management Standard that has been adopted by the company?	18	7
On its Governance Framework, does the company have a Quality Standard and/or Procedure?	15	12
Are employees involved in decision-making?	16	12
Is communication between Senior Management and staff effective?	15	12
Are there Quality Measurement Systems in place that have been adopted by the company (i.e. ASQ)?	21	5
Does the company measure customer satisfaction?	26	1
Are views and ideas from the customer entertained by the company?	23	4
Are employees satisfied with the company?	16	10
Does the company resist change?	9	17
Total	**180**	**106**

"Yes or No Selection" Results 1

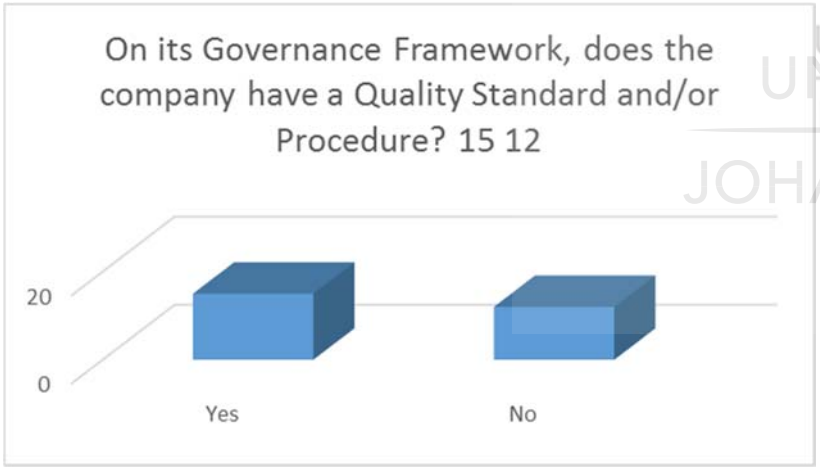
"Yes or No Selection" Results 2



"Yes or No Selection" Results 3

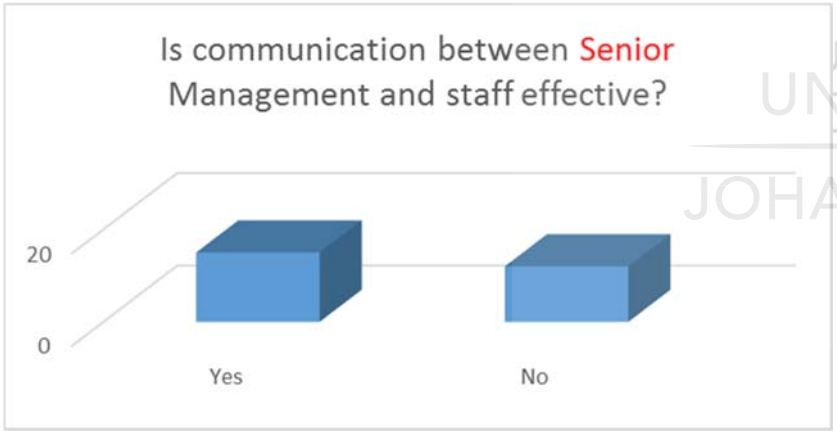


"Yes or No Selection" Results 4

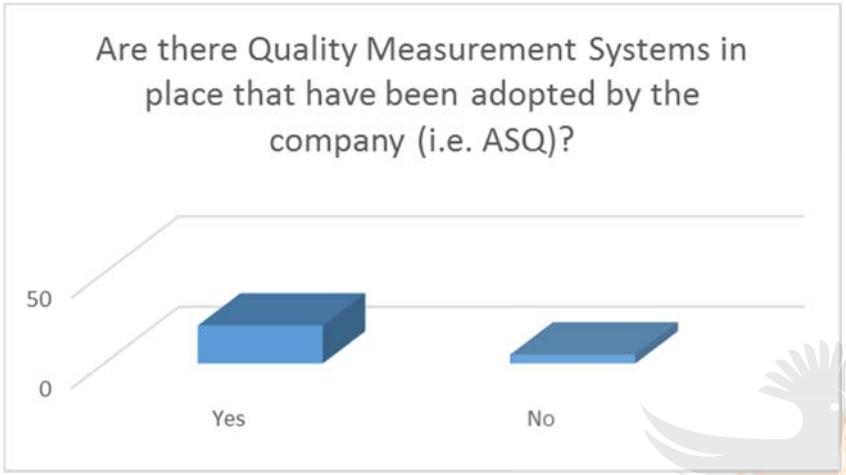


"Yes or No Selection" Results 5

"Yes or No Selection" Results 6

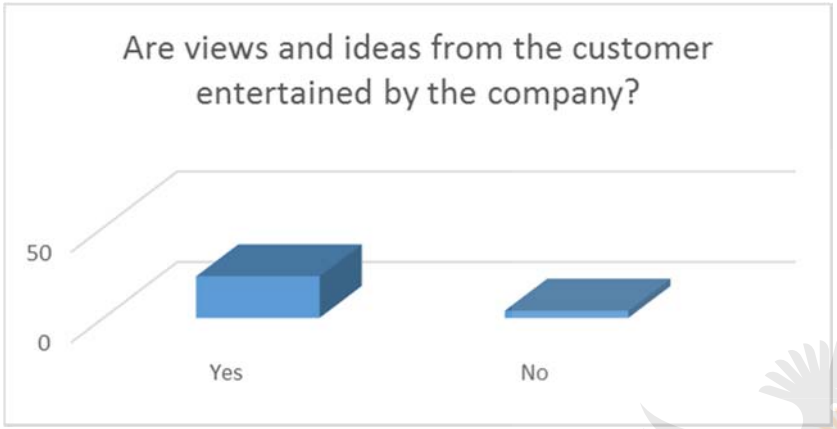


"Yes or No Selection" Results 7

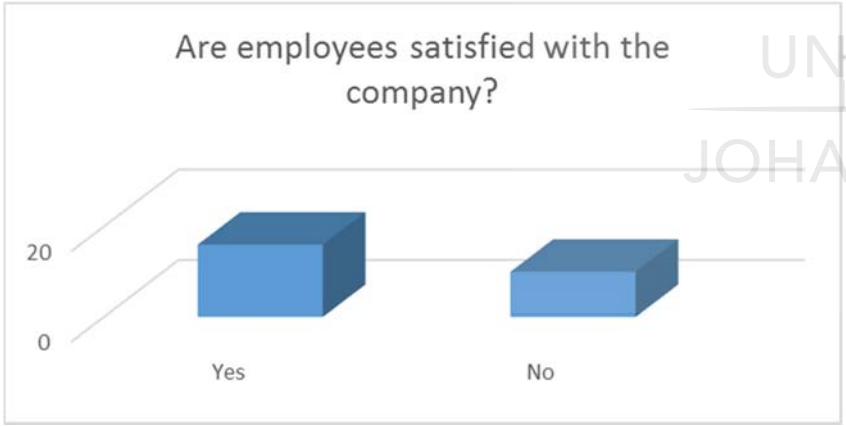


"Yes or No Selection" Results 8

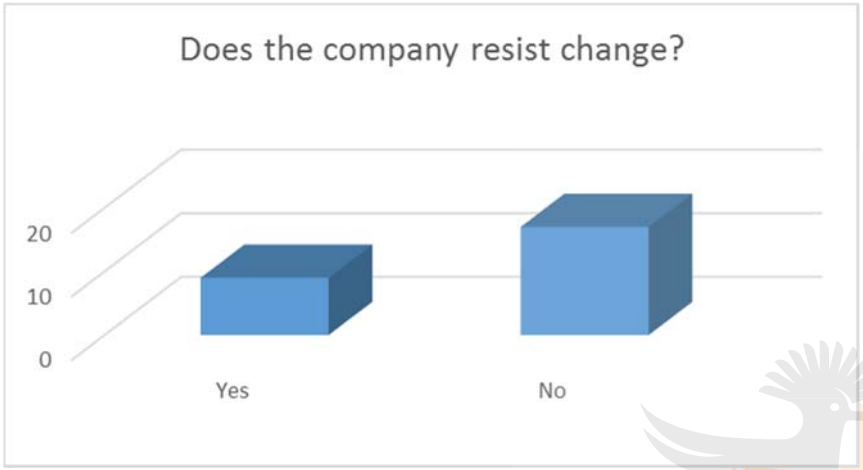
"Yes or No Selection" Results 9



"Yes or No Selection" Results 10



"Yes or No Selection" Results 11



Cronbach Alpha Test

The Survey Questions with Option1 to Option 5 were put through the Cronbach's Alpha Test.

De Vet, Mokkink, Mosmuller and Terwee (2017) also claim that Cronbach Alpha may be used to prove the test for internal consistency of results.

The Cronbach's Alpha Test tests for Internal Consistency of Reliability of the Data Sample and renders a coefficient of 0,00 to 1,00. The coefficient of 0,00 means that there is no "Consistency" in Measurement. The coefficient of 1,00 means that there is a perfect "Consistency" in Measurement. For example, the coefficient of 7,00 means that 70% of variance in the scores is reliable and that 30% is error variance.

For this research the Cronbach's Alpha Test returned a coefficient is 0,872 (Refer to Appendix 21: Cronbach's Alpha Test Results). Refer to Appendix 21: Cronbach's Alpha Test Results for the Data Set and calculations thereof for the Cronbach Alpha Test Analysis that has been performed.
For the full Cronbach Alpha Test refer to Appendix 21: Cronbach's Alpha Test ResultsBelow are the Cronbach Alpha Test Results done on "Anova: Two-Factor Without Replication":

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Rows	189.02	23	8.2182	7.8347	1E-22
Columns	386.24	27	14.305	13.638	8E-47
Error	651.4	621	1.049		
Total	1226.7	671			

Cronbach's Alpha = 0.8724

Due to the limitations of this research, the author wishes that a broader understanding of the TQM Field of Study could be done.

- The Research Design is the logic that links the information that has been collected during a research to the question of the research and in the process help to answer the research question "*What needs to be done to ensure Total Quality Management is implemented at OR Tambo International Airport in terms of the operations and the airport's projects?"*.

The Literature Review and the Survey Questionnaires revealed that Total Quality Management has been compromised in and may result in poor quality because possible factors such as presented in the Ishikawa Diagram below:

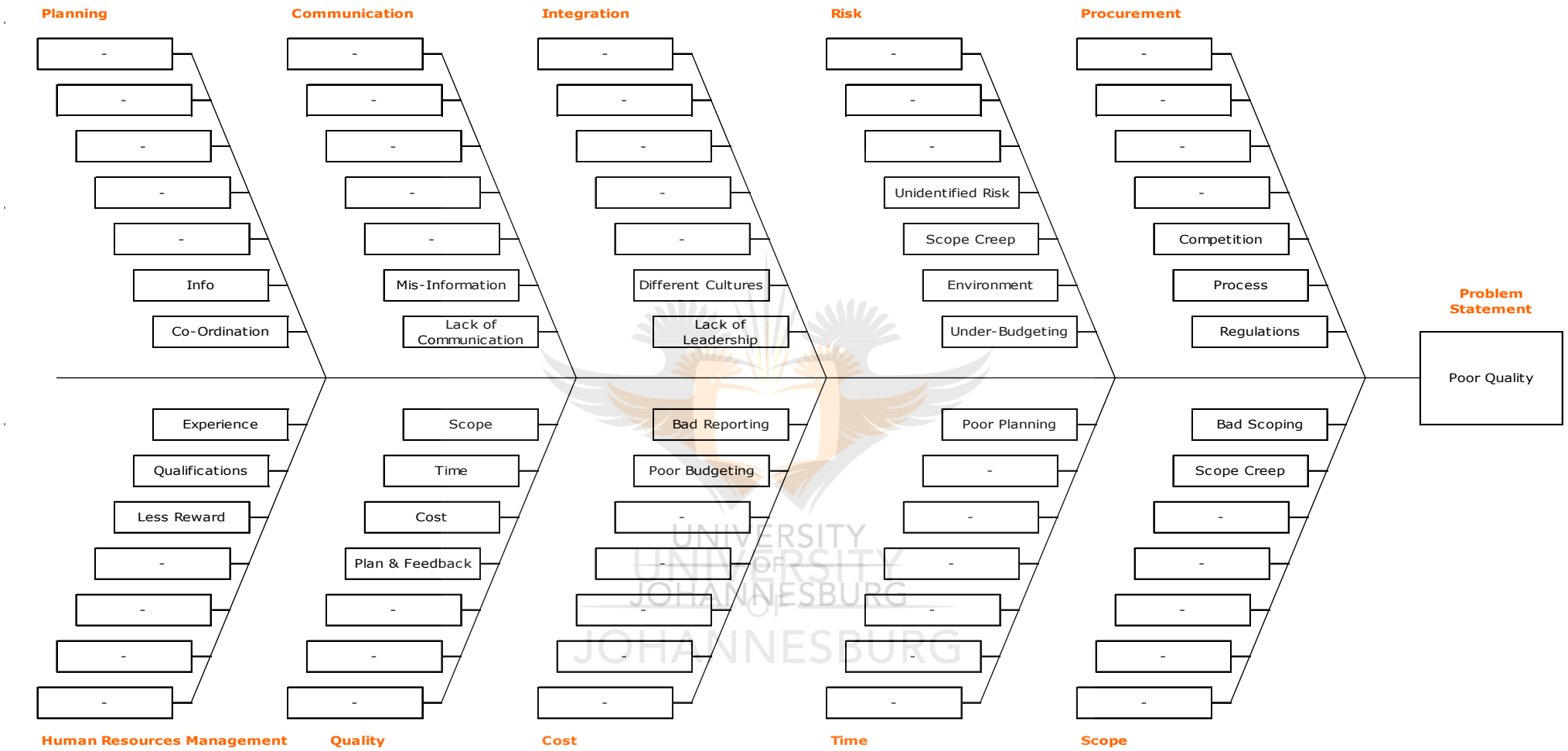


Figure 20: A Fishbone Model depicting Possible Sources of Poor Project Quality

5. Conclusions and Recommendations

The conclusion is based mainly from the responses from the Questionnaires and it is supported by the research done by the author. In addition, conclusion is supported by findings in terms of gaps that were identified during Literature Review.

5.1. Introduction

The main objective of this enquiry was to assess the compliance of the OR Tambo International Airport in terms of Total Quality Management, as there may be non-compliances in terms of application within its operations; namely maintenance and projects. It is to verify whether or not optimal measures are put in place to ensure Total Quality Management. This enquiry focuses on the Project Management Institute Knowledge Areas and compliance in terms of Quality Management. The study shows that the findings do however point to a few factors that may compromise the airport in terms of Total Quality Management. The next section points to the findings of this research.

5.2. Findings

- From the Research Questionnaires Surveys, it has been noted that even though the company has some form of Quality Management; it is subjective in nature. The company relies mostly ASQ Survey Questionnaires, which rely mostly on subjective feedback on a random and anonymous basis.

- From the Literature Review, it is clear that both subjective and objective measures must be adopted for an optimal Total Quality Management System.

- As for the Scope Management within the Total Quality Management perspective, Fageha and Aibinu (2013) say that all the affected stakeholders need to give an input to define the scope of the works, and as such, their input is invaluable. Scope definition is done to avoid major changes in the scope as the project progresses.
    - The nature of the wide variety of different stakeholders within the Airport Environment makes it hard to clearly define the scope because of the differing interests that are sometimes at odds and may also oppose each other. It is a hard balancing act to satisfy all the differing interests with the same scope definition.

- On time, regarding scheduling for resources over time Leung and Li (2016) have clearly shown that the relationship between scheduling and planning hinges on understanding the scope.
    - If the scope is not well-defined (because of the different or wide-ranging interest from different stakeholders) proper scheduling may be compromised.

- The finding above then leads to the issue on cost; Sato (2009) says that cost is related to risk and that the use of cheap materials or resources with inferior quality may cause an upsurge of risk.

- Bad scoping may lead to cost reduction measures which may in turn lead to increased levels of risk or in turn, consequently, poor quality.
- Then, in terms of our research, costing and risk proves a gap within the scope of this research.
- Nicholas and Steyn (2012) relate quality as an implication. They mention that Changes Quality imply Changes in either Cost, Time and Budget congruently.

- On risk, Sato et al. (2009) say that risk is the likelihood of events happening that may lead to adversative impact on project objective or performance. Sato et al. (2009) then say that there are positive risks that may trigger positive impact on attaining project objectives and this infers that there are also negative risks that may bring about unwanted results. In other words a good project manager play the pivotal role of balancing the act between ”good” and “bad” risk. And according to McManners P. J. (2016), there is an increasing drive for the conception of sustainability as a concept of quality management or per se TQM.
  - According to the relationship between Quality, Cost, Time and Budget; risk may be increased as pointed above because of the following:
    - bad scoping because of differing interests, which may lead to cost reduction measures which may in turn lead to increased levels of risk or in turn, poor quality;
    - Poor quality may compromise sustainability as mentioned by Todorut (2012).

- Also, another glaringly clear finding is that there is a negative answer (namely “Strongly Disagree and/or Disagree”) to the generalised question “Does the Company have Quality Management Strategy, Implementation, Assurance, Accreditation, Etc.?”… 40,8%. This is compared with the combined positive (Agree and/or Strongly Agree”) response of 35,2%; with an undecided (“I do not know”) response of 24%.

- The Survey Questions with Option1 to Option 5 were put through the Cronbach’s Alpha Test. The Cronbach’s Alpha Test tests for Internal Consistency of Reliability of the Data Sample and renders a coefficient of 0,00 to 1,00. The coefficient of 0,00 means that there is no “Consistency” in Measurement. The coefficient of 1,00 means that there is a perfect “Consistency” in Measurement. For example, the coefficient of 7,00 means that 70% of variance in the scores is reliable and that 30% is error variance.

  - The Cronbach’s Alpha Test Results

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	189	23	8.218	7.835	1E-22	1.547
Columns	386.2	27	14.31	13.64	8E-47	1.504
Error	651.4	621	1.049			
Total	1227	671				
Cronbach's Alpha:			**0.872**			

- For this research the Cronbach's Alpha Test returned a coefficient is 0,872 (Refer to Appendix 21: Cronbach's Alpha Test Results).

- Lastly, the following are the recommendations:
    - A clear Quality Management Strategy, and/or Guideline which is based on sound standards needs to be adopted urgently by the company.
    - The company must seek and get Quality Management Accreditation as a matter of urgency.
    - Also, the company must make Quality Management a priority and it must be adopted across the board across the "rank-and-file" of its human resources. And also that Total Quality Management principles must be adopted by all within its employ including "Suppliers and Contractors".

As it can be seen earlier, Rouse (2017) defines Total Quality Management (TQM) as a structured and comprehensive approach to organizational management that strive for the improvement of the quality of project deliverables and services. The enhancement of the quality of products and services is achieved through constant improvements as an answer to ongoing feedback from the end user. TQM requirements may be referred to disjointedly for a particular business or may be in observance of generally recognized and generally accepted standards and procedures, such as the International Organization for Standardization's ISO 9000 series (refer to ISO 9000 (2005)) and others. TQM requires the involvement of all the stakeholders and as such requires a common understanding from all the stakeholder that are involved in the project. Thus, the author recommends that ACSA OR Tambo International Airport should adopt the TQM as a working model.

Benavides-Velasco, Quintana-García and Marchante-Lara (2014) define Total Quality Management as a extensively acknowledged management philosophy that puts emphasis on constant improvement of the processes of the organizations to deliver higher customer value and satisfy the requirements of the customers. And that TQM is bringing about increased profitability and productivity.

5.3. Recommendations and Limitations

To round it all up, the following are the recommendations:

- A "Metric System", or say a system of measurables, must be defined, listed and adopted by the organisation so as to allow a more balanced approach to quality Management. The company must, as a minimum, adopt a TQM Framework that encompasses all the requirements of industry standards such as ISO and not only rely on subject measures that it currently uses such as ASQ Questionnaires.
    - Instead of only relying on, say customer satisfaction indexes and employee satisfaction indexes and so on and so forth, a point score system must be developed.
    - For Service Departments, like Customer Care, a benchmarking system must be adopted. The benchmarking ensure best practice policies are adopted.

    - Once the benchmarking is adopted then the measurables must be adopted, for an example, in terms of cleanliness, an area within the airport must be deemed clean if it meets the benchmark. That is to say, if it cleaning teams have achieved the amount of set goals, such as, the number of window washings per week, the number of cleaner per square area, etcetera; and the measure for cleanliness must not only be perception.
- Both the current method of the company's Quality Management, which relies mostly on subjective feedback, together with the proposed "Metric System" of measurables, which is mostly objective by nature, must be used concurrently.
- For every project, the stakeholders' input must be acknowledged and entertained or otherwise dismissed; on time.
    - Where there are conflicting stakeholder interests a resolution must be reached timeously.
    - To meet the requirements of Fageha and Aibinu (2013) the project, the project manager needs to act promptly to satisfy all the divided interests.
    - Proper scheduling has to be done and it must meet the requirements of the PMBOK in terms of the TQM.
    - As Mirza et al. (2013) confirm the statements above when they say that a correctly well-defined and managed scope brings about a quality product, in approved budget and within indicated timelines to the stake-holders and end-users.
- As for cost, Allahverdi (2015) concludes that the firms are forced by the global economy to be competitively economically viable such that they survive and thrive.
    - This concludes that organisations must have higher production rates, eradicate wastage and nuisance undertakings, and increase the effective and efficient use of its resources in terms of the Lean Six Sigma Method.
    - Further, I would recommend that the standard process of project planning should include the work breakdown structure (WBS) definition, development of activity network, cost estimation and timeline estimate of individual activities, and risk analysis as stated by Sato (2009).
        - Risk analysis includes and requires that :
            - The probable risk chances and their pertinent causes must be identified,
            - The likelihood and effect of each risk must be assessed,
            - Risks must be classified and prioritized, and
            - The risk response strategies and trade-off strategies must be developed and implemented. Then, the project cost is reconsidered and confirmed. The trade-off problem transpires from this stage, particularly with the preventive type of risk mitigation decisions bearing in mind the ad-hoc or corrective risk mitigation strategy.
        - I concur with Sato, T. (2009) regarding risk. Risk response strategies can be characterised into two types: pre-emptive and ad-hoc.
            - The risk response strategies are dependent on the types of risk-causes and the drivers of risk. Some instigators of risk can be alleviated with extra upfront costs to lessen or eliminate the risk.

- From the Questionnaire Surveys, one of the conclusions that can be drawn up is that the company in question needs proper accreditation with a credible Quality Assurance Regulator in terms of tried and tested standards like ISO 9000 (refer to ISO 9000 (2005)) as stipulated by Todorut (2012) regarding Total Quality Management. As a bare minimum standard, ISO 55 000 can be adopted (refer to ISO 55 000 (2014.
    - A clear Quality Management Strategy, and/or Guideline which is based on sound standards needs to be adopted urgently by the company.
    - The company must seek and get Quality Management Accreditation as a matter of urgency.
    - Also, the company must make Total Quality Management a priority and it must be adopted across the board across the rank-and-file of its human resources. And also that Total Quality Management principles must be adopted by all within the whole vale chain system including suppliers and contractors and sub-contractors.
- An objective approach to Total Quality Management must be adopted by using benchmarking with recognized industry standards and other TQM Techniques to achieve the required levels of quality in its operations.

5.4. Future Research

Todorut (2012) then maintains that certain management procedures that are specific to the model of sustainable development and the interventions between those management procedures need a complex management system; which is based on TQM principles. Todorut (2012) then says that those management procedures result in the adoption of a sustainable development approach.

There is room for future research in terms of defining the sustainable development with the framework of Total Quality Management including aspects like Lean Production, Six Sigma and the likes.

A more focused research is suggested to create an acceptable benchmark for system development, operation and maintenance such that a systems approach is achieved which supports sustainability within the TQM framework.

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Appendix 1: RPV Calculation Equations: Sato and Hirao (2013)

According to Sato and Hirao (2013) RPV at the instance afore the beginning of activity number i can be tabulated by the following equation:

$$RPV_i = \sum_{k=1}^{i=1} \left(S_k - S_k\right)\frac{n\pi x}{L}\Big) + [(1 - r_i)(S_i + H_i) - C_i] \qquad \text{Equation 3}$$

Where:

$$RPV_i = \sum_{k=i+1}^{N} \left(S_k \prod_{j=i+1}^{k}(1 - r_j) - C_k \prod_{j=i+1}^{k}(1 - r_j)\right)] \text{ and } r_0 = 1 \qquad \text{Equation 4}$$

And
C_i is Initial Expense
S_i is Final Income
R_i is Risk Probability, which is the Probability of Termination
S_i is the Income term
H_i is the anticipated future cash flows after activity i

And

$$CV_i = RPV_{i+1} - RPV_i \qquad \text{Equation 5}$$

Sato et al. (2013) then say that it must be noted that risk probability r is proportionate to CV.

Sato. et al further say that the CV of the last activity N is presented as the difference of RPV_N and the complete cash-flows attained after all the activities have been efficaciously finished:

$$CV_i = \sum_{k=1}^{N}(S_k - C_k) - RPV_N) \qquad \text{Equation 6}$$

From Equations 3 and 4, the following relationship is the resultant relationship:

$$CV_i = r_i(S_i - H_i) \qquad \text{Equation 7}$$

Sato. et al further say for this type of projet CV_i is also proportionate to the likelihood of risk.

Appendix 3: Equation to calculate the performance of the system: Dubi (2006)

Dubi (2006) then says that as a basis for calculation to solve the optimization problem is to take the system's performance as a function of the resources that maintain that performance. It can been revealed that the entire systems conform to the general transport equation as represented below:

$$\psi(\vec{B},\vec{\tau},t)=\sum_{\vec{B'}}\int_0^t\int_{\tau'}\psi(\vec{B}',\vec{\tau}',t')K(\vec{B}',t'\rightarrow\vec{B},t)d\vec{\tau}'dt'$$

Equation 8

With K(B', t '→B, t) as the transport kernel given that the probability density of the system starts approaching state B' at instance t.

Appendix 4: Equation for calculating Performance Detection: Fei, Haibin, Chengguang and Sihao (2007)

On Reliability Mathematics (Fei, Haibin, Chengguang and Sihao, 2007) say that in performance detection of the projectile of the rocket's reliability test characteristically is detection of a sample, the suitable extent of magnitude of the sample is the least sample extent of magnitude depending on the accuracy of meeting data processing. In the course of the reliability experiment the extent of magnitude of the sample of all the performance detection tests are calculated as follows:

$$n = \frac{Z^2(1-\gamma)/2(p_0 - p_0^{\ 2})/d^2}{1+1/N[Z^2{}_{(1-\gamma)/2}(p_0 - p_0^{\ 2})/d^2 - 1]} \quad \text{V1VI}$$

In the formula∠

γ : confidence level//

$Z_{(1-\gamma)/2}$: normal fractile//

N : number of measured rocket projectile//

P_0 : percent defective provided by experience//

d : absolute error permitted with experiment.

Equation 9

Appendix 5: Notes for the Questionnaires

Notes for the Questionnaire

1. You may disclose your identity (Anonymity is Guaranteed).

   If **you do not wish to disclose** your identity; at least, state the following:

   a. your position,

   b. your employer (company) and

   c. how your employer (company) relates to ACSA e.g. Contractor or Supplier.

2. ACSA is the Airports Company South Africa.

3. TQM is Total Quality Management.

4. CTQs are the Critical To Quality Trees.

5. QMS is the Quality Management System.

6. The ISO9000-2000 is a Quality Management System standard.

7. Six Sigma is a controlled, information-driven method and methodology for eradicating flaws or non-compliances in terms of Total Quality Management…

8. ASQ is the American Society for Quality.

9. For the Survey Questions that have the Options 1, 2, 3, 4 and 5 (Select **only one** "Option"):

   a. Option 1: I Completely Disagree

   b. Option 2: I Disagree

   c. Option 3: I Do Not Know

   d. Option 4: I Agree

   e. Option 5: I agree Affirmatively

10. For the Survey Questions that have the "Yes" or "No" Options (Select **only one** "Option"):

    a. Option "Yes": I agree with the statement or the answer to the question is TRUE.

    b. Option "No": I disagree with the statement or the answer to the question is FALSE.

Appendix 6: Consent to Do Research

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Gauteng, South Africa, 1627
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O·R·TAMBO
INTERNATIONAL AIRPORT
AIRPORTS COMPANY SOUTH AFRICA

13 January 2016

Yanga Sapepa (Mr)
Electrical Engineer
O.R. Tambo International Airport SOC
Private Bag X1
O.R. Tambo International Airport
1627

RE: Consent to conduct research for a Case Study at O.R. Tambo International Airport titled: "An inquiry into the Airfield Ground Lighting Projects' success and failure factors at OR Tambo International Airport from the year 2011 to 2015."

Dear Mr Sapepa

This letter serves to confirm that permission has been granted to Yanga Sapepa to conduct research at O.R. Tambo International Airport, as part of his studies towards his Master of Philosophy: Engineering Management (MPhil: Engineering Management) at the University of Johannesburg.

Sincerely

BONGIWE PITYI (MS)
General Manager: O.R. Tambo International Airport

Page 1 of 1

Appendix 7: Sample Survey Questionnaire

Name (Optional): _____

Position: _____

Company: _____

General

DMAIC is used as the basis for the Survey Questionnaires as stated by De Mast and Lokkerbol (2012).*
"**Define**: Problem selection and benefit analysis

	1	2	3	4	5
D1. Are all the Total Quality Management (TQM) processes identified and mapped?					
D2. Are all the Project management Stakeholders easily identifiable?					
D3. How easy is it to identify and prioritise the End-User's needs and requirements?					
D4. Do all ACSA Projects have a Business Case for the project?					

Measure: Translation of the problem into a measurable form, and measurement of the current situation; refined definition of objectives*

	1	2	3	4	5
M1. Is a selection one or more Critical-To-Quality Trees (CTQs) done for every Project?					
M2. Are all the operational definitions for CTQs and requirements determined?					
M3. For every Project we validate measurement systems of the CTQs.					
M4. For every Project we assess the current process capability.					
M5. For every Project objectives are defined.					

Analyse: Identification of influence factors and causes that determine the CTQs' behaviour*

1	2	3	4	5

A1. For every Project we identify potential influence factors.
A2. We then select the vital few influence factors.

Improve: Design and implementation of adjustments to the process to improve the performance of the CTQs*

1	2	3	4	5

I1. For every Project we quantify CTQs.
I2. For every Project we design actions to modify the process
Or settings of influence factors in such a way that the CTQs are optimized.
I3. For every Project we conduct pilot test of improvement actions.

Control: Empirical verification of the project's results and adjustment of the process management* and control system in order that improvements are sustainable

1	2	3	4	5

C1. For every Project we determine the new process capability.
C2. For every Project we implement control plans."

"Department"

Does the Senior Management demonstrate an ability to manage the changes that needed to improve the quality, in terms of TQM?

Scale 1 - 5

1	2	3	4	5

Does the Senior Management maintain an environment that enables and promote quality improvement?

Scale 1 - 5

1	2	3	4	5

Does the Senior Management take part in activities to improve the quality on a regular basis?

Scale 1 - 5

1	2	3	4	5

Are the CEO and Senior Management the primary driving force behind quality improvement efforts?

Scale 1 - 5

1	2	3	4	5

Does Senior Management have the information on needs and suggestions for quality improvement directly for Project Management?

Scale 1 - 5

1	2	3	4	5

Does the Senior Management encourage quality improvement by showing confidence in quality improvement initiatives?

Scale 1 - 5

1	2	3	4	5

Is your company accredited with any Quality Assurance Regulators?

Yes	No

Yes or No

Does your company have quality system; i.e. ISO 9000, SIX SIGMA, TQM?

Yes	No

Yes or No

Is there a Quality Management Standard that has been adopted by the company?

Yes	No

Yes or No

On its Governance Framework, does the company have a Quality Standard and/or Procedure?

Yes	No

Yes or No

Are employees involved in decision making?

Yes	No

Yes or No

Is communication between Senior Management and staff effective?

Yes	No

Yes or No

Are there Quality Measurement Systems in place that have been adopted by the company (i.e. ASQ)?

Yes	No

Yes or No

Does the company measure customer satisfaction?

Yes or No

Yes	No

Are views and ideas from the customer entertained by the company?

Yes or No

Yes	No

Are employees satisfied with the company?

Yes or No

Yes	No

Does the company resist change?

Yes or No

Yes	No

Comments: _____

Appendix 8: Consolidated Survey Results

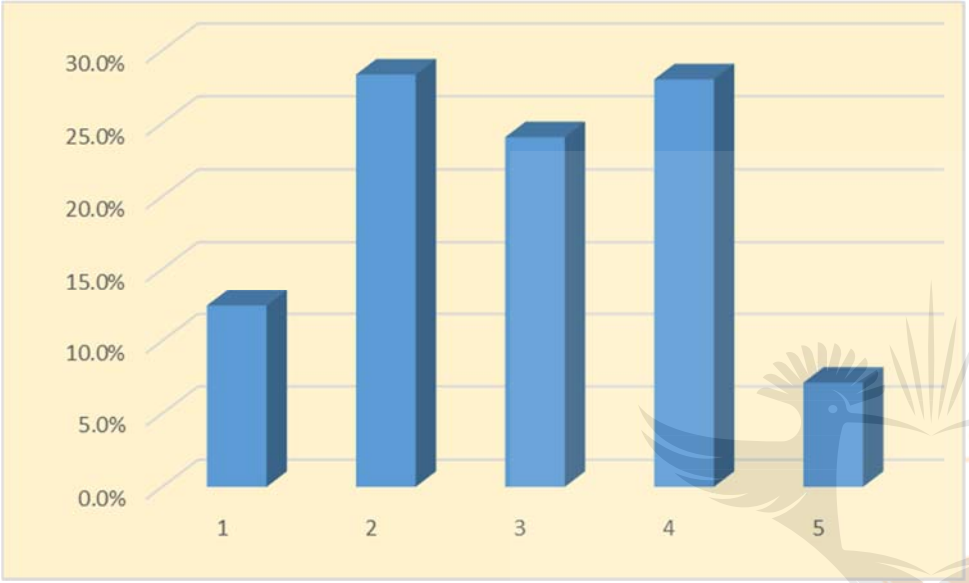
	No. of 1	No. of 2	No. of 3	No. of 4	No. of 5	Highest Response	
General							
"**Define**: Problem selection and benefit analysis							
D1. Are all the Total Quality Management (TQM) processes identified and mapped?	6	11	7	4		2	Disagree
D2. Are all the Project management Stakeholders easily identifiable?	1	4	3	16	3	4	Agree
D3. How easy is it to identify and prioritise the End-User's needs and requirements?	1	5	7	10	1	4	Agree
D4. Do all ACSA Projects have a Business Case for the project?	1	1	3	9	12	5	Strongly Agree
Measure: Translation of the problem into a measurable form, and measurement of the current situation; refined definition of objectives							
M1. Is a selection one or more Critical-To-Quality Trees (CTQs) done for every Project?	8	7	10	2		3	I Do Not Know
M2. Are all the operational definitions for CTQs and requirements determined?	6	8	9	5		3	I Do Not Know
M3. For every Project we validate measurement systems of the CTQs.	6	10	7	3	1	2	Disagree
M4. For every Project we assess the current process capability.	4	8	7	6	2	2	Disagree
M5. For every Project objectives are defined.	3		3	13	7	4	Agree
Analyse: Identification of influence factors and causes that determine the CTQs' behaviour							
A1. For every Project we identify potential influence factors.	3	4	6	11	3	4	Agree
A2. We then select the vital few influence factors.	3	5	7	9	2	4	Agree

Improve: Design and implementation of adjustments to the process to improve the performance of the CTQs							
I1. For every Project we quantify CTQs.	4	9	7	7		2	Disagree
I2. For every Project we design actions to modify the process	4	9	4	7	1	2	Disagree
Or settings of influence factors in such a way that the CTQs are optimized.	1	8	6	2		2	Disagree
I3. For every Project we conduct pilot test of improvement actions.	2	10	7	2		2	Disagree
Control: Empirical verification of the project's results and adjustment of the process management and control system in order that improvements are sustainable							
C1. For every Project we determine the new process capability.	3	9	8	6	2	2	Disagree
C2. For every Project we implement control plans."	2	9	9	4	3	3	I Do Not Know
Maintenance							
Does the Organisation's Maintenance Plan incorporate the TQM Framework?							
Scale 1 - 5	4	7	6	8	1	4	Agree
Does the Senior Management demonstrate an ability to manage the changes that needed to improve the quality, in terms of TQM?							
Scale 1 - 5	3	8	5	11	1	4	Agree
Does the Senior Management maintain an environment that enables and promote quality improvement?							

Scale 1 - 5	3	10	5	8	2	2	Disagree
Does the Senior Management take part in activities to improve the quality on a regular basis?							
Scale 1 - 5	4	12	3	8	1	2	Disagree
Is the CEO and Senior Management are a primary driving force behind quality improvement efforts?							
Scale 1 - 5	1	9	8	9	1	4	Agree
Does Senior Management have the information on needs and suggestions for quality improvement directly for Project Management?							
Scale 1 - 5	2	8	8	9		4	Agree
Does the Senior Management encourage quality improvement by showing confidence in quality improvement initiatives?							
Scale 1 - 5							
	75	**171**	**145**	**169**	**43**		
	12.4%	**28.4%**	**24.0%**	**28.0%**	**7.1%**		

Note: DMAIC is used as the basis for the Survey Questionnaires as stated by De Mast and Lokkerbol (2012).

Appendix 9: Consolidated Survey Results (Graphical)



Does the Company have Quality Management Strategy, Implementation, Assurance, Accreditation, Etc.?

1 is Strongly Disagree

2 is Disagree

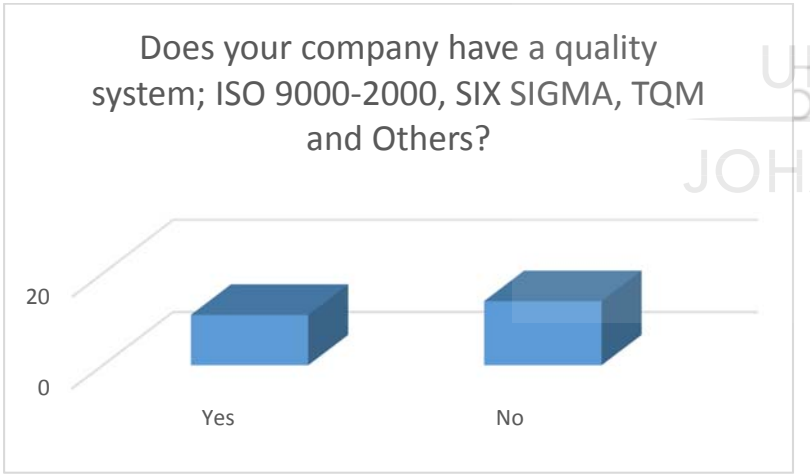
3 is I do not know

4 is Agree

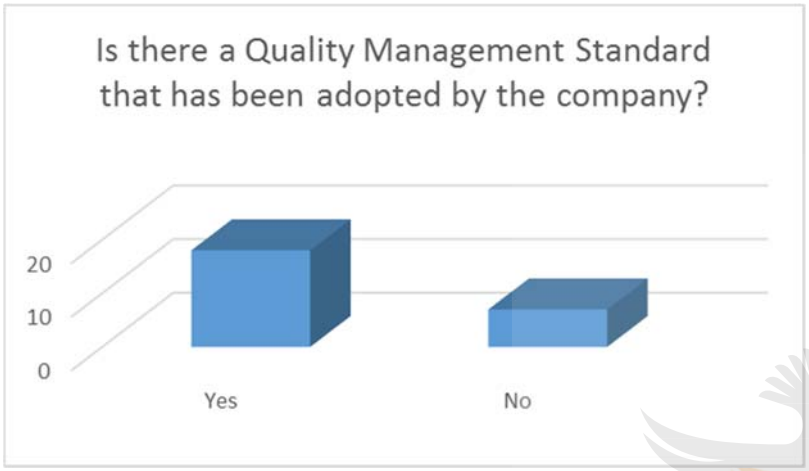
5 is Strongly Agree

Appendix 10: “Yes or No Selection” Results 1

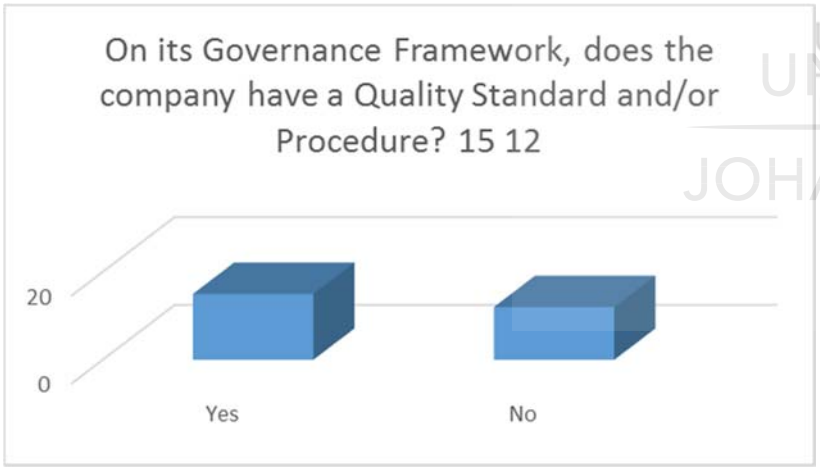
Appendix 11: “Yes or No Selection” Results 2



Appendix 12: "Yes or No Selection" Results 3

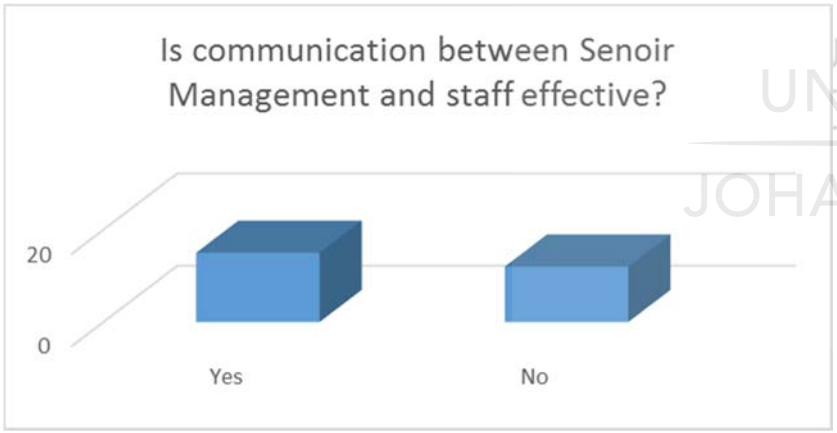


Appendix 13: "Yes or No Selection" Results 4

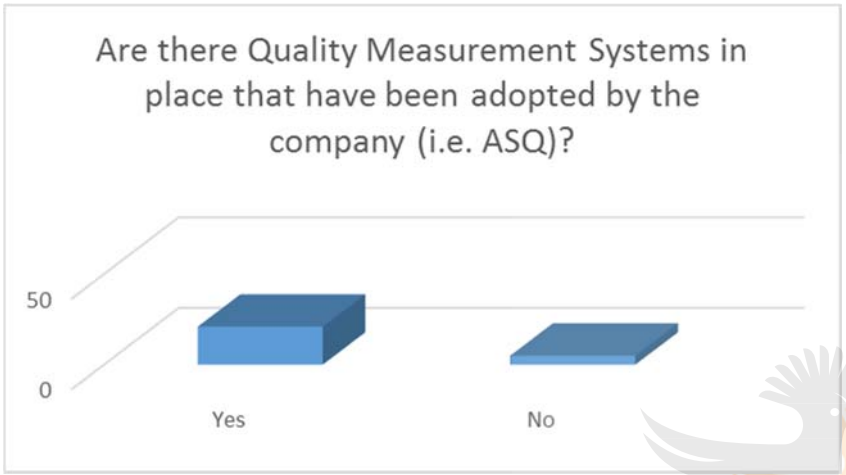


Appendix 14: "Yes or No Selection" Results 5

Appendix 15: "Yes or No Selection" Results 6

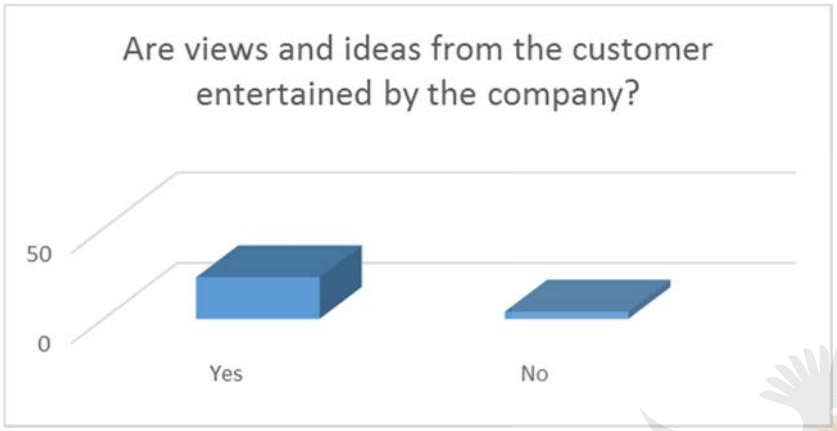


Appendix 16: “Yes or No Selection” Results 7

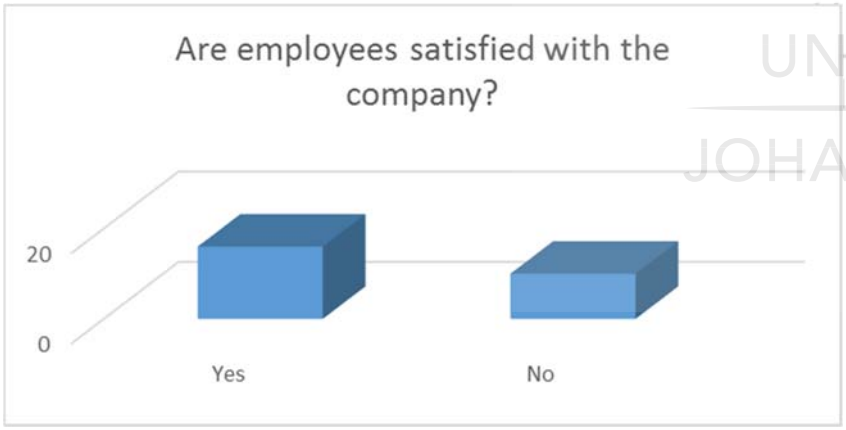


Appendix 17: “Yes or No Selection” Results 8

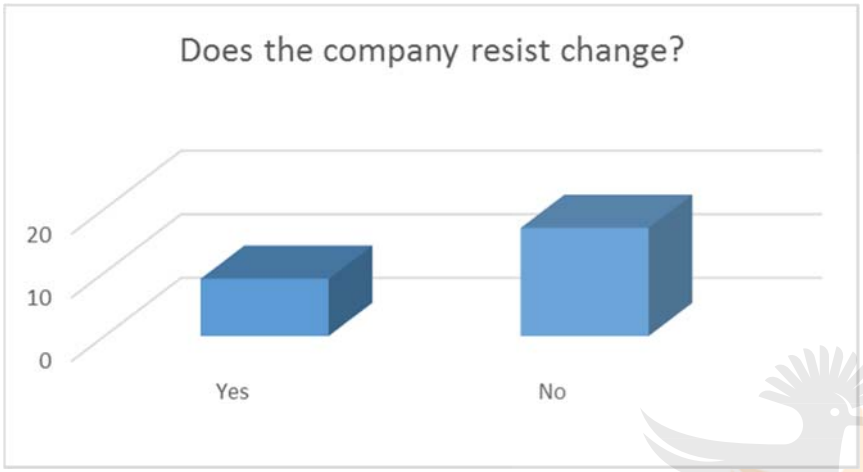
Appendix 18: “Yes or No Selection” Results 9



Appendix 19: “Yes or No Selection” Results 10



Appendix 20: “Yes or No Selection” Results 11



Summary of "Yes" or "No" Answers

	Yes	**No**
Is your company accredited?	10	12
Does your company have a quality system; ISO 9000-2000, SIX SIGMA, TQM and Others?	11	14
Is there a Quality Management Standard that has been adopted by the company?	18	7
On its Governance Framework, does the company have a Quality Standard and/or Procedure?	15	12
Are employees involved in decision making?	16	12
Is communication between Senoir Management and staff effective?	15	12
Are there Quality Measurement Systems in place that have been adopted by the company (i.e. ASQ)?	21	5
Does the company measure customer satifaction?	26	1
Are views and ideas from the customer entertained by the company?	23	4
Are employees satisfied with the company?	16	10
Does the company resist change?	9	17
Total	**180**	**106**

Appendix 21: Cronbach's Alpha Test Results

Data Set:

	Re: 1	Re: 2	Re: 3	Re: 4	Re: 5	Re: 6	Re: 7	Re: 8	Re: 9	Re: 10	Re: 11	Re: 12	Re: 13	Re: 14	Re: 15	Re: 16	Re: 17	Re: 18	Re: 19	Re: 20	Re: 21	Re: 22	Re: 23	Re: 24	Re: 25	Re: 26	Re: 27	Re: 28
Survey Question 1	4	2	1	2	2	3	2	2	1	1	2	4	2	4	3	1	2	1	2	3	2	3	3	1	3	2	4	3
Survey Question 2	4	2	2	4	4	4	4	3	1	2	4	4	4	5	4	2	4	4	3	0	4	4	3	4	4	5	5	4
Survey Question 3	4	3	2	2	3	4	4	0	2	2	4	4	4	4	4	4	5	2	3	0	0	3	3	1	0	3	4	3
Survey Question 4	5	3	1	5	4	5	4	4	4	5	5	4	4	5	4	2	5	5	4	0	0	5	3	5	3	4	5	5
Survey Question 5	3	2	1	2	1	1	2	4	1	2	3	3	2	4	3	1	1	1	2	0	3	3	3	1	3	3	2	3
Survey Question 6	3	2	1	2	1	2	2	3	2	2	4	3	4	4	3	1	1	1	2	4	3	3	3	1	2	3	3	4
Survey Question 7	2	3	1	2	1	2	2	4	2	2	2	3	2	5	4	1	1	1	2	0	3	3	3	1	2	3	3	4
Survey Question 8	3	2	1	2	1	2	2	4	2	4	4	3	2	5	4	1	3	3	2	0	3	4	3	1	2	3	4	5
Survey Question 9	4	3	1	5	5	4	4	4	3	4	4	4	5	5	4	1	5	4	4	0	4	4	0	5	1	3	4	5
Survey Question 10	4	3	1	5	4	4	2	4	2	1	4	4	4	5	0	3	1	4	2	3	3	3	3	4	2	4	5	4
Survey Question 11	3	3	1	4	4	4	2	4	2	1	4	4	4	5	0	3	1	4	2	0	3	3	3	2	2	4	5	3
Survey Question 12	4	2	1	4	1	2	2	3	2	2	3	4	2	4	3	2	1	3	2	0	3	3	3	1	2	4	4	4
Survey Question 13	4	2	1	2	1	2	2	4	2	2	2	4	4	5	3	2	1	0	2	4	3	0	3	1	0	4	4	3
Survey Question 14	0	3	0	2	1	0	2	0	2	2	0	0	0	4	3	2	3	2	2	0	3	3	3	0	2	0	4	0
Survey Question 15	3	3	1	2	0	3	0	4	0	2	2	2	2	4	3	0	0	1	2	0	3	2	3	2	2	2	0	3
Survey Question 16	3	3	1	4	1	2	2	4	2	2	2	4	4	5	4	1	2	3	2	3	3	3	3	2	2	4	5	3
Survey Question 17	3	3	1	5	3	3	2	4	2	2	2	4	4	5	3	1	3	2	2	0	3	3	3	2	2	2	5	4
Survey Question 18	4	3	1	2	0	2	1	0	2	1	4	3	4	5	1	2	3	4	2	3	4	4	3	2	3	2	4	4
Survey Question 19	4	2	1	2	3	1	2	4	3	1	4	3	4	5	2	2	3	4	2	4	4	4	3	2	4	2	4	4
Survey Question 20	4	2	1	2	3	1	2	4	2	1	4	4	4	5	2	2	2	3	2	3	4	4	3	2	3	2	4	5
Survey Question 21	3	1	1	2	2	2	2	4	2	1	2	4	4	5	2	2	1	2	2	4	4	2	3	2	3	4	4	4
Survey Question 22	4	2	1	3	2	3	2	4	3	2	4	4	2	5	2	2	2	4	3	3	4	3	3	3	4	2	4	4
Survey Question 23	4	3	1	0	2	3	4	4	3	2	2	4	2	4	2	2	1	3	2	4	4	3	3	3	3	2	4	4
Survey Question 24	4	2	1	0	2	3	2	4	2	2	4	4	4	5	0	2	1	0	1	0	0	0	0	0	0	0	4	4

Cronbach's Alpha Test:

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	28	65	2.32	0.97
Row 2	28	97	3.46	1.44
Row 3	28	77	2.75	2.12
Row 4	28	108	3.86	2.20
Row 5	28	60	2.14	1.09
Row 6	28	69	2.46	1.07
Row 7	28	64	2.29	1.32
Row 8	28	75	2.68	1.63
Row 9	28	99	3.54	2.33
Row 10	28	88	3.14	1.76
Row 11	28	80	2.86	1.90
Row 12	28	71	2.54	1.29
Row 13	28	67	2.39	1.95
Row 14	28	43	1.54	1.96
Row 15	28	51	1.82	1.63
Row 16	28	79	2.82	1.26
Row 17	28	78	2.79	1.51
Row 18	28	73	2.61	1.80
Row 19	28	83	2.96	1.29
Row 20	28	80	2.86	1.39
Row 21	28	74	2.64	1.35
Row 22	28	84	3.00	0.96
Row 23	28	78	2.79	1.21
Row 24	28	51	1.82	2.97

Column 1	24	83	3.46	0.95
Column 2	24	59	2.46	0.35
Column 3	24	25	1.04	0.13
Column 4	24	65	2.71	2.13
Column 5	24	51	2.13	1.94
Column 6	24	62	2.58	1.47
Column 7	24	55	2.29	1.00
Column 8	24	79	3.29	1.87
Column 9	24	49	2.04	0.65
Column 10	24	48	2.00	1.04
Column 11	24	75	3.13	1.42
Column 12	24	84	3.50	0.87
Column 13	24	77	3.21	1.48
Column 14	24	112	4.67	0.23
Column 15	24	63	2.63	1.72
Column 16	24	42	1.75	0.72
Column 17	24	52	2.17	2.14
Column 18	24	61	2.54	2.09
Column 19	24	54	2.25	0.46
Column 20	24	38	1.58	3.21
Column 21	24	70	2.92	1.56
Column 22	24	72	3.00	1.30
Column 23	24	66	2.75	0.72
Column 24	24	48	2.00	1.91
Column 25	24	54	2.25	1.33
Column 26	24	67	2.79	1.56
Column 27	24	94	3.92	1.21
Column 28	24	89	3.71	1.09

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	189.02	23	8.2182	7.8347	1E-22	1.5467
Columns	386.24	27	14.305	13.638	8E-47	1.5037
Error	651.4	621	1.049			
Total	1226.7	671				

Cronbach's Alpha: **0.8724**

0.8724