MEASURING QUALITY MANAGEMENT SYSTEM PERFORMANCE USING QUANTITATIVE ANALYSES

by

Richard Angus Smith

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Supervisor: Mr A Bester
Co-supervisor: Prof M Moll

Bellville

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DECLARATION

I, Richard Angus Smith, declare that the contents of this dissertation/thesis represent my own unaided work, and that the dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology or Eskom, Koeberg Power Station.

22 June 2013

Signed Date

ABSTRACT

Many top performing businesses, which achieve superior levels of success and sustainability, have a sound, implemented, and well maintained, Quality Management System (QMS). The correlation between business success and an implemented management system has been shown in numerous papers. This research, which culminates in a quantitative measure of QMS performance, was conducted at Eskom's Koeberg Nuclear Power Station (KNPS). The power station is the operating leg of the Koeberg Operating Unit (KOU). The researcher is a QMS lead auditor in the KNPS Quality Assurance Department.

A program of audits is planned based on the KOU quality and safety manual and the national regulatory licencing requirements. The audit monitoring program is then implemented over a three year period and considers all the management system processes which impact on nuclear safety and business performance. The individual audits each consider ISO 9001 criteria in context of the business area audited. Each major business area (e.g. design, maintenance, etc.) within the power station adheres to all generic ISO 9001 QMS clauses and considerations, such as documentation management, records management, etc. Each process or business area audit is thus effectively a QMS audit. The audit results, when combined are therefore a representative measure of the overall organisational QMS performance.

The potential value to be gained from the audit results and data accrued over the monitoring period has not been optimised to maximise the return on investment to Eskom. The research problem statement thus proposes that the performance measurement capability of the quality management system at Eskom's Koeberg Power Station is insufficient. This diminishes management's ability to identify business risk resulting from management system deficiencies, which impacts negatively on business performance. The research question seeks to determine how the performance

measurement capability of the QMS can be improved to assist management in identifying business risk resulting from quality management system deficiencies in order to improve business performance.

The research objectives are supported by the literature study, which identifies the quality management methods currently used in order to measure and subsequently improve business performance. It also shows how QMS performance measurement, when deconstructed and analysed can provide the required insight for supporting management decision making. The research approach is considered inductive in that a theory is developed based on the collection and the analysis of that data. Applied research, will thus serve as the basis of the research methodology as it is considered the most appropriate research approach, based on the need to answer practical questions around the measurement of QMS performance philosophy.

The research shows that by introducing additional theming and severity data into the secondary audit findings data, it is possible over time to extract high level strategic direction information when analysing the additional metadata. The dimensions and value of the QMS Performance measuring instrument are:

- A cause and effect theming philosophy of audit findings providing an additional context to business improvement advice to management.
- The provision of a QMS process deficiency locator / identifier which targets management action areas for improvement.
- The provision of a quantitative measure of the management system performance, providing a reference from which to improve.

By providing a quantifiable measure of an organisations QMS performance, a reference point is provided to gauge QMS performance and also render a definitive measure to enable performance improvement of the business.

ACKNOWLEDGEMENTS

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- My Supervisors Mr Andre Bester and Professor Mellet Moll for guiding and shaping this output.

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LIST OF ABREVIATIONS

QMS	Quality Management System
NC	Nonconfority
KNPS	Koeberg Nuclear Power Station
KOU	Koeberg Operating Unit
NEI	Nuclear Energy Institute
SNPM	Standard Nuclear Performance Model
NNR	National Nuclear Regulator
ISO	International Standards Organisation
BPIR	Business Performance Improvement Resource
IAEA	International Atomic Energy Agency
ASME	American Society of Mechanical Engineers
NQA	Nuclear Quality Assurance
ANS	American National Standard
KPI	Key performance indicator
PI	Performance indicator
SSG	Specific severity grading
GSG	Generic severity grading
NSG	Nonconformity severity grading
PSG	Process severity grading
SSC	Structure, system and component

GLOSSARY

Assurance:	Evidence (verbal or written) that gives confidence that something will or will not happen or has or has not happened (Hoyle, 2007:186).
Audit:	An examination of results to verify their accuracy by someone other than the person responsible for producing them (Hoyle, 2007:187).
Business management system:	The set of interconnected and managed processes that function together to achieve the business objectives (Hoyle, 2007:187).
Key performance indicators (KPI):	The quantifiable characteristics that indicate the extent by which an objective is being achieved (Hoyle, 2007:193).
Measures:	The characteristics by which performance is judged. They are the characteristics that need to be controlled in order that an objective will be achieved. They are the response to the question "What will we look for to reveal whether the objective has been achieved?" (Hoyle, 2007:194).
Measurement capability:	The ability of a measuring system (device, person and environment) to measure true values to the accuracy and precision required (Hoyle, 2007:194).
Quality management (QM):	The application of a quality management system in managing a process to achieve maximum customer satisfaction at the lowest overall cost to the organisation while continuing to improve the process (ASQ, 2012:**Online**).

Quality management system (QMS):	A formalised system that documents the structure, responsibilities and procedures required to achieve effective quality management.quality control The process relating to gathering process data and analysing the data to determine whether the process exhibits nonrandom variation (ASQ, 2012:**Online**).
QMS Performance Measurement	Audits, Reviews, Surveillances and Self Assessment monitoring activities that measure compliance to requirements of the QMS (Source: Adapted from Ramly, Ramly and Yusof, 2007:1).
QMS Performance Measure	That measurement intent on providing a clear quantitative reference representative of the health or performance of the QMS (Source: Own).
QMS Health Measure	That measurement intent on providing a clear quantitative reference representative of the health or performance of the QMS (Source: Own).

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CHAPTER 1:SCOPE OF RESEARCH

1.1 Introduction

"*When you can measure what you are speaking about, and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts advanced to the stage of science.*"

Baron William Thomson Kelvin (1824-1907)

This research aims to develop and establish a measurement methodology for Quality Management System (QMS) Performance in order to provide business managers with quantitative information to inform decisions and their associated actions, proactively.The scope of the research will expand on the following broad areas, which shows research framework:

- Background and statement of the research problem.
- The research question and investigative questions.
- Primary research objectives.
- The research process.
- Research design and methodology.
- Research data collection design and methodology.
- Ethics considerations.
- Research assumptions and constraints.
- Significance of the research.

1.2 Motivation

Many top performing businesses, which achieve superior levels of success and sustainability, have a sound, well maintained, implemented Quality Management System (QMS). Correlation between business benefits and an implemented management system have been shown in numerous papers and that the benefits accrued outweigh the costs (Fons, 2011:468). Current methods of accessing the success of the implementation of the

management system do not provide a quantitative measurement indicative of the management system health.

The benefit of a definitive measure of management system health lies in providing a point of reference, which can fuel the motivation to continuously improve compliance to the management system. This is the foundation for superior business performance. Quantifying the economic benefits also aids in informing management decisions (Fons, 2011:461). This research aims to develop a QMS health measure based on the coding and analysis of QMS audit findings data. This will provide management with information to inform decisions and their associated actions proactively. The informed decisions thus can be made prior to the business deficiencies manifesting themselves as a lagging indicators as used in some of the current business models and measurement systems.

1.3 Background to the research problem

The research problem relating to insufficient measurement capability of the quality management system performance was accentuated by customer feedback and a business process self-assessment. QMS trend reporting is presented to senior management periodically. The reporting includes minimal quantitative content, and does not show a clear reference point to implement continuous improvement from. ISO 9000 (2000:9) defines "effectiveness" as the "extent to which planned activities are realised and planned results achieved". The researcher proposes that the relationship between QMS ‘effectiveness’ and QMS "performance" is direct in that the "performance" is representative of the measure of "effectiveness". The researcher thus suggests that a "QMS performance measure" is defined as “that measurement intent on providing a clear quantitative reference representative of the health of the QMS”.

The QA business reporting process self-assessment showed deficiencies in the audit data analysis and traceability of insights to originating raw data. The amount of detail contained within overview reporting was also

perceived to be too shallow, in that management could not clearly establish the actual QMS risks that the business was exposed to. Chapter 2 expands of the pertinent areas which will provide context to the research problem. The expanded areas include content which shows the governance requirements of the quality management program and the quality management environment itself.

1.4 Statement of the research problem

The problem that is researched within the ambit of this study, reads as follows: The performance measurement capability of the quality management system at Eskom's Koeberg Power Station is insufficient. This diminishes management's ability to identify the business risk resulting from management system deficiencies, which impacts negatively on business performance.

1.5 The research question

The research question, forming the crux of this research study, reads as follows: How can the performance measurement capability of the quality management system of Eskom’s Koeberg power station be improved to assist management to identify business risk resulting from quality management system deficiencies, in order to improve business performance?

1.6 Investigative questions

The investigative questions, which will be researched in support of the research question, are listed below:

- What quality management methods are currently used to improve business performance?
- What performance measures are used for representing quality management system performance?

- What is the relationship between the quality management system performance measures and business performance?
- How can QMS performance measurement provide insight into management decision making?
- How can the existing QMS performance measurements be used to improve business performance?

1.7 Primary research objectives

The identified primary research objectives of this research study are listed below:

- **Primary objective:** The primary objective of this research study is to mitigate the research problem through the implementation of a feasible and viable problem solving mechanism.
- **Secondary objectives:** The secondary research objectives are:
  - To identify which quality management methods are currently used to improve business performance.
  - To determine which performance measures are used for representing quality management system performance.
  - To show the relationship between the quality management system performance measures and business performance.
  - To show how QMS performance measurement can provide insight into management decision making.
  - To show how existing QMS performance measurement (audit) data can be used to improve business performance

1.8 The research process

Watkins (2012:36) adapts the six fundamental stages in the research process as noted by Collis and Hussey (2003), and proposes the following logical sequence to be followed to perform research. The author's research process will follow Watkins proposed method with minor adaptions:

- Identification of the research topic.

- Identify a specific complex problem, which the researcher wishes to conduct the research on.
- Conduct an abbreviated literature review on the subject matter being investigated. The purpose being to not only provide insight into the complexity of the problem, but also to provide insight into the literature pertaining to the field of study of the proposed research.
- Formally describe, formulate and document the research problem.
- Describe and formulate the research question, and associated investigative questions.
- Select an appropriate research design and methodology, which includes the data collection design and methodology.
- Determine the key research objectives for the proposed research.
- Document the research process, which will be followed for the proposed research and formulate an associated work plan.
- Identify the limitations, which may impact on the proposed research.
- Clearly identify, list and articulate the assumptions, which would apply to the proposed research.
- Based on the above, formulate a formal research proposal and submit for approval.
- Establish a structured working relationship with the allocated supervisor or promoter.
- Conduct an in-depth literature review on the subject being researched.
- Collect, analyse and interpret the research data.
- Formulate a structured approach to mitigate the identified research problem. Furthermore, ensure that the identified research question and supporting investigative sub-questions have been answered as a result of the research. In addition, clearly indicate how the research objectives were met/not met, as a result of the research.
- Write up the dissertation or thesis.
- Proofread the dissertation/thesis, and submit for formal vetting.

1.9 Research design and methodology

The research approach is considered to be inductive in that a theory is developed based on the collection and the analysis of that data. (Saunders, Lewis & Thornhill, 2009:125-126). Applied research, will serve as the basis of the research methodology as it is considered the most appropriate research approach. Thunhurst and Randall (2010:398) state that the defining feature of applied research is that it is driven by the need to answer practical questions surrounding the topic being studied.

The applied research approach makes use of mixed methods to optimally achieve the research objective. Creswell (2009:203) notes that with the development and perceived legitimacy of both qualitative and quantitative research in the social and human sciences, mixed methods research, employing the combination of quantitative and qualitative approaches provides an expanded understanding of research problems.

1.10 Data collection design and methodology

The objective of the research is to propose and develop a QMS performance measurement methodology and show the correlation between this measure and actual business performance. Existing data resulting from audit findings collected over a three year period (2008 to 2010) will be analysed and QMS “cause and effect” themes will be assigned to the individual findings. The themes embedded in the existing primary data i.e. the QMS audit findings will be extracted as a secondary data source, and further analysed in order to provide a measure of overall QMS health. The quantified QMS performance data will inform management decisions and guide management action with the aim of improving business performance. Data triangulation will support the data collection methodology and validity of the research.

Saunders, Lewis and Thornhill (2009:150), notes that archival research makes use of administrative records and documents as the principal source of data. Watkins (2012:75) notes that the concept of ‘triangulation’, applies to not only the collection of data from different sources (data

triangulation) as described in this paragraph, but also to using multiple research methods (methodological triangulation). The author shares the definition by Collis and Hussey (2009), and amends the definition for the purpose of clarity and, which reads as follows: "Triangulation is the use of multiple sources of data (data triangulation), and different research methods (methodological triangulation). In this research study, data mining will serve as the primary vehicle, while questionnaires serve as mechanisms of data collection to provide validity and reliability measures for this study.

1.11 Ethics

According to Watkins (2012:77) ". . . ethics refer to the appropriateness of your behaviour in relation to the rights of those who become the subject of your work, or are affected by it".

Watkins (2012:77) notes that Leedy and Ormrod (2010), state that most ethical issues in research fall into one of four categories namely:

- Protection from harm.
- Informed consent.
- The right to privacy.
- Honesty with professional colleagues.

Watkins notes that Collis and Hussey (2009) expand on the above and add the following to the list of ethics:

- Voluntary participation.
- Anonymity.
- Confidentiality.

The main ethics consideration for this study will thus include, "informed consent", "the right to privacy", "honesty with professional colleagues", "voluntary participation", anonymity and confidentiality.

1.12 Research assumptions

Leedy and Ormrod (2001:62-63), provide for the following explanation of assumptions, which cited verbatim: “Assumptions are what the researcher takes for granted. But taking things for granted may cause much misunderstanding. What we may tacitly assume, others may have never considered. If we act on our assumptions, and if in the final result such actions make a big difference in the outcome, we may face a situation we are totally unprepared to accept. In research we try to leave nothing to chance in the hope of preventing any misunderstanding. All assumptions that have a material bearing on the problem should be openly and unreservedly set forth. If others know the assumptions a researcher makes, they are better prepared to evaluate the conclusions that result from such assumptions. To discover your own assumptions, ask yourself, what am I taking for granted with respect to the problem? The answer will bring your assumptions into clear view”.

The following assumptions are upheld with respect to the research in this research study:

- An implemented, well maintained QMS is essential to drive and improve business performance.
- The coders or raters of the reliability test questionnaires are all registered, competent quality management system lead auditors and all possess three or more years of auditing experience.
- The “QMS themes” measuring Instrument table seen in Annexure B is calibrated and the intrinsic uncertainty of the measure is negligible.

1.13 Research constraints

The following research constraints are noted.

- ‘Limitations’ pertaining to the research are the following:

- Ø A level of subjectivity exists in rating of certain elements (such as nonconformities and process areas) within an audit activity leading up to, and over the duration of the research.
- Ø The process outputs of QMS audits and reviews include non-conformities and observations. This research will only consider the nonconformities, taking cognisance that additional value may be obtained when analysing observation metadata.
- Ø The competency of the auditors and accordingly the rating and theming process is of utmost importance as an influence to the accuracy of the QMS performance / health indicator.
- Ø Staff movement i.e. arrival of new auditors and the loss of existing auditors, will influence the overall rating and measurement indirectly by their influence at audit conclusion stage.

Ø ‘De-limitations’ pertaining to the research include the following:

- Ø The research, even though biased toward nuclear power utilities management systems, may be generalised for use in any management system.

1.14 Chapter and content analysis

The following chapter and content analysis is applicable to the research.

Ø **Chapter 1 – Scope of the research**: In this chapter the scope of the research is discussed, in particular as it pertains to a specific research environment. Furthermore, the research problem is elaborated upon, which will not only form the crux of the research study, but will set the scene for the research. In addition, aspects pertaining to the research process, investigative questions, research objectives, research design and methodology, assumptions and significance of the research, are elaborated upon.

Ø **Chapter 2 – Background to the research environment: A holistic perspective:** In this chapter, the reader is provided with a holistic perspective of the research environment. The research environment will not only provide context to the research problem, but would provide a comprehensive background to aid the

understanding of the reader of not only where the research will take place, but also why it is necessary to be conducted in this particular environment.

- **Chapter 3 – Management System Performance Measurement - A Literature review:** In this chapter a literature review will be conducted on the primary theme of the thesis, providing an empirical underpinning to the research problem. More specific, the literature review will provide academic context to the unique aspects that would mitigate the research problem.
- **Chapter 4 – Research and Methodology:** This chapter provides an overview of the research design and methods used to interrogate and expose the solutions to the research problem.
- **Chapter 5 – Management system Theme Analysis - Data collection, analysis, and interpretation of results:** From a quantitative and or qualitative perspective, this chapter reflects the approach to data collection. Furthermore, data gleaned from the data collection exercise, will be analysed and interpreted.
- **Chapter 6 – Conclusion:** In this concluding chapter, key aspects pertaining to the research will be revisited. Research findings will be brought into the context of the overall research, recommendations will be made, and final analogies will be drawn. More specific, in this chapter the research problem will be mitigated through the implementation of a problem solving mechanism to the benefit of the organisation and its people.

1.15 Significance of the research

This research, while taking the assumptions and constraints into consideration, will provide a quantitative measure of a QMS performance or health status. This will enable organisations to respond to the QMS health measurement from a leading ‘business performance impact’ indicator perspective. Acting on the leading indicator will deliver less lagging (reactive) effects, enabling management to focus proactively on the management system foundations of the business.

This will impact positively on the sustainability of the business and allow for continuous improvement of both process and profit. There were no instances noted in the literature review which explicitly explore or focus on quantification of management system performance or health at audit finding level. The scarcity of research in this area further highlights the significance of the research.

1.16 Conclusion

This chapter of the research provided an introduction and overview of the overview of the current state of measurement of the QMS health status of Koeberg Power Station. The chapter also elaborated upon the research problem, which forms the crux of the research study, and also set the scene for the research. Aspects pertaining to the research process, investigative questions, research objectives, research design and methodology, assumptions and significance of the research, were also elaborated upon. The following chapter will provide additional data and expand upon the appropriate areas to clearly state the context, environment and background to the research problem statement.

CHAPTER 2: BACKGROUND ON THE RESEARCH ENVIRONMENT

2.1 Introduction

The research was conducted at Eskom's Koeberg Nuclear Power Station (KNPS). The power station is the operating leg of the Koeberg Operating Unit (KOU) which has additional support divisions to support KNPS. The author of this document is a member of a team of QMS auditors in the KNPS Quality Assurance Department. This chapter will elaborate on the elements important to understanding the context of the research and will therefore expand on the following:

- **Nuclear governance in South Africa:** shows the nuclear related bodies that influence the operations of the KOU
- **Eskom's nuclear power program and requirements:** The unique needs of nuclear power generation in South Africa
- **Quality management in Eskom:** The quality management standards basis that Eskom uses
- **Generic nuclear power utility business process interface overview:** An overview of the processes and their relationships with each other based on the Nuclear Energy Institute (NEI) performance model.
- **Quality management at KNPS:** The quality management standards basis that KNPS uses beyond ISO 9001, such as the applicable international standards and considerations.
- **KOUs quality management environment overview:** The environment in which quality management is practiced within KNPS.
- **KNPS quality management and QMS measurement:** The status quo of QMS measurement within KNPS.

2.2 Nuclear governance in South Africa

The National Nuclear Regulator (NNR) is responsible for exercising regulatory control over the safety of nuclear installations, certain types of radioactive waste, irradiated nuclear fuel, and the mining and processing of radioactive ores and minerals. The "National Nuclear Regulator" Act No 47 of 1999 established the National Nuclear Regulator (NNR). The objectives of the NNR are to provide for the protection of persons, property and the environment against nuclear damage through the establishment of safety standards and regulatory practices, and to exercise regulatory control related to the safety of nuclear installations through the granting of nuclear authorisations. The current revision of the Koeberg Nuclear Power Station: Koeberg Nuclear Installation Licence: NIL-01 (VARIATION 17)

The Institute for Nuclear Power Operations (INPO): INPO's mission is to promote the highest levels of safety and reliability, to promote excellence in the operation of nuclear electric generating plants.

The World Association of Nuclear Operators (WANO) is an organisation created to improve safety at every nuclear power plant in the world.

The South African Nuclear Energy Corporation (NECSA) is a state-owned company responsible for undertaking and promoting R&D in the field of nuclear energy and radiation sciences. It is also responsible for processing source material, including uranium enrichment, and co-operating with other institutions, locally and abroad, on nuclear and related matters.

The Department of Minerals and Energy ensures (DOE/ DME) the optimal utilisation and safe exploitation of mineral and energy resources.

The Nuclear Executive Committee (NEXCO) KOU's highest level at which key strategic decisions are taken. This committee is also responsible for the Division's overall business performance. NEXCO meetings are

scheduled on a monthly basis and are chaired by the division's senior general manager (Eskom, 2012:**Online**).

2.3 Eskom's nuclear power program and requirements

Eskom's nuclear power program is regulated by the National Nuclear Regulator (NNR) in terms of the National Nuclear Regulatory Act (47 of 1999). The NNR impose compliance to the Nuclear Installation License (NIL-1) and a number of Requirements Documents (RD's) and Licensing Documents (LD's). The nuclear installation license via "The Quality Management Requirements for Koeberg Nuclear Power Station" (LD1023), require that a comprehensive program of systematic audits be planned and carried out to verify compliance with all aspects of the quality management system and determine the effectiveness of the program.

A program of audits are planned, distributed and implemented over a three year period considering all the processes specified in LD1023, and also includes processes important for impact on business performance. Each major process (e.g. Design, Maintenance, etc.) within the power station adheres to all generic quality management system clauses and considerations (e.g. Documentation Management, Records Management, etc.). Each major process audit is thus effectively a QMS audit, and collectively over a three year program a detailed picture of the management system heath is visible based on the audit findings over the period.

2.4 Quality management in Eskom

Eskom has embarked on an ISO 9001 certification program for all its business units. Quality management within Eskom is seen as the overriding consideration that impact on plant safety and reliability. KNPS attained SABS ISO 9001 certification during August 2012.

A sound quality management system is essential to provide sustained customer focused process outputs which contribute to improved business

performance (Fons, 2011:468). The nuclear power generation industry has additional safety considerations and standards, which need to be considered in conjunction with ISO QMS standard to provide a more specific measure of QMS heath and performance.

2.5 Koebergs's quality management Imperative

Koeberg employs approximately 1200 people. Indirectly, the station creates about another 600 local jobs off-site, and about 2000 jobs in the general South African nuclear industry. In the non-nuclear industry about 100 local firms supply equipment to Koeberg. KNPS performs the role of a "base load" generation utility in that it operates at 100% power output consistently. This is important in the context of South Africa's power capability to supply the national electrical grid. Koeberg's sustainability via high calibre quality management, is thus essential in order to support its economic and technical value to South Africa.

The benefits of an implemented quality management system based on ISO 9000 and derivatives of that standard has been practically questioned and tested for many years. The volumes of organisations that have adopted this philosophy provide evidence of its acceptance as an important component to achieving, sustaining and surpassing business goals. In each industry the high level criteria of the standard is adopted, but in many cases, expansion of the requirements at an operational level is needed to provide more detailed instruction appropriate to the product, service or industry constraints.

2.6 KOU quality management environment overview

The KOU QMS is based on the requirements of ISO 9001:2008 and is supplemented by those of the National Nuclear Regulator (NNR) document RD-0034 "Quality and Safety Management Requirements for Nuclear Installations", ASME NQA-1:2008 "Quality Assurance Requirements for Nuclear Facility Applications" Part 1 (as referenced in

RD-0034) and IAEA document GS-R-3, "The Management System for Facilities and Activities" (Eskom Internal manual 238-8, 2010:8).

Figure 2.1: **Koeberg quality management process flow** shows the distinct phases from auditing to management overview reporting. The phases are described as follows:

- **Audits and reviews (1):** The audit and review monitoring activities are subdivided into planning, implementation and local process reporting to the process owner and others affected by findings raised.
- **Theme assignment and analysis (2):** During this phase, all audit reports and findings are collated and common themes are extracted from the data collectively in an attempt to highlight cross organisational issues.
- **Management Overview Reporting (3) and (4):**The result of the analysis forms the basis of both written and verbal reporting for management action.

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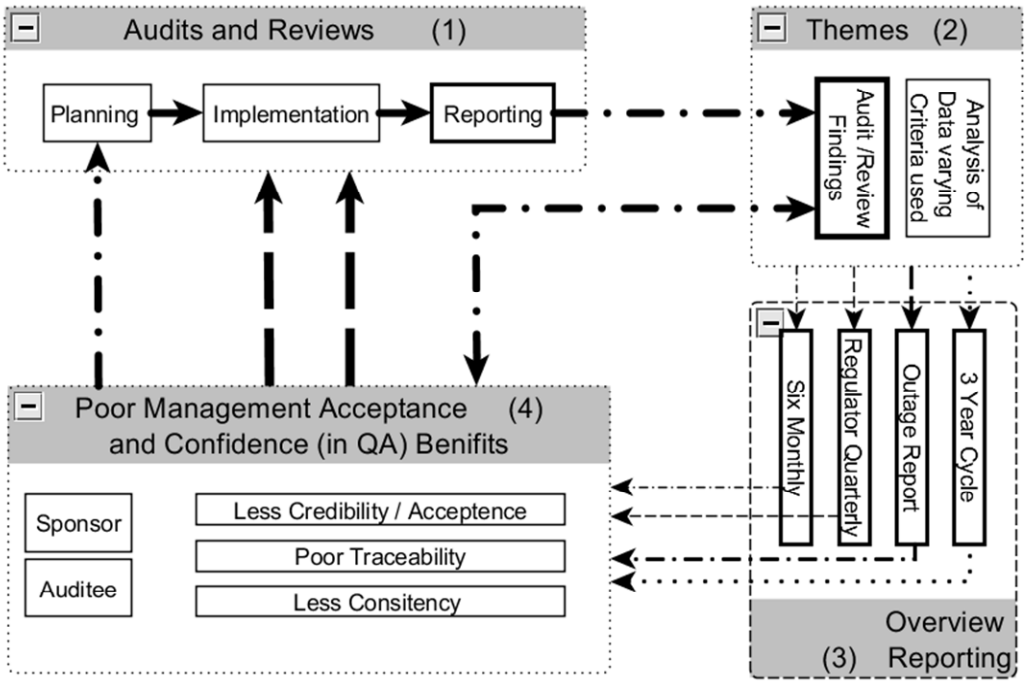

Figure 2.1: Koeberg quality management process flow **(Source:** own**)**

2.7 Generic nuclear power utility business process interface overview

The nuclear power generation industry is a complex industry. A balance must be obtained between resources expended on processes, interfaces and how they are integrated, with additional business considerations such as plant and personnel safety, environment, etc. The Nuclear Energy Institute (NEI) Standard Nuclear Performance Model (SNPM) provides guidance on prioritisation of the more important processes from a safety perspective. This prioritisation guidance is considered in the audit program planning phase, in order that resources may be directed efficiently to obtain the most value to the organisation, while still adhering to regulatory requirements.

The NEI SNPM (2004:7) has been considered extensively within the management systems of the KOU, and is used as the basis in this dissertation for describing the process relationships and the method for importance grading of the various elements of the KOU management system processes. Further detail can be seen in Chapter 3.

The executive summary of the NEI SNPM (2004:i) reads: “To improve benchmarking effectiveness, the Nuclear Energy Institute (NEI), Electric Utility Cost Group (EUCG) and Institute of Nuclear Power Operations (INPO) worked to define a Standard Nuclear Performance Model (SNPM). They indicate that their three-year effort resulted in closer coordination of process descriptions, key business performance indicators (KPIs) and activity based costing (ABC) definitions.

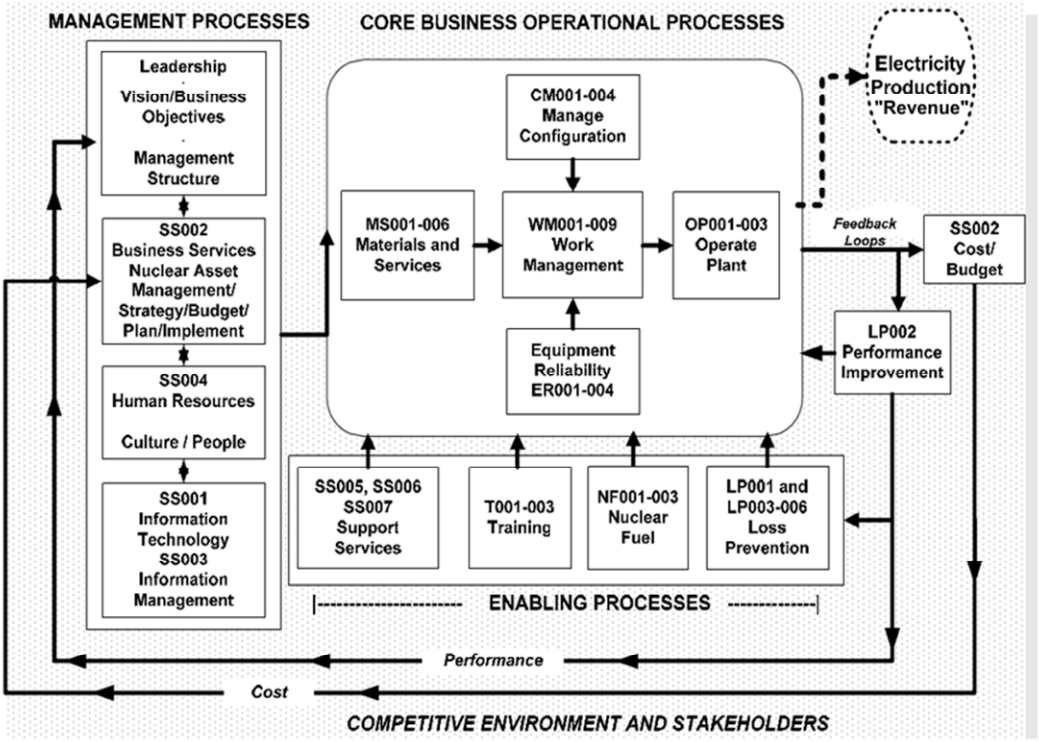

Figure 2.2: NEI process SNPM **(Source:**NEI SNPM:2004**)**

The NEI SNPM (2004:7) notes that the business outcome results of the combination of core and enabling processes. In nuclear generation, this result is the safe and reliable generation of electricity. Figure 2.2: **NEI process SNPM** (Source:**NEI SNPM:2004**) shows the process grouping and interfaces which makes up the NEI SNPM and is further described below:

- **NEI Core process:** The NEI SNPM (2004:7) identifies the core processes as those most directly related to nuclear safety and that accomplish a key business function. The core processes are Operate Plant, Work Management, Manage Configuration, Equipment Reliability and Materials and Services. The process scope is equivalent to the sum of scope definitions of the associated sub-processes. The corresponding performance indicators are known as level zero performance indicators within the NEI model.
- **NEI Enabling process:** An enabling process is a process that is applied in support of one or more core processes. The enabling processes are Management Processes and Support Services,

Training, Nuclear Fuel and Loss Prevention. The process scope is equivalent to the sum of the scope definitions of the associated sub-processes. The corresponding performance indicators are known as level zero performance indicators (NEI SNPM, 2004:7).

- **NEI Sub-process**: A description for a subset of process steps within the bounds of a single process. All 45 categories within the nine standard processes are referred to as sub-processes. Sub-processes may have a stand-alone process description. The corresponding performance indicators are known as level one performance indicators (NEI SNPM, 2004:7).

2.8 KOU graded approach to quality management

The applicability of the QM requirements on processes, activities and Structure, System and Component (SSCs) is determined by their importance to nuclear safety and availability of generation capability of that process or SSC function. This consideration is seen as a graded approach. Management will determine and classify the activities and processes of the KOU and its business areas in terms of their potential impact on quality and nuclear safety, and then subsequently manage these processes accordingly (Eskom Internal manual 238-8, 2010:8).

The Eskom Internal manual 238-8 (2010:8), requires that the degree to which the management system requirements are applied to an activity should reflect the importance of the activity to safety, health, environment, and the possible consequences if the activity is carried out incorrectly and results in equipment failure or failure to meet an objective. This can result in minimising the impact on valuable resources (and total costs) while improving overall safety. By using a graded approach it may be possible to identify activities of lesser significance within a process, and then define which controls and checks of the process are necessary (Eskom Internal manual 238-8, 2010:8).

The graded definitions noted in the NEI SNPM namely core and enabling will be used as a weighting criterion in Chapters 4 and 5 to provide a significance dimension to the QMS health indictor for a nuclear QMS. The enabling processes have been further subdivided into management and support areas to further differentiate significance between nonconformities.

2.9 KNPS quality management and QMS measurement

Providing a quantifiable measure of the Quality Management System (QMS) performance is important to the defining the status, and predicting capability of the resources and processes to achieve business goals. For business goals to succeed, the processes which lead to its success needs to be enabled by a structured, implemented quality management system. The nuclear power generation industry has additional safety considerations and standards which need to be considered in conjunction with ISO QMS standard to provide a more specific measure of the QMS heath and performance. The understanding by management of the relationship between a well maintained QMS and the related business performance is often variable and not adequate. The variation in the understanding of relationship impacts on the commitment by management to support QMS maintenance and improvement initiatives.

Data is gathered from audits and reviews and is assessed by KNPS QA personnel, and a QMS performance measurement reported to NEXCO biannually. The assessment takes place in the form of analysis of all data gathered from audits and reviews such in the form of reports, nonconformities and observations. The largely qualitative assessment includes numerous elements and biased perceptions, which reduces the reliability of feedback. Accurate, timeous quality data is important to inform strategic decisions taken by such forums such as NEXCO. Figure 2.1: **Koeberg quality management process flow** highlights the fact that improvement in the reliability of information and traceability of data is required to grow confidence in QA reporting.

2.10 Limitations of the KNPS QMS reporting environment

The limitations associated the current QMS reporting for overview or summary reporting environment include the following:

- Ø Variation in identification of common themes due to the sequential nature of the analysis.
- Ø Data is analysed long after the event leaving room for assumtion.
- Ø Data is not analysed by the auditor performing the monitoring activity.
- Ø Variation in assigned themes as themes are not consistant from one reporting period to another.
- Ø It is difficult to assess improvement across reporting periods.
- Ø Theming is time consuming due to the manual and inconsistent theming process.
- Ø There is a low level of repeatability in the data analysis and theming process.
- Ø Data traceability from insight to themes to findings is combersome.

The points above suggest that a process improvement is required to ensure that reliable timeous information may be produced to inform management decisions.

2.11 Conclusion

This research provides the methodology to quantify the QMS performance, and highlight its relationship to business performance, in order to direct management action to deficient areas of the management system. Improved data analysis will both support improving the QMS and positively impact on business performance. The research introduces significance tags to both process area level, and the audit finding level in order to reduce the level of collective uncertainty embedded in current periodic reporting of QMS performance.

CHAPTER 3: MANAGEMENT SYSTEM PERFORMANCE MEASUREMENT - A LITERATURE REVIEW

3.1 Introduction

The literature review examines the elements and processes which support the research question, which states: "How can the performance measurement capability of the quality management system of Eskom's Koeberg power station be improved to assist management to identify business risk resulting from quality management system deficiencies, to improve business performance?"

The review considered the broader elements of the research scope which highlights the following key considerations in support of the primary research question and the investigative sub questions.

- Quality management systems and their role.
- Quality management methodologies and philosophies.
- Business performance measurement and the relationship between quality management and business performance.
- Quality measurement instruments and their influences.
- Causal and effect relationship methodology in the QMS context.
- The development basis and use of QMS themes.
- The impact of good management system implementation on business performance.
- The importance of obtaining management commitment.

The review also provides an overview of management system models and standards pertaining to the nuclear power quality industry, which is important to the detail of the research in further chapters.

3.2 Quality management systems and their role

The Quality Management systems (QMS) standard, ISO 9000 (2000:1), notes that the rationale for quality management systems as being able to assist organisations in enhancing customer satisfaction. It states that customers require products with characteristics that satisfy their needs and expectations. It goes on to highlight that needs and expectations are expressed in product specifications and collectively referred to as customer requirements.

The ISO 9000 (2000:1), standard notes that customer requirements may be specified contractually by the customer, or may be determined by the organisation itself. In either case, the customer ultimately determines the acceptability of the product. The standard notes that customer needs and expectations are changing, and because of competitive pressures and technical advances, organisations are driven to continually improve their products and processes.

The quality management system approach encourages organisations to analyse customer requirements, define the processes that contribute to the achievement of a product which is acceptable to the customer, and keep these processes under control. A quality management system can provide the framework for continual improvement to increase the probability of enhancing customer satisfaction and the satisfaction of other interested parties. It provides confidence to the organisation and its customers that it is able to provide products that consistently fulfill requirements (ISO 9000, 2000:1).

3.3 Business performance measurement

According to Kellen (2003:3), business performance measurement and control systems are the formal, information-based routines and procedures, managers use to maintain or alter patterns in organisational activities. Kellen (2003:3), notes that a typical performance measurement

helps businesses in periodically setting business goals and then providing feedback to managers on progress towards those goals.

The author notes that the time horizon for these goals can typically be about a year or less for short-term goals or span several years for long-term goals. Since a business performance measurement system measures performance, Kellen (2003:3), deems it of importance to define what performance is, and cites Lebas and Euske's (2002) definition of performance as, "Doing today what will lead to measured value outcomes tomorrow." Kellen (2003:3), concludes that business performance measurement then is concerned with measuring this performance relative to some benchmark, be it a competitor's performance or a preset target. The overview of this domain distinguishes between Non-nuclear (International Business Excellence Models) and Nuclear Industry specific models and standards.

3.4 Quality management methods and philosophies

Ghalayini and Noble (1996:63) note that in order for companies to ensure achievement of their goals and objectives, performance measures are used to evaluate, control and improve production processes. A variety of quality management methods and philosophies such as Business Excellence Models, Balanced Scorecards and QMS Standards have been employed to aid measurement of performance. The quality method chosen would be unique depending on market situations, product strategies and competitive environments the business is exposed to. Paragraphs 3.4.1 to 3.4.8 provide an overview of some of these.

3.4.1 International business excellence models

Talwar (2011:24), notes that during the last two decades, business excellence models have been considered an effective way to pursue excellence in many industries worldwide. According to Talwar (2011:30) citing Lakhe and Mohanty (1994) and Hendricks and Singhal (1997),

several organisations have reported that with implementation of business excellence models, their process orientation, customer orientation and improvement orientation have improved. Winners of business excellence models have not only improved their product quality, but have also reported improvements in market share, sales, profits, employee morale and competitiveness as a result of implementing these models

The criteria below was extracted from the writings of Business Performance Improvement Resource (BPIR) (2012:**Online**), which provides overviews of the various models listed below, namely, the Australian Business Excellence Framework, the Canadian Framework for Business Excellence, the Singapore Quality Award Framework, the EFQM Excellence Model and the Baldrige Criteria for Performance Excellence.
The first six elements are common to all the models, while the last two elements were noted in only two and three models respectively.

The elements of the models were drawn from the writings at BPIR (2012:**Online**), which are elaborated upon below:

- **Leadership**: How upper management leads the organisation, and how the organisation leads within the community.
- **Strategic Planning**: How the organisation establishes and plans to implement strategic directions.
- **Customer and Market Focus**: How the organisation builds and maintains strong, lasting relationships with customers.
- **People / Workforce Focus**: How the organisation empowers and involves its workforce.
- **Process Management**: How the organisation designs, manages and improves key processes.
- **Business Results / Success**: How the organisation performs in terms of customer satisfaction, finances, human resources, supplier and partner performance, operations, governance and social responsibility, and how the organisation compares to its competitors.

- **Measurement, Analysis and & Knowledge / Information Management**: How the organisation uses data to support key processes and manage performance.
- **Partnerships and Suppliers**: How the organisation manages and interacts with suppliers and partners in order to for the relationship to be mutually beneficial.

The models described below are considered to be more established and are widely used internationally:

- **Baldrige Criteria for Performance Excellence:** This is the model behind the US Malcolm Baldrige National Quality Award, an award process administered by the American Society for Quality (ASQ) and managed by the National Institute of Science and Technology (NIST), an agency of the US department of Commerce. This framework is used as the basis for over 70 other national Business Excellence/Quality awards around the world (BPIR, 2012:**Online**).
- **EFQM Excellence Model:** This is the model behind the European Business Excellence Award, an award process run by the European Foundation for Quality Management (EFQM). This framework is used as the basis for national business excellence and quality awards across Europe (BPIR, 2012:**Online**).
- **Singapore Quality Award Framework:** The Singapore Quality Award (SQA) framework is used as a basis for assessing Singapore's organisations to the highest standards of quality and business excellence. The award aims to establish Singapore as a country committed to world-class business excellence. The framework and award is administered by SPRING Singapore (BPIR, 2012:**Online**).
- **Canadian Framework for Business Excellence:** The Canadian Framework for Business Excellence is used by Canadian organisations as a management model for organisational excellence and also as the basis for adjudication of the Canada

Awards for Excellence. The framework is administered by the National Quality Institute (BPIR, 2012:**Online**).

- **Ø** **Australian Business Excellence Framework:** The Australian Business Excellence Framework is the premier framework for business excellence in Australia and provides the criteria for the Australian Business Excellence Awards. The framework is administered by SAI Global (BPIR, 2012:**Online**).

3.4.2 The balanced scorecard

Wongrassamee, Simmons and Gardiner (2003:18), note that in early 1990, the Nolan Norton Institute, the research arm of KPMG, sponsored a study in "Measuring performance in the organisation of the future". David Norton, CEO of Nolan Norton, served as the study leader and Robert Kaplan as an academic consultant. The authors state that after a yearlong research program with 12 companies, the study group produced a comprehensive framework, named the "Balanced Scorecard", in which an organisation's mission and strategic objectives can be translated into a set of performance measures.

3.4.3 The purpose of the balanced scorecard

Wongrassamee, Simmons and Gardiner (2003:18), continue and state that purpose of the Balanced Scorecard is to help communicate and implement an organisation's strategy. The authors note that the Balanced Scorecard is a framework containing a set of financial and non-financial measures chosen to aid a company in implementing its key success factors, which are defined in the company's strategic vision. Wongrassamee, Simmons and Gardiner (2003:18), note that to counter the traditional emphasis on the financial aspect of profit, Kaplan and Norton (1992) introduced three additional measurement categories that highlight non-financial aspects. The authors state that these are customer satisfaction, internal business process, and learning and growth and note that Kaplan and Norton consider these three additional categories as sets

of measures of the firm's drivers of future performance, whereas the financial perspective represents the past performance.

3.4.4 The balanced scorecards need for cutomisation

Wongrassamee, Simmons and Gardiner (2003:19), note that the Balanced Scorecard is not a template that can be applied to businesses in general or even industry-wide. The authors state that different market situations, product strategies and competitive environments require different scorecards. Business units the authors continue thus devise customised scorecards to fit their mission, strategy, technology and culture. In fact a critical test of a scorecard's success is its transparency: from 15 to 20 scorecard measures, an observer should be able to see through to the business unit's competitive strategy the authors note.

3.4.5 Nuclear industry specific quality models and standards

The considerations for management systems (MS) and models for the nuclear power industry, even though they contain the same MS components as conventional non-nuclear business, is heavily biased toward prioritisation of personal and public safety. IAEA GS-G-3.5 (2009: 4) states, “Safety shall be paramount within the management system, overriding all other demands."

Models and standards aim to enhance nuclear safety in compliance with nuclear quality requirements, nuclear community industrials must develop and continuously improve safe, reliable products that meet or exceed customer and applicable statutory and regulatory requirements. Nuclear utilities thus need to make business sense and question safety in all decisions (IAEA GS-G-3.5, 2009:4). The following paragraphs provide an overview of the more prominent nuclear specific models and standards.

3.4.6 Nuclear Energy Institute Standard Nuclear Performance Model (NEI SNPM)

The executive summary of the NEI SNPM (2004:i) reads: “To improve benchmarking effectiveness, the Nuclear Energy Institute (NEI), Electric Utility Cost Group (EUCG) and Institute of Nuclear Power Operations (INPO) worked to define a Standard Nuclear Performance Model (SNPM). This three-year effort resulted in closer coordination of process descriptions, key business performance indicators (KPIs) and activity based costing definitions. The concept for the SNPM was developed as an objective of the industry Nuclear Power Oversight Committee’s Strategic Plan for Improved Economic Performance established in 1993. The SNPM was originally issued in 1998.”

This NEI SNPM (2004:i), provides a summary of nuclear processes, cost definitions and key business performance measures together with references and industry leader contact information. The material is useful for understanding the overall methods for how electricity is produced by a nuclear power plant. The processes and related data are useful for making business performance comparisons and benchmarking.

3.4.7 International Atomic Energy Agency (IAEA), GS-R-3, The management System for Nuclear Facilities and Activities

The International Atomic Energy Agency (IAEA) produced GS-R-3 (2006) to address a need for integration of management systems taking all safety aspects of the nuclear industry into consideration.

The IAEA GS-R-3 (2006:3), standard states that its objective is to define the requirements for establishing, implementing, assessing and continually improving a management system that integrates safety, health, environmental, security, quality and economic elements to ensure that safety is properly taken into account in all the activities of an organisation.

Furthermore in terms of IAEA GS-R-3 (2006:3), the main objective of the requirements for the management system is to ensure, by considering the implications of all actions not within separate management systems but with regard to safety as a whole, that safety is not compromised. These requirements must be met to ensure the protection of people and the environment and they are governed by the objectives, concepts and principles of the IAEA Safety Fundamentals publication

3.4.8 American Society of Mechanical Engineers (ASME) NQA-1

The ASME NQA-1 (2008:3), nuclear quality assurance standard provides requirements and guidelines for the establishment and execution of quality assurance programs during siting, design, construction, operation and decommissioning of nuclear facilities. This Standard reflects industry experience and current understanding of the quality assurance requirements necessary to achieve safe, reliable, and efficient utilisation of nuclear energy, and management and processing of radioactive materials. The Standard (NQA-1, 2008:3), focuses on the achievement of results, emphasises the role of the individual and line management in the achievement of quality, and fosters the application of these requirements in a manner consistent with the relative importance of the item or activity.

3.5 The relationship between quality management and business performance

Management of the quality of products and processes, and the management system enabling that quality, is an important contributor to business performance. This has been proven empirically over the years (Fons, 2011:468). Business performance is easier to link directly to business excellence models as better measurement criteria are embedded in implementation of the models. The relationship is thus expanded upon at “excellence model vs. management system” level.

ISO 9000 (2000:6), expands on the relationship between quality management systems and excellence models They note that approaches of quality management systems given in the ISO 9000 family of standards and in organisational excellence models are based on common principles. They agree that both approaches:

- Ø Enable an organisation to identify its strengths and weaknesses.
- Ø Contain provision for evaluation against generic models.
- Ø Provide a basis for continual improvement.
- Ø Contain provision for external recognition.

It is maintained (ISO 9000, 2000:6), that the difference between the approaches of the quality management systems in the ISO 9000 family and the excellence models lies in their scope of application. The ISO 9000 family of standards provides requirements for quality management systems and guidance for performance improvement; evaluation of quality management systems determines fulfillment of those requirements.

The excellence models contain criteria that enable comparative evaluation of organisational performance and this is applicable to all activities and all interested parties of an organisation. Assessment criteria in excellence models provide a basis for an organisation to compare its performance with the performance of other organisations (ISO 9000, 2000:6).

3.6 Models vs. standards

The ISO standard clarification ISO TC 176 (2010:6), answers the question of defining the relationship between ISO 9004:2009 and the Excellence / Award models such as NMBQM, EFQM and Deming Award Prize in the following way. It states that ISO 9004 (2009), is compatible with the main international and national Excellence/Award models. This implies that ISO compliance and certification is possible within an organisation which successfully implements a EFQM model for example. The document sates that it is not a competitor, but gives complementary guidance on the path towards excellence.

3.7 QMS performance measurement by means of audit

Ramly, Ramly and Yusof, (2007:1) note that the need to improve organisational performance has been a major discussion issues due to competitive pressure in manufacturing industries. The authors state that in order to achieve the higher competitiveness level, these organisations must be able to identify the current quality performance and realign their strategies, operations and process to improve the quality performance. Ramly, Ramly and Yusof, (2007:1) continue by stating that "Audit" is one of the many tools that have been found useful to identify the current quality performance by diagnosing the opportunities for improvement and plan for improvement action.

3.7.1 QMS audits

Ramly, Ramly and Yusof, (2007:1) state that the purposes of the audits can be divided into compliance audits and management audits, where compliance audits look for conformance to the audit criteria, while management audits look for conformance to the audit criteria and the effectiveness of the process and opportunities for improvement in achieving organisation goals. The authors note examples of conformance audits and include financial audits, tax audits and regulatory audits. Ramly, Ramly and Yusof, (2007:1) note examples of management audits and include manufacturing audits, product and process audits, and improvement audits. The authors note that both compliance audits and management audits can be integrated, but normally the organisations adapt the compliance audit based on audit criteria (i.e. compliance to ISO 9001) before the auditor can suggest area for improvements which is outside the audit criteria.

3.7.2 The role of QMS audits

Borror, (2008:73), cites the American National Standard (ANS, 1978) definition of an audit as a systematic examination of the acts and decisions with respect to quality to independently verify or evaluate compliance to the operational requirements of the quality program, specifications, or contract requirements of the product or service. She notes that the term compliance, often meaning compliance to documented procedures, is used instead of the term adequacy. Borror (2008:73), again cites the ANS (1978) standard, and defines the system audit as a documented activity performed to verify, by examination and evaluation of objective evidence, that applicable elements of the quality system are suitable and have been developed, documented, and effectively implemented in accordance with specified requirements.

The standard further defines the process audit as an analysis of elements of a process and appraisal of completeness, correctness, or conditions, and probable effectiveness. The product audit is a quantitative assessment of conformance to required product characteristics. Simply stated, the product audit verifies that the system and processes used to produce the product are capable of producing a product that conforms to the established specifications/requirements.

3.7.3 Quality data collection and analysis

Quality data is often not accessible enough or analysed and processed to provide digestible actionable content. Baird, Hu and Reeve (2011:804-805), show that by examination of the association between the core TQM practices (quality data and reporting, supplier quality management, product/service design and process management) and operational performance (inventory management performance and quality performance) that quality data and reporting was positively associated with supplier quality management and product/service design. Baird, Hu and Reeve (2011:804-805), show that their findings support Kaynak's (2003) findings in the USA. Baird, Hu and Reeve (2011:804-805), conclude that

organisations should devote more effort to collecting and disseminating quality-related data.

3.7.4 Frameworks and structure for data collection and analysis

It is important to provide rules and standards for data collection and analysis. Tavana, Mohebbi and Kennedy (2003:520-521), show this in their paper where they propose in their study, a Total Quality Index (TQI) which is an information technology-supported benchmarking tool, that helps managers assess a total quality management program by enabling the cost-effective measurement of key organisational processes. Tavana, Mohebbi and Kennedy (2003:520-521), reflect that statistical analysis showed a difference between the clinical and non-clinical departments on critical organisational processes, quality data and reporting. On this process, they showed that clinical departments have a larger gap than the non-clinical.

Tavana, Mohebbi and Kennedy (2003:520-521), concluded that clinical employees have a tradition of data collection and analysis. This included physicians and nurses who do research as well as other skilled clinical employees who must maintain records to satisfy licensing agents or regulatory bodies. This ongoing process of data collection and analysis makes clinical departments more acutely aware of weaknesses in actual practice. The result, noted may also have reflect the absence of a management philosophy that uses the information collected in a way that has a positive impact on the quality of health care provided. In other words, the data cannot be interpreted without a clearly defined and understood management policy.

3.8 Quality management Instruments

Many differing opinions have been noted on the definition of “Quality”, as the environmental context of the definition seems to be important in how any person would define it. Similarly when attempting to manage quality,

the context of the environment needs to be taken into account. In order to manage quality it must be measured. Van der Wiele and Van Iwaarden (2002:1) note that recent research has shown that a universalistic approach is inappropriate because quality management is in fact context dependent. The management control discipline has acknowledged the importance of the business context already more than a decade ago, and can provide important insights for quality management. The researcher thus proposes that the quality measurement instrument considerations and criteria will adopt the context of its quality objectives. This narrative expands on two instruments with differing quality objectives and measurements philosophies, namely:

- The SERVQUAL instrument and,
- the critical factors of quality.

3.8.1 SERVQUAL instrument

Pan, Kuo and Bretholt (2010:6) notes that the SERVQUAL instrument,, developed by Parasuraman (1988), is widely used for measuring quality in the service industry. They note that Parasuraman's research reveals that a consumer's assessment of service quality fits into ten potentially overlapping dimensions. These dimensions are tangibles, reliability, responsiveness, communication, credibility, security, competence, courtesy, understanding or knowing the customer, and accessibility. They state that to simplify the ten dimensions, Parasuraman (1988) removed the items with relatively low item-to-total correlations and developed a refined scale with 22 items spread over the following five dimensions (quoted verbatim):

- **Tangibles:** Physical facilities, equipment, and appearance of personnel.
- ***Reliability*:** Ability to perform the promised service dependably and accurately.
- ***Responsiveness***: Willingness to help customers and provide prompt service.

- Ø ***Assurance***: Knowledge and courtesy of employees and their ability to inspire trust and confidence.
- Ø ***Empathy***: Caring, the individualised attention the firm provides its customers.

3.8.2 The "Critical factors of quality" Instrument

An instrument was developed by Saraph, Benson and Schroeder (1989) which supports measuring the critical factors of quality. Their paper identified eight critical factors (areas)of quality management in a business unit. Operational measures of these factors were then developed using data collected from 162 general managers and quality managers of 89 divisions of 20 companies. The authors note that the measures can be used individually or in concert to produce a profile of organisation-wide quality practices (Saraph, Benson and Schroeder 1989:810).

Saraph, Benson and Schroeder (1989:811) note that operational measures of quality management in terms of certain critical factors would be useful to both decision makers and researchers. They state that decision makers need to know the status of the organisational controllable so that they can manipulate to make organisation-wide improvements in quality performance. They further state that researchers can use such measures to better understand quality management practice and build theories and models that relate the critical factors of quality management in an organisation to improve the organisation's quality performance and quality environment.

3.9 Quality performance measurement inputs

To enable reliable measurement of quality performance, quality data collected from audits and other monitoring activity types must be rationalised, simplified and questioned via complementary quality methodologies. Pan, Kuo and Bretholt (2010:15) imply that methods such as the use of performance indicators enable conversion of the qualitative

data into a quantitative domain makes it easier to uncover more meaningful information. The researcher proposes that performance indicators and segregating data into cause and effect domains provides additional context to information for management reporting.

3.9.1 Key Performance Indicators (KPIs)

Davies and Davis (2011:74) state that “measure” is the general term used to describe precise criteria through which we quantify performance. The authors note that there are two types of measures, lead and lag indicators:

- **Lead indicators:** Lead indicators, also called performance drivers, could be events which must happen first in order to cause consequences, or lag indicators,
- **Lag indicators**: Lag indicators are measures of outcome or consequences.

Davies and Davis (2011:74) further note that there are two other commonly used terms, namely Key Performance Indicator (KPI) and Performance Indicator (PI):

- **KPI**: KPI is often used to denote measures included within a strategic level Balanced Scorecard, whereas
- **PI**: PI refers to measures in tactical and operational level Balanced Scorecards. Both KPIs and PIs can comprise lead and lag indicators.

Pan, Kuo and Bretholt (2010:15) emphasise KPI’s and their ability to move information into the quantitative domain. They note that Service quality is a matter of finding out what creates value to customer and then offering that value. They continue in saying that providing value requires familiarity with the customer and deep understanding of the problematic situation on hand. They showed that KPI play an important role in service quality assurance since it provides a quantitative measure of service quality.

3.9.2 Cause and effect relationaships

Davies and Davis (2011:74) state that causal relationships are cause and effect links between deliverables, drivers and benefits (consequences). The authors note that the relationships generally are, many-to-many relationships, i.e. a deliverable can influence several drivers and/or any one driver can be changed by the effect of several deliverables.

Davies and Davis (2011:74) maintain that the most effective way to identify, define and quantify causal relationships is using real stories from real people. They note that causal stories are complete chains of causal relationships, expressed as a story and corroborated with a calculation which quantifies the storyline. The authors propose that storylines read as IF-THEN statements between deliverables, drivers and benefits. The example they use is, "*IF straight through processing (deliverable) automates the payment process THEN there will be fewer errors (driver); IF fewer errors THEN there will be reduced correction costs (benefit)*".

3.9.3 Cause and effect themes

Themes are complete chains of cause and effect relationships between objectives and measures within a Balanced Scorecard context. At the highest level, themes define business strategy. Themes can also define causal links between Balanced Scorecards that are cascaded at various levels within the business, to provide a clear line of sight through aligned objectives and measures (Davies & Davis, 2011:74).

3.9.4 Metrology considerations for measuring instruments

Bell (2001:ii) states that every measurement is subject to some uncertainty. The author notes that a measurement result is only complete if it is accompanied by a statement of the uncertainty in the measurement. Measurement uncertainties can come from the measuring instrument, from the item being measured, from the environment, from the operator, and

from other sources. The author states that such uncertainties can be estimated using statistical analysis of a set of measurements, and using other kinds of information about the measurement process. Bell (2001:ii) emphasises that there are established rules for how to calculate an overall estimate of uncertainty from these individual pieces of information. Bell (2001:ii), notes that the use of good practice – such as traceable calibration, careful calculation, good record keeping, and checking – can reduce measurement uncertainties. Bell (2001:ii) concludes that when the uncertainty in a measurement is evaluated and stated, the fitness for purpose of the measurement can be properly judged.

Bell (2001:7-8), notes that many things can undermine a measurement. Flaws in the measurement may be visible or invisible the author notes. The author continues by stating that real measurements are never made under perfect conditions, and that errors and uncertainties maybe introduced into measurement. Bell (2001:7-8) identifies the following (quoted verbatim):

- **The measuring instrument:** Instruments can suffer from errors including bias, changes due to ageing, wear, or other kinds of drift, poor readability, noise (for electrical instruments) and many other problems.
- **The item being measured**: The measured item may not be stable. (Imagine trying to measure the size of an ice cube in a warm room.)
- **The measurement process**: The measurement itself may be difficult to make. For example measuring the weight of small but lively animals presents particular difficulties in getting the subjects to co-operate.
- **Imported uncertainties**: Calibration of your instrument has an uncertainty which is then built into the uncertainty of the measurements you make. The uncertainty due to not calibrating would however be much worse.
- **Operator skill:** Some measurements depend on the skill and judgement of the operator. One person may be better than another at the delicate work of setting up a measurement, or at reading fine

detail by eye. The use of an instrument such as a stopwatch depends on the reaction time of the operator. Gross mistakes are a different matter and are not to be accounted for as uncertainties.

- **Sampling issues:** The measurements made must be representative of the process you are trying to assess. If you want to know the temperature at the work-bench, don't measure it with a thermometer placed on the wall near an air conditioning outlet. If you are choosing samples from a production line for measurement, don't always take the first ten made on a Monday morning.
- **The environment:** Temperature, air pressure, humidity and many other conditions can affect the measuring instrument or the item being measured.

Bell (2001:8), notes that where the size and effect of an error are known (e.g. from a calibration certificate) a correction can be applied to the measurement result. But, in general, uncertainties from each of these sources, and from other sources, would be individual 'inputs' contributing to the overall uncertainty in the measurement.

3.10 Quality management system themes

To enable categorisation of qualitative audit data the researcher employed the use of QMS themes table as shown in Annexure B: QMS Process Themes Listing. The version of the listing was derived using a combination of process functional decomposition, and thematic analysis.

3.10.1 Functional decomposition

Fink (2006:82) notes that the technique of decomposition is well known in the information systems and computer science disciplines and that it is commonly applied during the phases of systems analysis in producing data flow diagrams in which a system is broken down into smaller and smaller pieces. Fink (2006:82) states that during systems design it is practiced in the normalisation of data to reduce redundancy and in the

construction of structure charts to reduce complexity in the cohesion and coupling of the data. The author notes the technique of decomposition is essentially a top-down approach to solving a complex problem.

3.10.2 Thematic analysis

Guest, MacQueen and Namey (2012:10) note that thematic analyses, as in grounded theory and development of cultural models, require more involvement and interpretation from the researcher. The authors state that thematic analyses moves beyond counting explicit words or phrases and focuses on identifying and describing both implicit and explicit ideas within the data, that is, themes. The authors continue and state that codes are then typically developed to represent the identified themes and applied or linked to raw data as summary markers for later analysis. Such analyses may or may not include the following: comparing code frequencies, identifying code co-occurrence, and graphically displaying relationships between codes within the data set.

Guest, MacQueen and Namey (2012:11) note that generally, reliability is of greater concern with thematic analysis than with word-based analyses because more interpretation goes into defining the data items (i.e., codes) as well as applying the codes to chunks of text. The authors state that this issue is even more pronounced when working in teams with multiple analysts. To maintain rigor, strategies for monitoring and improving intercoder or rater agreement, and therefore reliability, should be implemented in the analytic process. The authors propose that despite the few issues related to reliability, they feel that a thematic analysis is still the most useful in capturing the complexities of meaning within a textual data set.

3.11 The Impact of good management systems on business performance

Fons (2011:468), cites many examples of where there was evidence of a good Return on Investment (ROI) and highlights that actions, regarding implementation of a QMS is worthwhile, and that the benefits outweigh the cost. In general, the revenue increase and the cost decrease are greater than the cost increase as the company improves its quality. Fons (2011:468), continues and states that if observed with greater detail and seriousness, his report findings shows that preventive actions (training) in the context of the QMS will have a yet higher overall economic impact.

Kanter and Page (2011:1), provides examples of business and economic success related to compliant implementation of the of management systems via the Baldrige criteria, which further emphasises the beneficial impact of an implemented management system.

3.11.1 The importance of obtaining management commitment

The International Atomic Energy Agency management standard, IAEA GS-G-3.5 (2009:19-20), requires that management at all levels show its commitment to the establishment, implementation, assessment and continual improvement of the management system and that they allocate adequate resources to carry out these activities.

IAEA GS-G-3.5 (2009:19-20) management standard, also requires that senior management develop individual values, institutional values and behavioral expectations for the organisation to support the implementation of the management system and that they shall act as role models in the promulgation of these values and expectations. Management at all levels are also required by IAEA GS-G-3.5 (2009:19-20), to communicate to individuals the need to adopt these individual values, institutional values

and behavioral expectations, as well as to comply with the requirements of the management system.

3.11.2 The role of top management during the implementation of ISO 9001 or other management standard

ISO TC (2010:5), states that the top management of an organisation should take the role of the most important supporter and sponsor of such an implementation program. It states that implementation of the management system will change the way an organisation thinks and behaves, and how it communicates both internally as well as externally. Hoyle (2007:83-84) further emphasises the importance of and the requirements for top management driving the implementation of ISO 9001.

3.11.3 Leadership competencies for implementing QM principles

Das, Kumar and Kumar (2011:198), states that leadership competencies are the knowledge, skills, abilities, and attribute that leaders should possess and demonstrate in order to perform their roles and jobs competently. Das, Kumar and Kumar (2011:198) cite Kotter (1990), in saying that leaders play three roles, namely setting a direction, aligning people, and motivating and inspiring people. The author's review of leadership competencies shows that research has focused on the issue of leadership competencies for some time, with the idea of identifying the qualities and abilities possessed by successful leaders.

Das, Kumar and Kumar (2011:198), states that according to Gonzalez and Guillen (2002), committed managers use their power for implementing the process, but this does not necessarily mean that they are leaders of the process. By using their formal power, committed managers lead the process by facilitating the allocation of resources and supporting those who develop the QM project. The authors note that leadership, however, goes beyond the boundary of formal power. Leaders create a new

environment in the organisation by their inter-personal influence, which involves others in the change initiative.

3.11.4 Leaderships ability to influence followers

Das, Kumar and Kumar (2011:198) note that some authors in the TQM literature have pointed to the fact that leaders are able to influence the feelings of their followers to provoke creativity, develop integrated teams, define and communicate a shared vision, and generate compromise. The authors note that that complete implementation of all the principles of TQM is not possible without the participation of leaders whose capacity for influence and mobilisation rests on all the dimensions of their leadership competency. Das, Kumar and Kumar (2011:198), note in their review of TQM literature that there was evidence of confusion between the terms management commitment and managerial leadership. The authors note that in some literature, commitment and leadership are used synonymously, while others argue that the scope of leadership goes beyond the scope of commitment.

3.12 Conclusion

The literature review considered the broader elements of the research scope, highlighting the key considerations in support of the primary research question and the investigative sub questions. These included:

- Ø Quality management systems and their role.
- Ø Quality management methodologies and philosophies.
- Ø Business performance measurement and the relationship between quality management and business performance.
- Ø Quality measurement instruments and their influences.
- Ø Causal and effect relationship methodology in the QMS context.
- Ø The development basis and use of QMS themes.
- Ø The impact of good management system implementation on business performance.

- Ø The importance of obtaining management commitment.

The literature review highlighted the variation in focus of research information on the measurement of quality management, and found minimal focus on QM system performance data and analysis of that data at audit level. It showed that most measurement criteria start at the excellence model domain, which focuses on many lagging business output indicators, rather than complementary leading QMS measurement indicators.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The research design and methodology will expand on the philosophy and methods used to interrogate and expose solutions to the research problem.

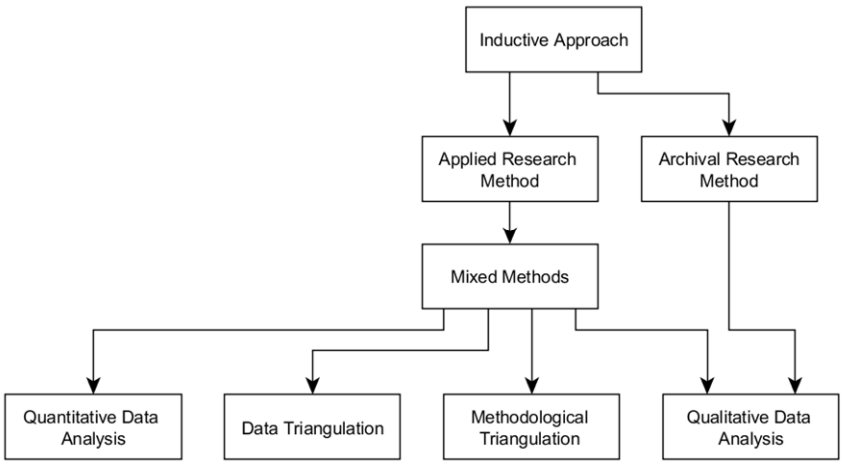

Figure 4.1: Research overview (**Source:** Adapted from Saunders, Lewis & Thornhill, 2009)

Figure 4.1 shows a broad overview of the research methods employed. This chapter will however include descriptions of the following:

- An overview of the high level inductive research approach
- The applied research methodology
- The archival research methodology
- The applicability of the use of mixed methods i.e. combining qualitative and quantitative methods
- The data collection and processing methods
- The validity and reliability considerations

4.2 Inductive applied research

The research approach is considered inductive in that a theory is developed based on the collection and the analysis of that data (Saunders, Lewis & Thornhill, 2009:125-126).

Thunhurst and Randall (2010:398) state that defining feature of applied research is that it is driven by the need to answer practical questions surrounding the topic being studied. The authors note that applied research is methodologically eclectic, in that practical decision- making will need to call upon a range of evidence bases. They further note that applied research projects can help to bridge the theory/practice divide. As such, they can play a valuable role in developing the workforce, both at the student and practitioner level. Involvement in solidly underpinned applied research projects can translate seemingly abstract theoretical considerations into issues of critical practical significance.

Applied research, will thus serve as the basis of the research methodology as it is considered the most appropriate research approach, based on the need to answer practical questions around the measurement QMS health philosophy

4.3 Archival research

Saunders, Lewis and Thornhill (2009:150), note that archival research makes use of administrative records and documents as the principal source of data. They note that although the term archival has historical connotations, it can refer to recent as well as historical documents. They state that all research that makes use of data contained in administrative records is inevitably secondary data analysis. This is because the data was originally collected for a different purpose. When this data is however used in an archival research strategy they are analysed for the value they provide to the current research. The authors continue by noting that archival research data however may not contain the precise information required to answer the research question(s) or meet research objectives. Using an archival research strategy therefore necessitates establishing what data is available and designing the research to make the most of it.

4.4 The applicability of mixed methods research

Creswell (2009:203) notes that with the development and perceived legitimacy of both qualitative and quantitative research in the social and human sciences, mixed methods research, employing the combination of quantitative and qualitative approaches, has gained popularity. This popularity is because research methodology continues to evolve and develop, and mixed methods is another step forward, utilising the strengths of both qualitative and quantitative research. The author also notes that the problems addressed by social and health science researchers are complex, and the use of either quantitative or qualitative approaches by themselves are inadequate to address this complexity. Creswell (2009:203), continues by stating that the Interdisciplinary nature of research, as well, contributes to the formation of research teams with individuals with diverse methodological interests and approaches. Finally, there is more insight to be gained from the combination of both qualitative and quantitative research than either form by itself. Their combined use provides an expanded understanding of research problems.

4.5 The quantitative and qualitative comparison

In the opinion of the researcher, Leedy and Ormrod (2010:96), provides the most practical perspective of the differences between the qualitative and quantitative research paradigms. Table 4.1 show these differences the in terms of the research focus.

Table 4.1: Qualitative and quantitative research characteristics (**Source:** Adapted from Leedy & Ormrod (2010:96))

Research Focus	**Quantitative research paradigm**	**Qualitative research paradigm**
Purpose of the research	To explain and predict To confirm and validate To test theory	To describe and explain To explore and interpret To build theory
Nature of the research	Focused	Holistic

process	Known variables Established guidelines Predetermined methods Context-free Detached view	Unknown variables Flexible guidelines Emergent design Context-bound Personal view
What is the data like, and how is such data collected?	Numeric data Representative, large sample Standardised instruments	Textual and/or image-based data Informative, small sample Loosely structured or non-standardised observations and interviews
How is data analysed to determine its meaning?	Statistical analysis Stress on objectivity Deductive reasoning	Search for themes and categories Acknowledgement that analysis is subjective and potentially biased Inductive reasoning
Method of communicating findings	Numbers Statistics, aggregated data Formal voice, scientific style	Words Narratives, individual quotes Personal voice, literary style

From the above, the analogy can be drawn that there is much overlap between qualitative and quantitative research methods. Most qualitative-style researchers examine quantitative-type data and vice versa, however they differ in significant ways.

4.6 The QMS audit methodolgy

The QMS audit process steps applicable to the research design and methodology is expanded upon to provide the audit process links to the research design and methodology.

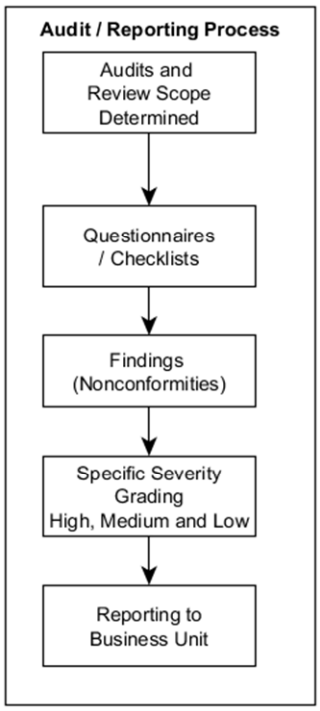

Figure 4.2: Simplified audit process steps KNPS employs (**Source**: Adapted from Eskom Internal Procedure, KAA-832)

Figure 4.2 shows the simplified audit process. In order to produce the secondary data which is analysed in this study, the following process took place over a three year period prior to the study being initiated by the researcher:

- Audits and reviews are scoped and resourced in accordance with an audit program.
- Questionnaires or checklists are designed to test implementation of the process areas defined in the audit scope.
- Findings or Nonconformities (NCs) are raised where noncompliance is noted.
- The NCs are rated and a severity grading is assigned to the NC.
- Audit findings and conclusions are reported to process owners and process management.

Figure 4.3 expands on the simplified audit process showing the applicable audit process steps and their alignment with the research design and methodology. It also shows the mixed method evolution of data and

analyses, as the data moves from qualitative to quantitative format and vice versa.

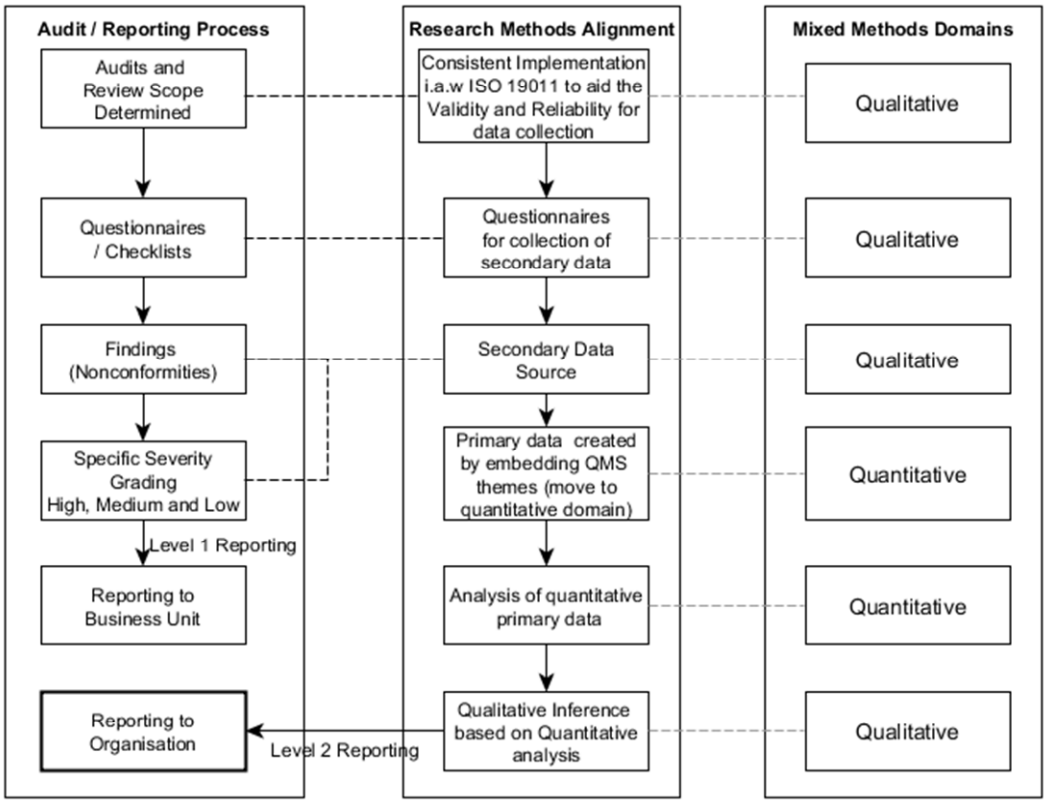

Figure 4.3: Audit process / research methodology links (**Source**: Own)

The study thus commences with three years' worth of audit findings available for review, and continues with the following steps:

- Ø The secondary audit findings data, which consists of 255 nonconformities is analysed in conjunction with the "Themes Listing" shown in Annexure B.
- Ø "Cause" and "Effect" themes are assigned to each finding.
- Ø A generic severity grading is assigned to the process area where the NC took place.

The primary data embedded within the secondary findings data is then analysed to produce qualitative inferences relating to business process and personnel interactions.

4.7 The reliability of audit results

In order to have minimal variation within the audit process and audit results, all auditors practicing within the Koeberg Operating Unit (KOU) are required to be registered with a professional certification body. The Southern African Auditor and Training Certification Association (SAATCA) have developed certification criteria for Quality Management System (QMS) auditors in order to certificate auditors conducting independent internal or external audits, indicating that they have the skills required to effectively perform Quality Management System audits (SAATCA, 2012:**Online**). The body notes that the criteria for the scheme has been aligned with the requirements of the International Personnel Certification Association (IPC), the requirements of ISO 19011 (Guidelines for auditing management systems), ISO 17021 (Conformity assessment - Requirements for bodies providing audit and certification of management systems) and ISO 9001 (Quality management systems – Requirements).

This SAATCA auditor certification program has been developed to meet the following objectives:

- Ø To raise the level of professional recognition for QMS auditors.
- Ø To add value to QMS audits by ensuring auditor competence.
- Ø To provide international recognition of auditors certified in Southern Africa.
- Ø To assist organisations in selecting appropriately qualified auditors.
- Ø To provide credible and accountable QMS auditor certification program.

The above criteria and objectives reduce the amount of uncertainty at the input stage of the QMS health measuring instrument. Auditors are also exposed to internal training and alignment workshops to further reduce this uncertainty.

4.8 Data collection design and methodology

The objective of the research is to quantify information embedded in QMS audit findings collected over a period of three years, in order to provide a measure of QMS health. The quantified QMS health data will inform management decisions and guide management action with the aim of improving business performance. Data triangulation will serve as data collection methodology.

Watkins (2012:74) notes that the concept of ‘triangulation’, applies to not only the collection of data from different sources ('data triangulation'), but also to using multiple research methods (methodological triangulation). Watkins (2012:74) cites Collis and Hussey (2009), and provides an amended definition of their concept of 'triangulation', and, which reads as follows: "Triangulation is the use of multiple sources of data (data triangulation), and different research methods (methodological triangulation). Data triangulation culminates in diverse data collection techniques, which can be triangulation culminates in diverse data collection techniques, which can be juxtaposed for example questionnaires, interviews, surveys and field studies". In this research study, data collection forms and data mining will serve as mechanisms of data collection.

4.9 The use of secondary data analysis

Blaxter, Hughes, and Tight (2006:170) note that researchers who base their studies on historical documents (or secondary content) may make considerable use of secondary data; that is, data which has already been collected, and possibly also analysed, by somebody else. They note that the most common forms of secondary data are official statistics collected by governments and government agencies and that the potential for secondary analysis of qualitative data is increasingly being realised.

Blaxter, Hughes, and Tight (2006:170) state that secondary analysis can give fresh insights into data, and ready-made data sets or archives do provide extremely valuable and cost-efficient resources for researchers. They however note several cautions that have to be born in mind. They propose questions needing to be asked of any existing documents are:

- What were the conditions of its production? For example, why, and when, was the document produced/written and for whom?
- If you are using statistical data sets, have the variables changed over time? For example 'ethnicity' was not recorded in the British Census until 1991. This means that you cannot undertake some forms of analysis.
- If you are using statistical data sets, have the indicators used to measure variables changed? For example, the measurement of unemployment has undergone many changes in the last two decades which impacts on any comparative or historical analyses that one might seek to make.

Blaxter, Hughes, and Tight (2006:171) conclude that researchers often cannot avoid the use of secondary data to some extent, and that it is legitimate and interesting to base your research project entirely upon such data. They note the following reasons favoring the use of secondary data:

- Collecting primary data is difficult, time-consuming and expensive.
- You can never have enough data.
- It makes sense to use it if the data you want already exists in some form.
- It may shed light on, or complement the primary data collected.
- It may confirm, modify or contradict your findings.
- It allows you to focus your attention on analysis and interpretation.
- You cannot conduct a research study in isolation from what has already been done.
- More data is collected than is ever used.

4.10 Types of secondary data and uses in research

Saunders, Lewis and Thornhill (2009:258) note that secondary data includes both quantitative and qualitative data, and that they are used principally in both descriptive and explanatory research. They note that data used may be raw data, where there has been little if any processing, or compiled data that has received some form of selection or summarising. The authors note that within business and management research such data are used most frequently as part of a case study or survey research strategy. They state that there is no reason not to include secondary data in other research strategies, including archival research, action research and experimental research. They note that other researchers have generated a variety of classifications for secondary data. They propose three main sub-groups of secondary data by building on previous opinions i.e. documentary data, survey-based data, and those compiled from multiple sources.

The following summary is adapted form Saunders, Lewis and Thornhill (2009:258-263):

- **Documentary secondary data**: Documentary secondary data is often used in research projects that also use primary data collection methods. However, you can also use them on their own or with other sources of secondary data, for example for business history research within an archival research strategy.
- **Survey-based secondary data**: Survey-based secondary data refers to data collected using a survey strategy, usually by questionnaires that have already been analysed for their original purpose.
- **Multiple-source secondary data**: Multiple-source secondary data can be based entirely on documentary or on survey secondary data, or can be an amalgam of the two. The key factor is that different data sets have been combined to form another data set prior to your accessing the data.

4.11 Data collection using forms

The form used to produce primary data in this study will comprise two components. The first component requires predetermined “theme” codes shown in Annexure B, to be applied to the entire population of audit findings (255 elements), initiated and produced over a three year period (2008 to 2010). This completed form is shown in Annexure A. The aim of the first form is to embed QMS themes within the entire population of audit findings data. The second form, supporting the reliability of the study, collected QMS themes or codes applied a small random sample of audit findings taken from the population of audit findings to be analysed in the same manner as the first component, using the same criteria. The smaller sample of data is analysed by three independent auditors. This is to determine the measure of validity and reliability of the coding results when comparing the independently analysed sample data set with the same elements analysed in the entire population.

4.12 Data mining

Witten, Frank and Hall (2011:5), define data mining as the process of discovering patterns in data. Witten, Frank and Hall (2011:5), state that the process must be automatic or (more usually) semi-automatic, and that the patterns discovered must be meaningful in that they lead to some advantage, usually an economic one. Witten, Frank and Hall (2011:4), propose that data mining is about solving problems by analysing data already present in databases. In this research, the existing audit finding data will be themed with predetermined codes, which will then be analysed using data mining techniques.

The authors note that the unit of analysis of the research is a relationship. In the instance of this study, the relationships between qualitative audit findings, the quantitative measure of QMS health and the actual business performance will be explored. The variables considered in this research are the ratings assigned to audit findings, which is the independent

variable, and the collective quantitative QMS health measure, which is the dependent variable.

4.13 Data sets and sources

The data that will be analysed to support the research comprises the following:

- **Secondary data:**
  - Audit findings data (Set 1) collected over a period of three years 2008 to 2010, comprising 254 nonconformities which include a severity grading of each nonconformity. The entire population was used. See Annexure A for the detail.
  - Plant events reported between 2008 and 2011 (Set 2) – This is required to show a causal relationship between the two secondary data sets.
- **Primary data:**
  - Pilot study on a small sample of nonconformities by assigning themes independently (Set 3) to support directing methodology for establishing reliability of this and future research(data triangulation)
  - Data resulting from theming by the author of historical audit findings. (Set 4) to produce QMS process location information on the audit findings.
  - Data resulting from inserting quantitative generic severity information (Set 5) by the author into QMS process areas related to the historical audit findings.

Investigator triangulation used for data set three involves using more than one observer (interviewer / coder / data analyst) in the study. Confirmation of data among observers, without prior discussion or collaboration with one another, lends greater credibility to the observations (Thurmond, 2001:253).

4.14 Source data sensitivity

Koeberg Power station is identified as a national key point. The National Key Points Act (NKPA) 102 Of 1980 10 (2) (c) sharing of any information relating to the security measures, applicable at or in respect of any National Key Point (NKP) or in respect of any incident that occurred there, without being legally obliged or entitled to do so. The detailed content of secondary data sources have thus been formatted to adhere to the NKPA. All data appropriate to the study is however available to support traceability of the research conclusions.

4.15 Mixed method analysis

A mixed method analysis methodology has been used to support the data analysis process. Two domains of qualitative data has been selectively merged to provide triangulation of generic problem areas and also to satisfy the research objective of outputting a quantitative measure of management system performance.

4.16 Pareto charts

Due to the nature of the research, extensive use of Pareto charts will be used. Foster (2004:290) notes that Pareto charts are used to identify and prioritise problems to be solved. The author states that these are actually histograms that are aided by the 80/20 rule adapted by Joseph Juran from Vilfredo Pareto, the Italian economist. The 80/20 rule the author continues, states that roughly 80% of the problems are created by roughly 20% of the causes. This means that there are a vital few causes that create most of the problems. Foster (2004:290), notes that this rule can be applied in many ways, and 80% and 20% are only estimates; the actual percentages may vary. In the case of this research, the 80/20 principal may be considered to gain large strides to improve management system implementation performance, but due to emphasis on nuclear safety, data

classified as safety significant will be interrogated irrespective of their Pareto position. Foster (2004:290), notes that there are rules that need to be adhered to when constructing Pareto charts:

- Ø Information must be selected based on types or classifications of defects that occur as a result of a process. An example of this might be the different types of defects that occur in a semiconductor.
- Ø Data must be collected and classified into categories.
- Ø A histogram or frequency chart is constructed showing the number of occurrences.

Foster (2004:290) proposes that the steps used in Pareto analysis should include the following:

- Ø Gathering categorical data relating to quality problems.
- Ø Drawing a histogram of the data.
- Ø Focusing on the tallest bars in the histogram first when solving the problem.

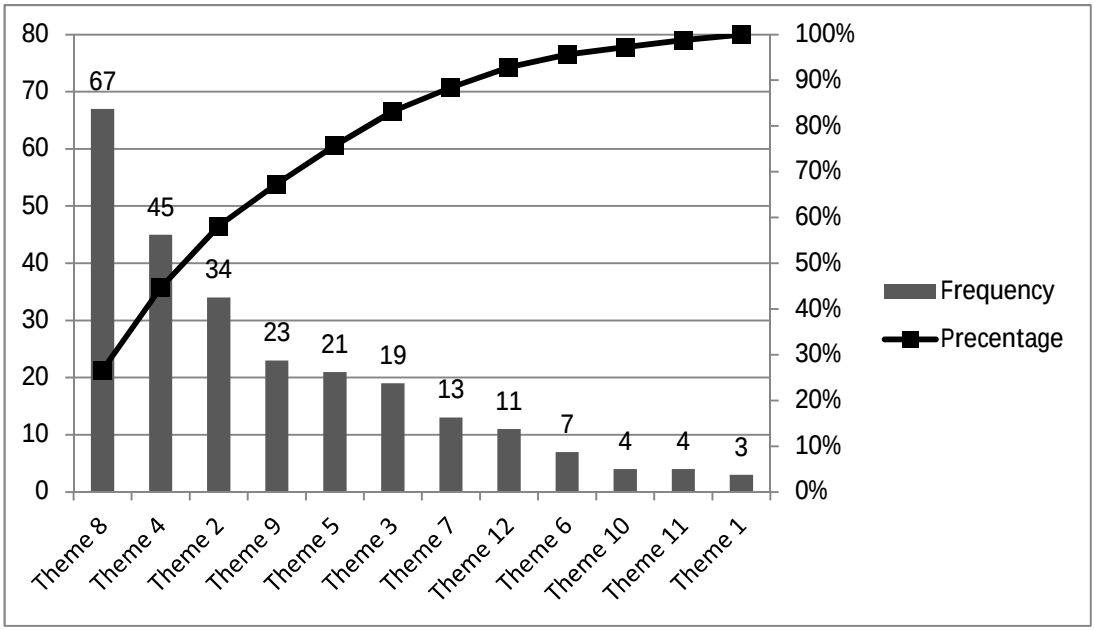

Figure 4.4: Pareto theme identification example **(Source:** Own)

Fosters (2004:290) proposed methodology has generally been adhered to during this research however the cumulative percentage is not used due to the number of themes being analysed at any time.

4.17 Data analysis

The data were analysed in the following sequence in order to lead the reader ultimately to the research objective i.e. Producing a quantitative measure of the QMS health.

- Ø Validation and reliability survey results
- Ø Pareto analysis of the cause and effect themes
- Ø The Pareto results of cause and effect themes ditributed across various domains such as QMS proces, Organisational area, NEI Catagory, etc.
- Ø Introduction of the quantitative values to the themes data
- Ø Quantitative results ditributed across various domains such as QMS proces, Organisational area, NEI Catagory, etc.
- Ø The QMS health indicator

The data are exposed to various levels of enrichment, and milestones of the data enrichment process leading up to the reasearch objective are expanded on.

4.18 Data formats and analysis path

As noted in paragraph 4.13 (Data Sets and Sources), Primary and secondary data are merged to enable additional reporting dimensions. Table 4.2 shows the historical secondary data to the left of the "Effect Theme" heading and the primary data comprises the "Effect Theme" and the "Cause Theme". Annexure "A" shows the entire population.

Table 4.2: Example – Secondary and primary research data format (**Source:** Own)

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR37513	NC00018	2008/02/01	Low - 3	The process for the . . .	1e,8b	1d,10e
PR37424	NC00019	2008/02/14	High - 1	The CRACK process is not	1d,1e	1c,10n
PR37625	NC00020	2008/02/18	Medium - 2	The Training Record Form	10n,2d	2b
PR37625	NC00021	2008/02/18	Medium - 2	OTG has not established,	1b	1c
PR37625	NC00022	2008/02/18	Medium - 2	Some aspects of the LORT	1d	1e
PR37727	NC00024	2008/02/21	Medium - 2	The records of surveillance	3e	3b
PR38400	NC00023	2008/02/21	Medium - 2	Post decontamination . . .	1e,12f	10n

4.19 The validation and reliability survey intent

According to Golafshani (2003:604), Reliability and validity are conceptualised as trustworthiness, rigor and quality in qualitative paradigm. It is also through this association that the way to achieve validity and reliability of a research get affected from the qualitative researchers' perspectives which are to eliminate bias and increase the researcher's truthfulness of a proposition about some social phenomenon using triangulation. The authors conclude that triangulation then is defined to be "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study".

The intent of this survey was to show the methodology which could be used to support validity and reliability of this research and extensions thereof. The research constraints noted however do not make an extensive reliability exercise viable. The reduced scale results provide positive encouragement for the success capability of this methodology.

4.20 QMS deficiency location

The assignment and analysis of QMS themes support locating the management system deficiencies within the organisation and within its

overall QMS. This location happens at various levels within the organisation, various data levels, and hence various levels of action may result, i.e. strategic or operational .

4.21 QMS theme coding notation

The Table 4.3 below shows an excerpt from the Annexure B. The theme code is made up of a numeric prefix and an alpha suffix, e.g. "1c". In the example shown in Table 5.6: **QMS theming notation example**, "1c" would be assigned to a nonconformity which had a process or interface flavour.

Table 4.3: Example - QMS theming notation (**Source:** Own)

1	**a**	**PROCESS MANAGEMENT**
1	**b**	Process has not been adequately defined or documented
1	**c**	The sequence Interactions between various processes have not been adequately determined or documented (GS-R-3 5.2)
1	**d**	Process not effective (required process outputs not consistently achieved)

The numeric prefix, "1" in our example denotes that the theme is a component of a "process management" set, while the "c" in our example denotes a specific descriptor related to "process management". This multi layered methodology allows for reporting at various levels of detail. When the coding process is repeated over the entire population of nonconformities, a new relational data layer is available for analysis and reporting. The multilayered methodology was derived from functional process decomposition and thematic analysis expanded upon in paragraph 3.10 of Chapter 3.

4.22 Data validity and reliability

According to Watkins (2012:74) citing Collins and Hussy (2009), “validity” is concerned with the extent to which research findings accurately represent what is happening. More specifically, whether the data is a true picture of what is being studied.

According to Cooper and Schindler (2006:318-320), three major forms of validity can be identified, namely, “content validity”, “criterion related validity” and “construct validity”. All of the three major forms of validity testing will be used in this study. The sub-elements of “criterion related validity”, namely, “relevancy”, “freedom from bias”, “reliability”, and “availability” will all be considered in this study.

Leeuw and Vaessen (2009:35), state that validity can be broadly defined as the “truth of, or correctness of, or degree of support for an inference”. The authors note four types of validity, which can be explained in a concise manner by looking at the questions underlying the four types:

- **Internal validity**: How do we establish that there is a causal relationship between intervention outputs and processes of change leading to outcomes and impacts?
- **Construct validity**: How do we make sure that the variables we are measuring adequately rep- resent the underlying realities of development interventions linked to processes of change?
- **External validity**: How do we (and to what extent can we) generalise about findings to other settings (interventions, regions, target groups, etc.)?
- **Statistical conclusion validity**: How do we make sure that our conclusion about the existence of a relationship between intervention and impact variable is in fact true? How can we be sure about the magnitude of change?

Leeuw and Vaessen (2009:35), continue by stating that applying the logic of comparative advantages makes it possible for evaluators to compare methods on the basis of their relative merits in addressing particular aspects of validity. They note that this provides a useful basis for methodological design choice; given the evaluation’s priorities, methods that better address particular aspects of validity are selected in favor of others. In addition, they state that the logic of comparative advantages can support decisions on combining methods to be able to simultaneously address multiple aspects of validity.

Reliability (also referred to as 'trustworthiness'), is concerned with the findings of the research (Collis & Hussey, 2009:64). The findings can be said to be reliable if you or anyone else repeated the research and obtained the same results. There are three common ways of estimating the reliability of the responses to questions in questionnaires or interviews, namely 'test re-test method', 'split-halves method' and the 'internal consistency method'.

Trochim (2012:**Online**), identifies four general classes of reliability estimates, each of which estimates reliability in a different way. The four classes are expanded upon below:

- **Inter-Rater or Inter-Observer Reliability:** Used to assess the degree to which different raters/observers give consistent estimates of the same phenomenon.
- **Test-Retest Reliability:** Used to assess the consistency of a measure from one time to another.
- **Parallel-Forms Reliability:** Used to assess the consistency of the results of two tests constructed in the same way from the same content domain.
- **Internal Consistency Reliability:** Used to assess the consistency of results across items within a test.

A combination of the "Parallel-Forms Reliability" and the "Inter-Rater or Inter-Observer Reliability" method's will however be used in this study.

4.23 Data analysis tools

The research study primarily utilises two desktop applications for collecting, preparing and analysing data. Secondary data was extracted from enterprise database servers and imported into Multiple **Microsoft Excel** spread sheets. These formatted spread sheets were then imported into a personal edition of Qliktech's **Qlikview** desktop business intelligence application. Qliktech describes Qlikview as "Qlikview Desktop

is a Windows application that is a single point of interaction for extracting and transforming data, designing analytics, and building dashboards and reports. With Qlikview, users can test and prototype with their data, learning all the while, without taking their eyes off the data or interrupting their thought process." All data collection formatting and analysis was performed by the researcher.

4.24 Conclusion

The research design and methodology provides insight as to the philosophy and methods used to interrogate and expose solutions to the research problem which included:

- An overview of the high level inductive research approach which proposes concluding with a model or theory.
- The applied research methodology which seeks to answer or provide a solution for a practical industry challenge.
- The archival research methodology.
- The applicability of the use of mixed methods i.e. combining qualitative and quantitative methods.
- The data collection and processing methods.
- The validity and reliability considerations.

The researcher proposes that the elements of the research design and methodology do comprise the formula for achieving the research objectives

CHAPTER 5: MANAGEMENT SYSTEM THEME ANALYSIS: DATA COLLECTION, ANALYSIS, AND INTERPRETATION OF RESULTS

5.1 Introduction

This chapter forms the heart of the research as it uses the platform created by chapters one to four. This chapter will describe and show how the following have been practically implemented:

- Ø Current QMS monitoring and reporting environment and its limitations.
- Ø The various data sources and levels of data.
- Ø The data collection methods and the collection environment.
- Ø Data weighting criteria basis and methods.
- Ø Data Analysis results.
- Ø QMS deficiency location measurement.
- Ø QMS performance measurement.
- Ø Research reliability and validity.

The secondary source data used by the author originates from 84 QMS monitoring activities (audits and reviews) distributed over a three year period between the beginning of 2008 and the end of 2010.

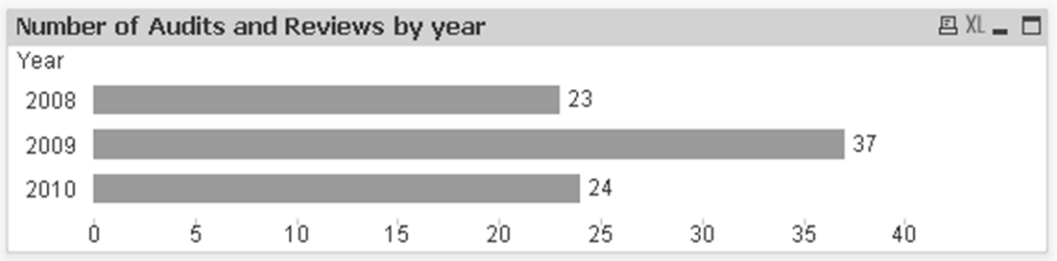

Figure 5.1: Audit and review distribution (**Source:** Own)

Figure 5.1 shows the number of audits and reviews performed on the KOU over the three year period. The monitoring activities are implemented in accordance with a predetermined approved monitoring program.

5.2 The QMS monitoringand reporting environment

A nuclear operating license is given to Eskom and is based on the expectation of consistent compliance to the license requirements by Eskom, KNPS. One element of the license requires that KNPS provide assurance of the implementation of KNPS QMS. This assurance is realised by implementing a series of audits and reviews (monitoring activities) over a three year period. This series of monitoring activities is obliged to incorporate all process areas of the QMS.

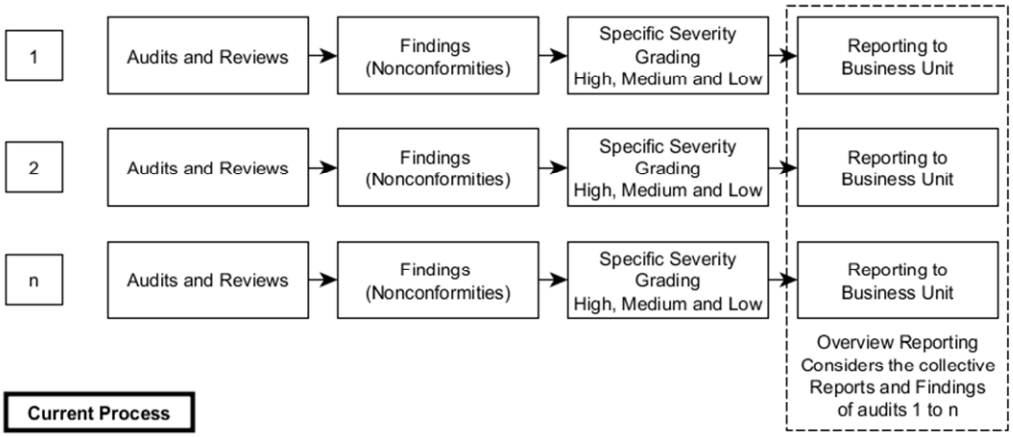

Figure 5.2: KNPS quality monitoring process flow **(Source:** Own**)**

The Figure 5.2 above shows that multiple monitoring activities (1 through n) will take place over a period of time. These monitoring activities result in findings or Nonconformities (NCs) being raised where QMS deficiency is noted. The NCs are graded based on their potential consequence on the business. This grading takes place in accordance with procedures and are aligned to pre-set documented criteria (see Annexure C).

Reporting of the audit results is then provided to the auditee. This takes place during audit closing meetings, and via an official written audit report. Overview reports are presented to senior management on biannual bases or as required. All monitoring activity output data for the reporting period (e.g. biannual) is collected and analysed to make up the overview report.

Action additional to the individual audit finding actions may be prescribed by management as a result of trends observed over the reporting period.

5.3 QMS performance measuring instrument dimensions

The objective of introducing additional theming data into the audit findings (secondary) data is to provide locating tags related to the QMS, and to enhance the severity information embedded within audit findings collected over a defined period. The dimensions and value of the QMS Performance measuring instrument are twofold:

- Ø The benefits of a cause and effect theming philosophy.
- Ø Provision of a QMS process deficiency locator / identifier.
- Ø Provision of a quantitative measure of the management system performance or health.

5.3.1 QMS process deficiency locator

The QMS process deficiency locating capability is achieved by assigning QMS themes (see Block "C" in Figure 5.3) to audit findings. The themes are selected from a standard controlled list of themes (see Annexure B) aligned and linked to accepted QMS process areas. The QMS process deficiency locator (or identifier) provides the following benefits:

- Ø Identifies the peaks of the common processes where the QMS is deficient across monitoring periods (using Pareto methodology).
- Ø Identifies the major **effects** on the business related to the QMS.
- Ø Identifies the major **causes** for those effects.
- Ø Provides this information (noted at bullets1, 2 and 3) in real-time (instantaneously). I.e. as audits are implemented the theme data is assigned to NCs immediately, which then becomes accessible to the instrument.

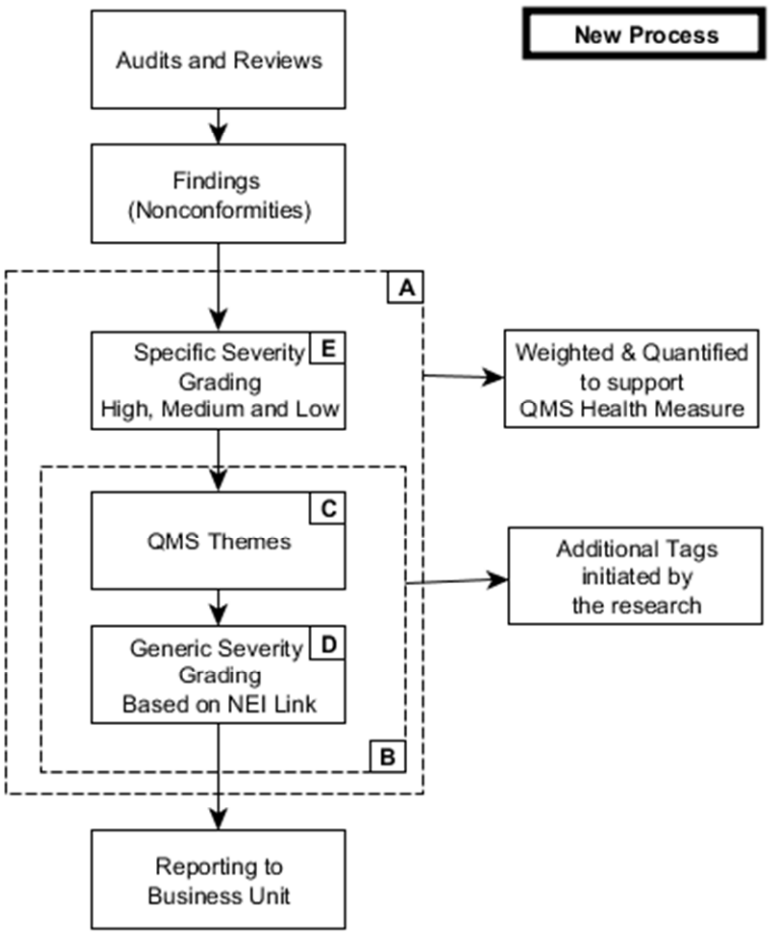

Figure 5.3: The modified monitoring process **(Source:** Own)

5.3.2 QMS "quantitative measure" tag

The "quantitative Measure" tag is made up of two components i.e. the specific severity grading measure (see Block "E" in Figure 5.3) and the generic severity grading measure (see Block "D" in Figure 5.3). The specific indicator (High, Medium and Low) is assigned to a nonconformity by the QMS auditor at the time of the audit, while the generic severity grading will already have been assigned to the process area, or may be assigned to the finding at the same time. During this research all generic severity grading's were assigned by the researcher due to the analysis being implemented on historical data.

5.3.3 Resultant finding metadata

The result of assigning the “value adding” data to each finding (NC) is shown in X and Y of Figure 5.4.

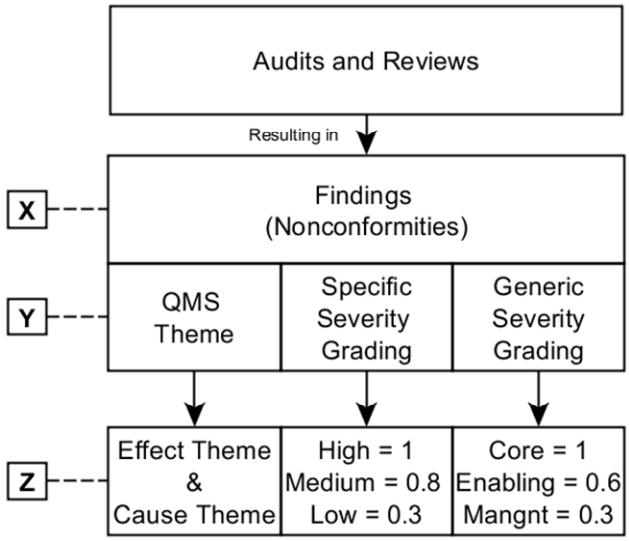

Figure 5.4: Resultant finding metadata (**Source**: Own)

The QMS theme serves as the QMS process deficiency locator / identifier while the two severity grading's serves as an input to the quantitative measure of the management system health. Arbitrary values were used for the specific and generic severity grades in order to obtain a representative output measure of QMS health. Hubbard (2010:23) defines "Measurement" as "A quantitatively expressed reduction of uncertainty based on one or more observations". Even though additional research may be performed to approach more accurate severity values, the researcher proposes that the values used provide sufficient reduction of uncertainty to show the viability of the philosophy.

5.3.4 QMS process theme listing basis

The intent of theming audit findings such as nonconformities and observations is to provide timeous information on the nature and location of deficiencies within the QMS process landscape. It enables us to extract credible insight and trends from the QA findings and also provide traceability pathways between recommendations to management, and the low level process implementation anomalies.

The QMS Themes Listing shown in annexure "B" is used to assign themes to monitoring activity findings. The listing was developed taking guidance taken from a wide range of applicable documents, with the major influences (*Theme listing basis documents*) shown below:

- **36-188**: Quality Management Manual for Nuclear Generation.
- **LD1023**: Quality Management Requirements for KNPS.
- **IAEA GSR-3**: Management System for Facilities and Activities.
- **NEI SNPM Rev 4**: Standard Nuclear Performance Model.
- **RD-034**: Quality and Safety Management Requirements for Nuclear Installations.
- **ASME NQA-1**: Quality Assurance Requirements for Nuclear Facility Applications.

Common areas and categories were extracted from the above mentioned source documents and standards to provide the major theme headings noted in Table 5.1: **QMS theme processes**.

Table 5.1: QMS theme processes **(Source:** Adapted from the *Theme listing basis documents***)**

Process Ref	Process Area
1	Process Management
2	Documentation Control
3	Record Control
4	Management Responsibility
5	Training And Competency
6	Organisational Control
7	Monitoring And Corrective Action
8	Configuration Management
9	Interface Management
10	Cultural Controls
11	Electronic Information
12	Process Implementation

Each theme heading was then expanded to accommodate requirements and expectations extracted from the source documents to produce the example shown in Table 5.2. The full listing of themes, adapted for this study, is shown in annexure "B".

Table 5.2: QMS theme detail example (**Source:** Own)

1	**a**	**PROCESS MANAGEMENT**
1	**b**	Process has not been adequately defined or documented
1	**c**	The sequence Interactions between various processes have not been adequately determined or documented (GS-R-3 5.2)
2	**a**	**DOCUMENTATION CONTROL (Procedures, drawings, etc)**
2	**b**	Documentation has not been controlled (reviewed / approved / authorised) as required
2	**c**	Documentation change control process has not been implemented
2	**d**	Documented procedures do not reflect current practice
2	**e**	General documentation management process (KAA-500/KSA-011) Non-Compliance
3	**a**	**RECORD CONTROL**
3	**b**	Records have not been properly identified, authenticated or classified
3	**c**	Non complainant storage conditions of records
3	**d**	Records are not easily retrievable (GS-R-3)
4	**a**	**MANAGEMENT RESPONSIBILITY**
4	**b**	Planning by managers ineffective
4	**c**	Management direction not effectively communicated
4	**d**	Management oversight tools not effectively used

The listing consists of twelve (12) major theme headings and one hundred and twenty one (121) separate themes in total including the major theme headings. The amount of separate themes necessitated an extensive data population (3 years' worth) in order to obtain useful research results.

5.3.5 Cause and effect chain phylosophy

Ciardiello (2002:34) implies that events, or in the case of this research nonconformities, are all located within a "cause/effect" chain of events as depicted in Figure 5.5. This implies that the nonconformity problem statement can be located dynamically within the "cause/effect" chain. This introduces the difficulty that different auditors may position the same nonconformity effect or consequence, in a different location on the chain. This potentially results in variation in local and overview reporting based on the overall variance due to auditor bias.

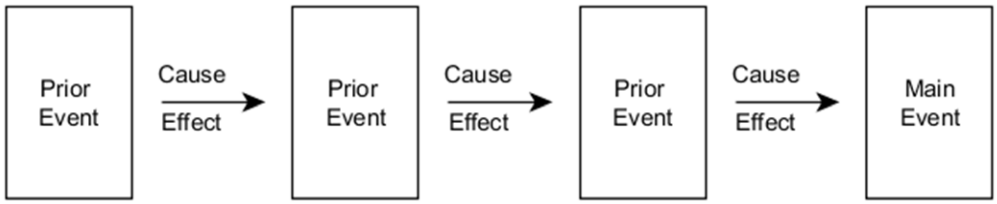

Figure 5.5: Cause and effect chain **(Source:** Ciardiello,(2002:34))

At least one **cause**, and one **effect** QMS theme is assigned to each monitoring activity nonconformity which results in a data format as shown in the example Table 5.3

Table 5.3: Cause / effect QMS themes example (**Source**: Own)

NC No	Cause Theme	Effect Theme	Non-conformity
NC00018	1d,10e	1e,8b	The process for the extension of Temporary Alterations was not f
NC00019	1c,10n	1d,1e	The CRACK process is not effectively implemented at Koeberg Pov
NC00020	2b	10n,2d	The Training Record Form (KFT-002) is not used for all training int
NC00021	1c	1b	OTG has not established, implemented and maintained and effect
NC00022	1e	1d	Some aspects of the LORT process have not been effectively imp
NC00024	3b	3e	The records of surveillances for the Operating Department require
NC00023	10n	1e,12f	Post decontamination monitoring/measurement of protective cloth
NC00025	10i	1b	There is no programme for the random testing of chemical produc
NC00026	10n	3g,3e	The records of surveillances for the Operating Department require
NC00027	10n	1e,3e	The outage safety plan records have not been processed as requ
NC00028	1b	8c	There is no status board for systems that are to remain in a state
NC00029	1b	1b	There is no implementation of a formal process for the managem
NC00030	4d	6g,6i	There is a lack of formal management and maintenance of the Pe
NC00031	6g	4d	There is non-compliance to the review and audit cycle requirement
NC00032	4d	4c	There is non-compliance to the self audit and internal audit cycle re
NC00033	2b	8d	Configuration management of HR documentation is not maintainec

5.3.6 Cause and effect theming phylosophy

As noted in Chapter 3, Davies and Davis (2011:74) state that causal relationships are cause and effect links between deliverables, drivers and benefits (consequences). The relationships generally are, many-to-many, i.e. a deliverable can influence several drivers and/or any one driver can be changed by the effect of several deliverables.

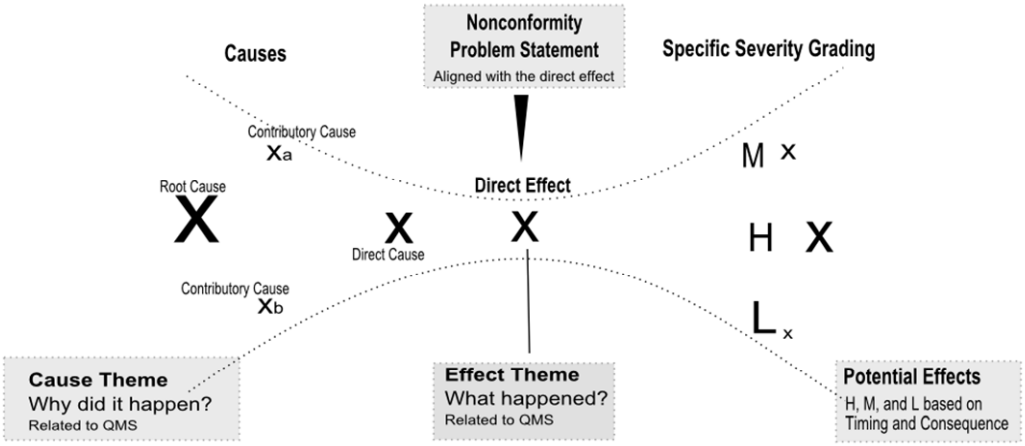

Figure 5.6: Nonconformity theme and severity selection options (**Source**: Own)

The QMS cause / effect theme, and specific severity selection options are shown in Figure 5.6. The tags are assigned using the following criteria:

- **Effect Theme:** Relating to the problem statement - Answering the question "What was the issue?" or "What was discovered?"
- **Cause Theme:** Relating to the issue or what was discovered. - Answering the question "Why did this happen?" or "What was the main cause?" of what happened in the problem statement.
- **Potential effects**: The potential effects are those effects or consequences that have not occurred, but may potentially occur at various levels of severity depending on the circumstances of the NC.
- **Specific Severity Grading (SSG)** – Relating to the potential effects or consequences of the nonconformity taking the context in which the nonconformity manifested itself – graded High (H), Medium (M) or Low (L) consequence. Detailed criteria to inform selection of the SSG are seen in annexure "C"

The **Generic Severity Grading (GSG)** in contrast to the SSG only considers the process area as dictated by the NEI SNPM shown in Figure 2.2: **NEI process SNPM** (Source:**NEI SNPM:2004**).

5.3.7 QMS health measurement inputs relationships

Figure 5.7 shows the relationship between the various components in order to produce the QMS health Measure. The **effect** theme is the theme on which the quantitative elements act to produce the measurement. The **cause** theme is used to inform action and strategy for corrective and preventive action ultimately causing improvement in the QMS health measurement.

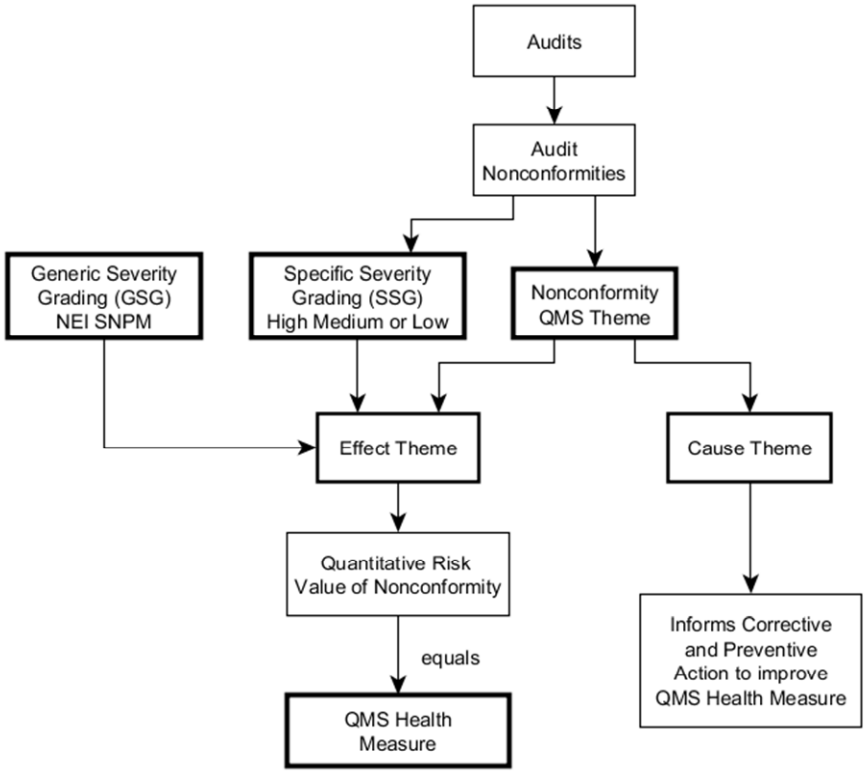

Figure 5.7: QMS health measure component relationships **(Source:** Own)

The QMS health measure is considered a dynamic measure that will indicate QMS implementation improvement as nonconformities are closed, and will indicate weakening of the QMS implementation as more nonconformities are raised. The performance or health measurement is thus related directly to all open nonconformities and their individual severity grading's. This research assumes all nonconformities noted in Annexure A are open.

5.3.8 QMS measuring instrument uncertainty in context

Bell (2001:ii) states, as noted in 3.9.4, that every measurement is subject to some uncertainty. The author notes that a measurement result is only complete if it is accompanied by a statement of the uncertainty in the measurement. Measurement uncertainties can come from the measuring instrument, from the item being measured, from the environment, from the operator, and from other sources. Such uncertainties can be estimated using statistical analysis of a set of measurements, and using other kinds of information about the measurement process.

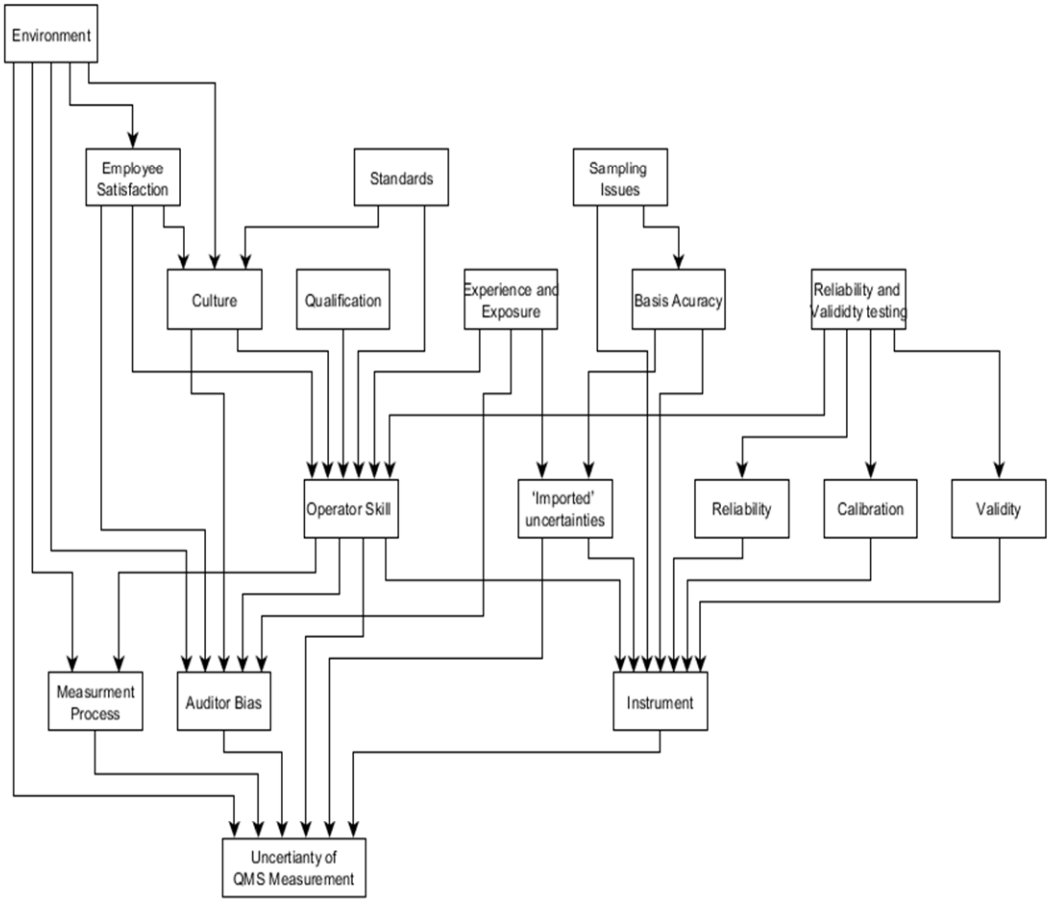

Figure 5.8: Measurement uncertainty inputs (**Source:** Adapted from Bell (2001:7-8))

The influences applicable to the QMS health measure are noted hereafter and expanded in context of the research environment. It is noted that the context of Bells influences relate to physical measuring instruments, but this author acknowledges their applicability to the qualitative nature of the

QMS health measure. Figure 5.8 was adapted from Bells (2001:7-8) influences.

- **The measuring instrument:** Auditor bias influenced by: operator skill, experience, culture, employee satisfaction.
- **The item being measured:** Variation in perception of criteria, accuracy of the criteria, understanding of the problem and context.
- **The measurement process**: The actual theming process, the sequence of theming, how the process is documented and interpreted.
- **Imported' uncertainties:** Calibration of the instrument, the interpretation of applicable components from the source standards i.e. the development of the instrument. The built in uncertainty of the instrument.
- **Operator skill:** Some measurements depend on the skill and judgement of the operator. One auditor may be more experienced than another at the performing the measurement, or at locating the problem in the event chain, competency of use of the instrument, attitude and culture.
- **Sampling issues**: The measurements you make must be properly representative of the process you are trying to assess. Again the location of the problem in the event chain, auditor fatigue.
- **The environment:** Auditor fatigue, the environment in which the measurement takes place and the timing of the measurement i.e. measurement too long after the audit will impact on the freshness of the measurement influences.

Bell (2001:8), notes that where the size and effect of an error are known (e.g. from a calibration certificate) a correction can be applied to the measurement result. But, in general, uncertainties from each of these sources, and from other sources, would be individual 'inputs' contributing to the overall uncertainty in the measurement. In the research instance, value would be obtained to ensure that all the influences of measurement uncertainty is kept to a minimum by providing optimal consistent criteria for the measurement to take place such as, "theming will take place on the

Monday following the audit week", "at least one lead auditor must be present during the theming process", etc.

5.4 Improving the reporting environment

Figure 5.9 shows both the current audit to reporing process and the modified process.

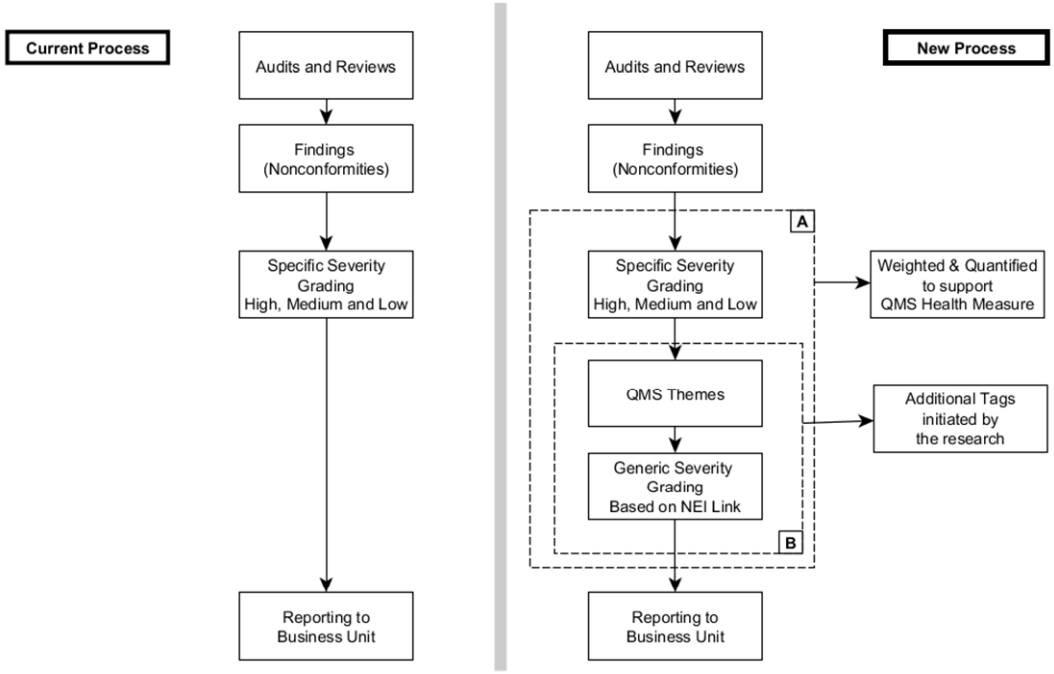

Figure 5.9: Process modified to extract quantitative data (**Source:** Own)

The Figure 5.9 shows in block "B", the additional tags that are assigned to each audit finding namely the "QMS Themes" and the "NEI Process Link" (GSG). The "QMS Themes" provides location information to show where within the management system the majority nonconformity exists and potential causes of the nonconformity. The "NEI Process Link" provides a generic severity indicator at a process level. Block "A" includes Block "B" and the original severity grading assigned to the nonconformity.

5.5 Data analysis

The data were analysed in the following sequence in order to lead the reader ultimately to the research objective i.e. Producing a quantitative measure of the QMS health.

- Ø Validation and reliability survey results.
- Ø Pareto analysis of the cause and effect themes.
- Ø The Pareto results of cause and effect themes ditributed across various domains such as QMS proces, Organisational area, NEI Catagory, etc.
- Ø Introduction of the quantitative values to the themes data.
- Ø Quantitative results ditributed across various domains such as QMS proces, Organisational area, NEI Catagory, etc.
- Ø The QMS health indicator.

The data are exposed to various levels of enrichment, and milestones of the data enrichment process leading up to the reasearch objective are expanded on.

5.5.1 Data formats and analysis path

As noted in paragraph 4.13, Primary and secondary data are merged to enable additional reporting dimensions. Example Table 5.4 shows the historical secondary data to the left of the "Effect Theme" heading and the primary data for this research comprises the "Effect Theme" and the "Cause Theme". Annexure "A" shows the entire population.

Table 5.4: Example - research data for analysis format (**Source**: Own)

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR37513	NC00018	2008/02/01	Low - 3	The process for the	1e,8b	1d,10e
PR37424	NC00019	2008/02/14	High - 1	The CRACK process is not	1d,1e	1c,10n
PR37625	NC00020	2008/02/18	Medium - 2	The Training Record Form	10n,2d	2b
PR37625	NC00022	2008/02/18	Medium - 2	Some aspects of the LORT	1d	1e

5.5.2 The validation and reliability survey intent

According to Golafshani (2003:604), Reliability and validity are conceptualised as trustworthiness, rigor and quality in qualitative paradigm. It is also through this association that the way to achieve validity and reliability of a research get affected from the qualitative researchers' perspectives which are to eliminate bias and increase the researcher's truthfulness of a proposition about some social phenomenon using triangulation. Then triangulation is defined to be "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study".

The intent of this survey is to show a plausible methodology which could be used to support validity and reliability of this research and applications thereof. The research constraints noted however do not make an extensive reliability exercise viable. The reduced scale results provide positive encouragement for the success capability of this methodology.

5.5.3 Validation and reliabilty survey results

A survey was performed on a sample of three QMS lead auditors, including the author. The participants were required to observe a random sample of seven non-conformities which form part of data set 1. They were then required to provide at least one cause theme, and at least one effect theme per nonconformity. It must be noted that for this study, the criteria for acceptance of reliability was as follows:

- Ø Actual cause and effect data inputted by the participants is generalised to the process level as shown in Table 5.1, and not the theme detail level.
- Ø Reliability of the rating per nonconformity is accepted if two or more participants themes align at the QMS process level.

Table 5.5 shows the results of the survey which is further expanded upon graphically in Annexure E.

Table 5.5: Reliability survey results **(Source:** Own**)**

Rater	NC No:	Effect Themes	Cause Themes
Rater 1	NC00029	1b,4h	10g,10n
Rater 2	NC00029	1b	1b
Rater 3	NC00029	10n	1b
Rater 1	NC00038	**4b,1e,1f**	6h
Rater 2	NC00038	**6f**	4b
Rater 3	NC00038	**5f**	5i,4b,6d
Rater 1	NC00045	3f,3h	1b
Rater 2	NC00045	1e	3e
Rater 3	NC00045	3f,3g	3b,1e
Rater 1	NC00049	1e	4h
Rater 2	NC00049	2d	1d
Rater 3	NC00049	2d	1f,1k
Rater 1	NC00060	1e	5c,5d,5g
Rater 2	NC00060	5j	5g
Rater 3	NC00060	5b,5c	5d,5i
Rater 1	NC00070	1e,10g,12o	10n,5j
Rater 2	NC00070	1e	11g
Rater 3	NC00070	1b	5f,5j,1e
Rater 1	NC00073	1f,1c,3a	8a
Rater 2	NC00073	10i,1e	3g,3d
Rater 3	NC00073	1e	3c,3e,3i

Referring to Table 5.5 and further supported by Annexure E, the following is noted:

- Ø Reliability of the all of the "cause" results are accepted based on the criteria that two or more out of the three raters agree or align at process level.
- Ø Only six of the seven "effect" results are accepted in accordance with the specified acceptance criteria.
- Ø The nonconformity NC00038 for the “effect” theme did not attain alignment of two or more survey participant's results.

The researcher proposes that that were alignment was not obtained, the measurement uncertainty inputs noted in paragraph 5.3.8 should be considered to encourage alignment. In the case of NC00038 the cause /effect chain and the locating of the QMS theme on the chain is the main cause of misalignment in the opinion of the researcher.

5.6 QMS deficiency location

The assignment and analysis of QMS themes support locating the management system deficiencies within the overall QMS context. This location happens at various data levels such as the indevidual finding and also at process level, hence various levels of action are possible depending where management would like to address corrective action. The corrective action can address only the nonconformity, or a generic process issue affecting wider influences.

5.6.1 QMS theme coding notation

The Table 5.6 below shows an excerpt from the Annexure B. The theme code is made up of a numeric prefix and an alpha suffix, e.g. "1c". In the example shown in Table 5.6: **QMS theming notation example**, "1c" would be assigned to a nonconformity which had a process or interface flavour.

Table 5.6: QMS theming notation example (**Source:** Own)

1	**a**	**PROCESS MANAGEMENT**
1	**b**	Process has not been adequately defined or documented
1	**c**	The sequence Interactions between various processes have not been adequately determined or documented (GS-R-3 5.2)
1	**d**	Process not effective (required process outputs not consistently achieved)

The numeric prefix, "1" in our example denotes that the theme is a component of a "process management" set, while the "c" in our example denotes a specific descriptor related to "process management". This multi layered methodology allows for reporting at various levels of detail. When the coding process is repeated over the entire population of nonconformities, a new relational data layer is available for analysis and reporting.

5.6.2 Pareto analysis of the effect and cause themes

When assigning themes the coder must consider the same nonconformity from two different perspectives, i.e. the "effect" and the "cause" perspectives. The "effect" question that must be answered is "What is the effect of the nonconformity?" and the "cause" question is, "What was the likely cause of the nonconformity?"

Table 5.7 and Figure 5.10 shows the collective totals of each QMS theme assigned per nonconformity. Analysis of the data a theme specific level provides the detail of the common nonconformity within the business. As noted previously the effect theme is the indicator of current nonconformity which could be seen as the current business risk related to QMS deficiency. Theme "1e", "Process not fully implemented" is related to procedure noncompliance, and management thus have some direction as to where further investigation needs to take place and resultant corrective action.

Table 5.7: Pareto “effect” theme - top 10 frequency of occurrence (**Source:** Own)

Theme	No of Hits	Effect Theme Description
1e	39	Process not fully implemented
3e	31	Records have not been transmitted as per QRL
2b	23	Documentation has not been controlled (reviewed / approved / authorised) as required
8d	20	Inadequate consideration of configuration management in processes /procedures and practices
2d	16	Documented procedures do not reflect current practice
1d	11	Process not effective (required process outputs not consistently achieved)
3b	11	Records have not been properly identified
2e	11	KSA-011 / KAA-500 Non-Compliance
8b	10	Lack of configuration control (related to e.g. design
3g	10	Records are incomplete(GS-R-3)

A graphical representation of Table 5.7 is shown in Figure 5.10.

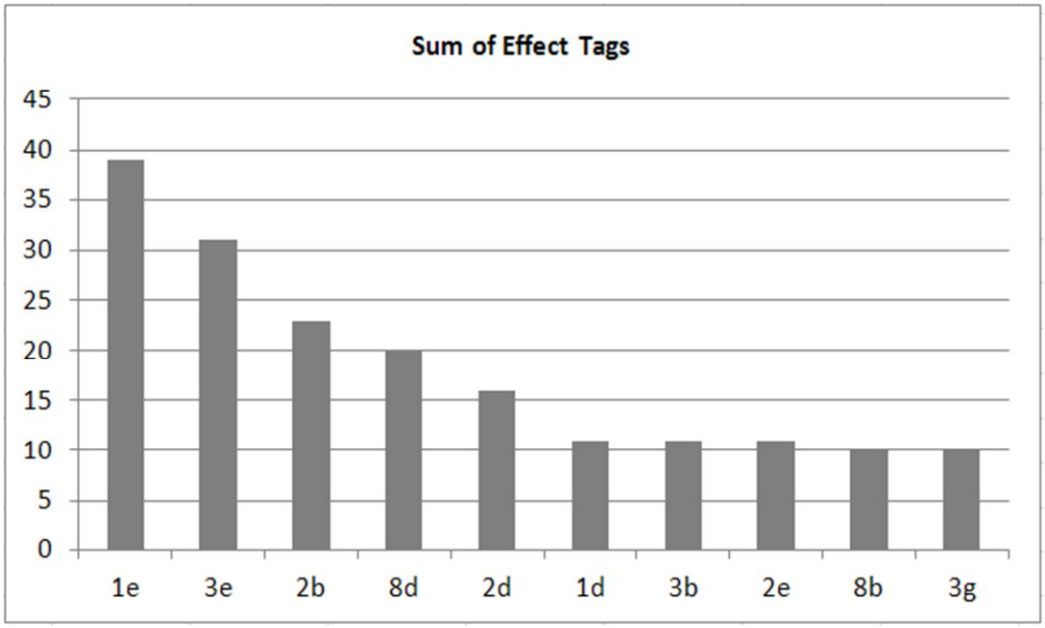

Figure 5.10: Sum of Nonconformities Effect Tags (**Source:** Own)

The collective summary of allocated "cause" themes is shown in Table 5.8 and Figure 5.11: **Sum of NC cause tags**. The "cause" theme data provide guidance to management as to where corrective action and preventive action must be directed to reduce the effects or consequences of management system nonconformity.

Table 5.8: Pareto “cause” theme - top 10 frequency of occurrence (**Source:** Own)

Theme	No of Hits	Only (Cause Theme Description)
10i	88	Lack of ownership of safety and/or quality
5j	58	Individuals do not know the importance and/or understand the consequences of their activities and how their activities contribute to safety in the achievement of the Org objectives. (GS-R-3 4.4)
1e	37	Process not fully implemented
2b	20	Documentation has not been controlled (reviewed / approved / authorised) as required
10n	14	Lack of or inadequate enforcement of rules
1b	10	Process has not been adequately defined or documented
4d	10	Management oversight tools not effectively used (such as benchmarking
6f	9	Roles
10l	7	Lack of corporate oversight
4b	6	Planning by managers ineffective (resource needs such as capital

From the results seen in Table 5.8 and Figure 5.11, the major causes over the period are related to "cultural controls" and "training and competency" issues.

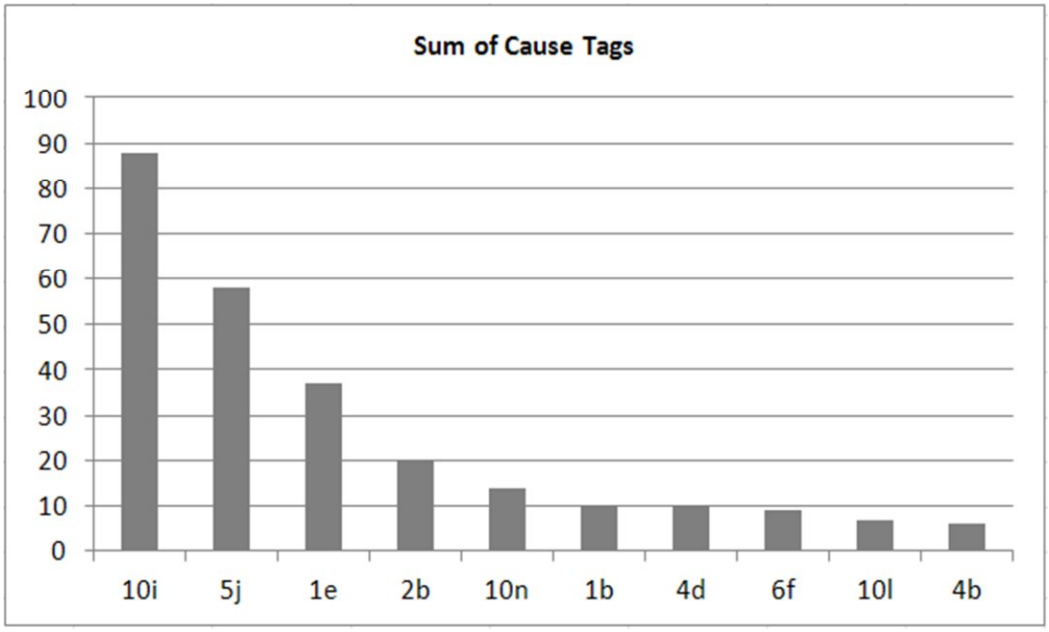

Figure 5.11: Sum of NC cause tags (**Source:** Own)

5.6.3 Pareto Analysis at QMS Process Level

High level trends are observable from analysis at the process level. To obtain the process level information, the individual themes are counted if they are associated with the same process heading, e.g. Process Management, Records Management or Interface Control. Process level information may then be dissected as required to expose information that may direct action. Figure 5.12 shows the summary of themes collected for the period 2008 to 2010 from the "Effect" themes. The "Effect" theme shows the consequence of the nonconformity. Records management is crucial in the nuclear environment and the results shown will direct management to attend to this larger process area.

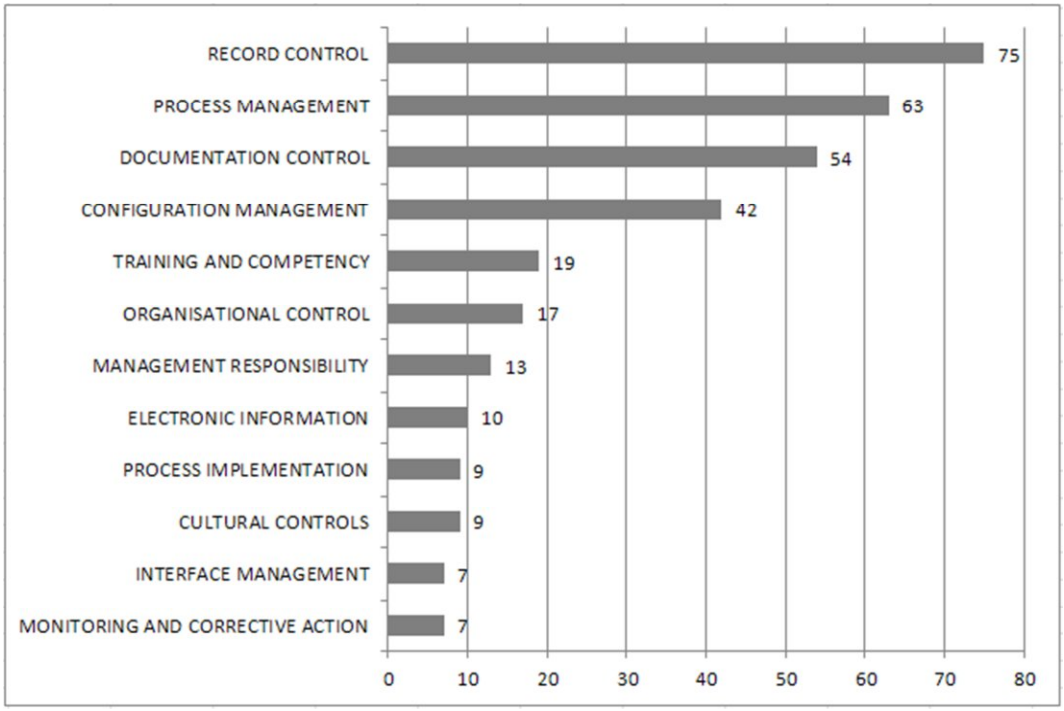

Figure 5.12: Pareto QMS “effect” themes at process level (**Source:** Own)

Figure 5.13 shows the "Cause" themes summary, and the major contributor over the three year period is seen to be cultural controls.

A link between the increase of nonconformity in the "cultural control" area of (Cause NC) and the "records Control" area of Figure 5.12 (Effect NC) can be made, however this will require a more detailed analysis.

The "Cause" themes direct management to areas where the most value can be obtained by implementing corrective and preventive action to address the causes.

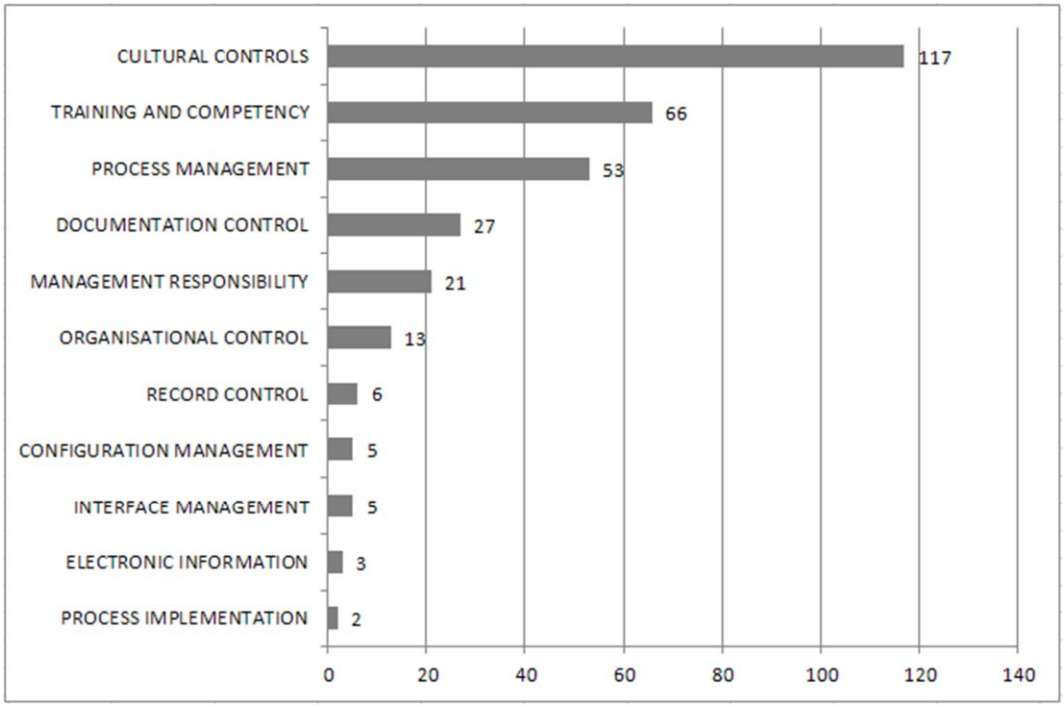

Figure 5.13: Pareto QMS "cause" theme at process Level **(Source:** Own)

5.7 QMS related perfomance measurement

As oppose to purely providing locating information as seen in paragraph 5.6, the QMS related performance measurement provides the additional dimension of severity. This allows management to better prioritise as to where the more urgent action is required. The severity component is obtained by considering both the specific severity grading and the generic or process severity grading.

5.7.1 NEI coding value

The NEI generic severity grading is assigned to the organisational process while taking Figure 2.2: NEI process SNPM (Source:NEI SNPM:2004), into consideration. Table 5.10 shows the alignment with their respective organisational process areas. All nonconformities have a direct relationship with an organisational process area. The nonconformities thus inherit the NEI process coding and its associated quantitative value. This enables extrapolation shown in Figure 5.14**:** NCs by NEI .

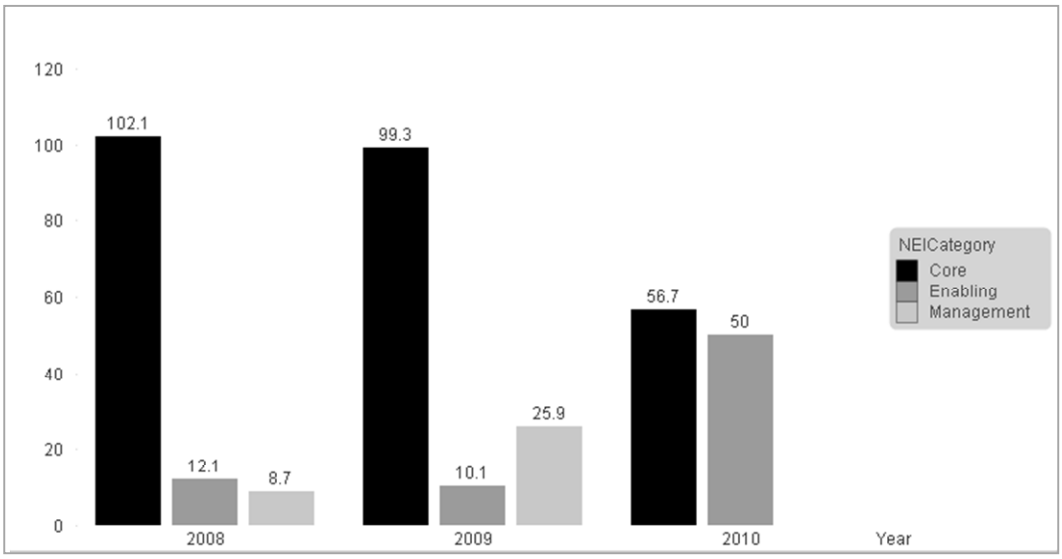

Figure 5.14: NCs by NEI category (**Source**: Own)

As noted in paragraph 5.3.2, arbitrary values were assigned to the three main clusters of the NEI model namely:

- Ø Core processes are assigned “1”.
- Ø Enabling processes are assigned “0.6”.
- Ø Management processes are assigned “0.3”.

The literature review did provide pure a business oriented content to support selection of the values assigned by this study, but the nuclear safety dimension was considered more appropriate. The Table 5.9 below was adapted from Talwar’s (2011:58-61) study of averaging weightings assigned to the various elements of the Excellence Models (EM) and National Quality Awards (NQA). Twenty EM’s / NQA’s were included in the study. Talwar’s results are considered of value in a generic ISO 9001 oriented study. The results have not influenced the weighting in this study due to some of the business requirements and expectations of the nuclear power generation industry.

Table 5.9: Average weighting assigned to EM / NQA's (**Source:** adapted from Talwar (2011:59))

Model Area	Ave Rank Value	Rank
Customers	43	1
People	49	2

Business results	51	3
Processes	70	4
Leadership	75	5
Strategic planning	118	6
Knowledge and IM	126	7
Society	148	8
Suppliers/partners	160	9

5.7.2 NEI coding assignment

Table 5.10 shows the weighting assigned based on the NEI SNPM guidance. The organisational process areas were extracted from the population of nonconformities, and may vary if additional data were added to the population. This is seen as an area for improvement in future studies to enhance reliability of the study.

Table 5.10: NEI coding and safety weighting (**Source:** Adapted from NEI SNPM:2004)

Organisational Process Area	NEI Link	Safety Weighting
Maintenance Management	Core	1
Configuration Management	Core	1
Radiological Protection	Core	1
Operating	Core	1
Work Control	Core	1
Outage Management	Core	1
Asset Management	Core	1
Nuclear Engineering	Core	1
Foreign Material Exclusion	Core	1
Plant	Core	1
Repair and Replace program (KAM038)	Core	1
Control of Chemicals (CRACK)	Core	1
Project Engineering	Core	1
Turbine Activities	Core	1
Vendor Management	Core	1
Training	Enabling	0.6
Oversight	Enabling	0.6
Fire Risk Management	Enabling	0.6
Inspection &Test	Enabling	0.6
Safety	Enabling	0.6
Fuel Management	Enabling	0.6
Emergency Preparedness	Enabling	0.6
Security	Enabling	0.6
Corrective Action	Management	0.3
Quality	Management	0.3
Record Management	Management	0.3
Documentation Management	Management	0.3
Finance	Management	0.3
Human Resources	Management	0.3

To obtain a quantitative severity value per nonconformity the sum of the **SSG** (High, Medium and Low) and the **GSG** (Core, Enabling and Management) value assignments are used. The sum of the Nonconformity Severity Grading's (**NSG's**) within each process area will then make up the Process Severity Grading (**PSG**). For each of the nonconformities and QMS process areas, the equation to obtain a quantitative value is as follows:

- **SSG** = {High =1; Medium = 0.8 and Low = 0.3}
- **GSG** = {Core = 1; Enabling = 0.6 and Management = 0.3}

Nonconformity Severity Grading (NSG):

NSG = SSG + GSG *Hence*

Process Severity Grading,

PSG = ∑ **NSG** (severity grading related to the process area)

The example below shows the total Process Severity Grading (PSG) for the "Documentation Control" process area for 2008 equalling 10.8 and made up of the sum of NSGs within the process area for 2008.

Table 5.11: "Documentation Control" process area for 2008 (**Source:** Own)

NC No	Rating	Effect Theme	Non-conformity	Rating Val	Safety Weight
NC00020	Medium - 2	10n,2d	The Training Record Form . . .	0.8	0.6
NC00052	Medium - 2	2b	All procedures have not been reviewed . . .	0.8	1
NC00102	Medium - 2	2b	The contracts files maintained at the Project . . .	0.8	1
NC00103	Low - 3	2d	The content of the obsolescence procedure	0.3	1
NC00104	Low - 3	2d	The content of the reverse engineering documentation . . .	0.3	1
NC00105	Medium - 2	2d	The Classification Process does not meet the . . .	0.8	1
NC00111	Medium - 2	2b,2d	The Met Operations Manual is out-dated . . .	0.8	0.6
				4.6	6.2
			Total for the "Documentation control" process area for 2008		**10.8**

Figure 5.15 shows the overall process nonconformity value distribution in 2008. The identifier “A” in Figure 5.15 shows the “documentation control” area in context of the other process areas for 2008.

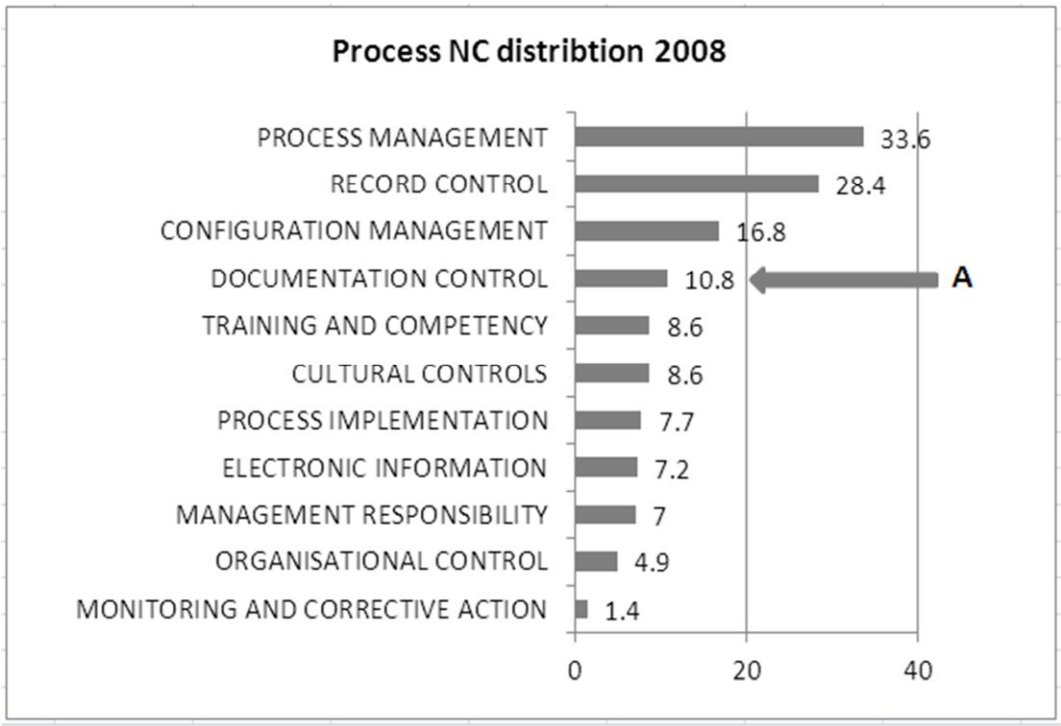

Figure 5.15: Process nonconformity distribution for 2008 (**Source**: Own)

The overall QMS performance measure over a time period equates to the sum of the quantitative value of the PSG's within that time period

The Qlikview business intelligence application incorporates the applicable formulas and allows for instantaneous visualisation of the data based on the combination of secondary and primary data. The associated scripts to support the analyses are shown in Annexure H. This allows us to see the "cause vs. effect" at various levels of detail namely:

- Ø Nonconformity level.
- Ø Process / System level.
- Ø Organisational level.

5.8 QMS performance measure results

The quantitative outputs will thus also be visible at the above levels. Hence we may be able to see some of the following:

- Ø The nonconformities which carry the most risk to the KOU, while taking cognisance of the various facets of organisational risk, e.g. Nuclear Safety, Regulatory noncompliance, Plant health, etc.
- Ø The process area where the most energy needs to be expended to reduce the overall risk (again taking cognisance of the various facets of risk).
- Ø The organisational area that requires the most attention to reduce risk on business reliability.

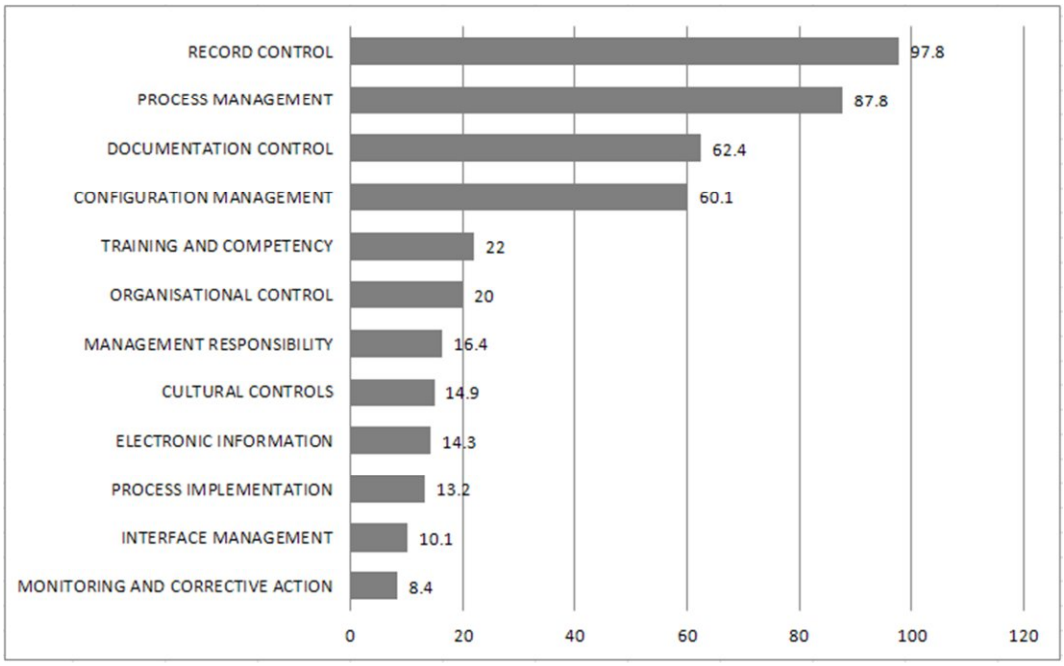

Figure 5.16: Effect" QMS related process grading's **(Source:** Own**)**

Figure 5.17 shows the distribution of QMS process anomalies and includes severity data by year. We can thus see a decrease in "process management" severity over the three year period i.e. from 33.6 (2008) to 31.6 (2009) to 22.6 (2010).

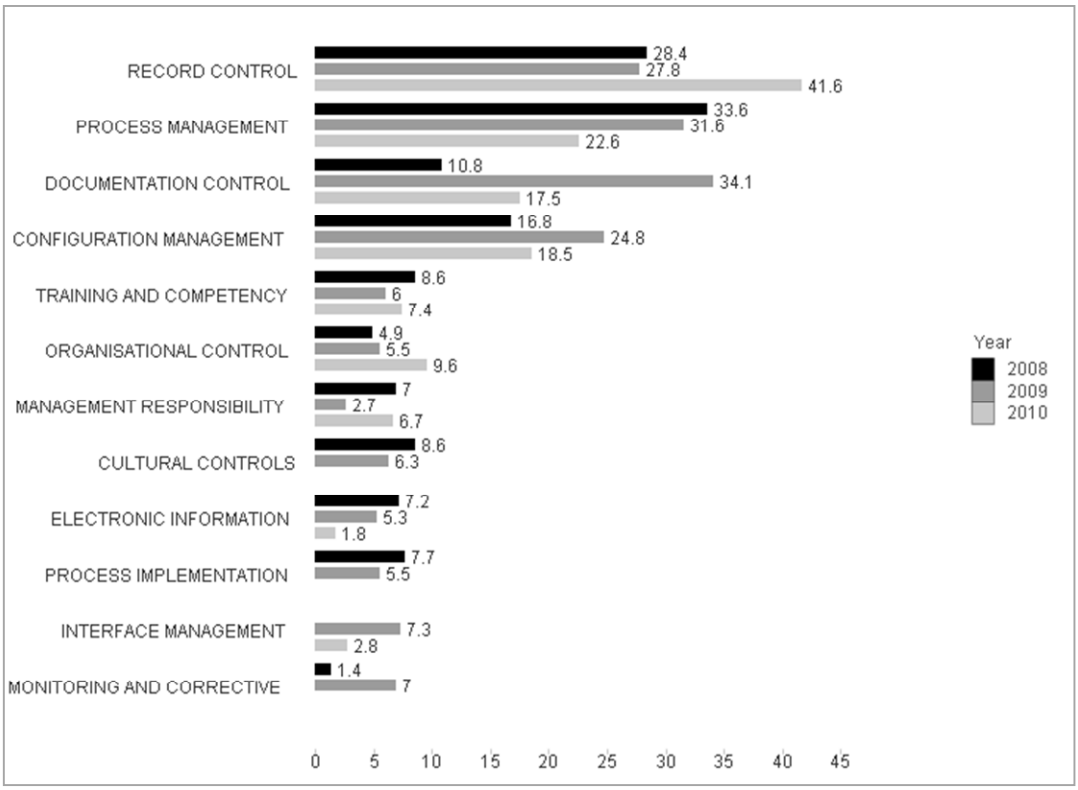

Figure 5.17: NC severity distribution by year **(Source:** Own**)**

The severity data informs the urgency of action by providing management with additional risk oriented data which may invoke different or additional actions than if only the QMS deficiency location data was considered.

5.9 QMS performance measure vs. business performance

The researcher tested correlation between the QMS Performance Measure and actual business (plant) performance. This is achieved by comparing the aggregated QMS nonconformity data to plant events of a more serious nature (see Annexure D) which had occurred within the same period of time. The results showed a level of correlation between the two data sets when comparing the plant data to the QMS nonconformities. It was noted that in the months where more serious plant events peaked, the QMS nonconformities associated with the "core" and "enabling" process areas peaked one to two months prior to the plant event peak. While a level of correlation is thus claimed, the researcher is cognisant of the uncertainties posed by the research assumptions and constraints as noted in 1.12 and 1.13. Additional research in the areas of uncertainty is

required to improve the confidence level of any prediction capability of the measure. The QMS performance model does thus claim limited but definite prediction capability.

Figure 5.18 below shows the correlation of the peaks A to E from 2008 to the end of 2010. A higher resolution image is shown in Annexure F.

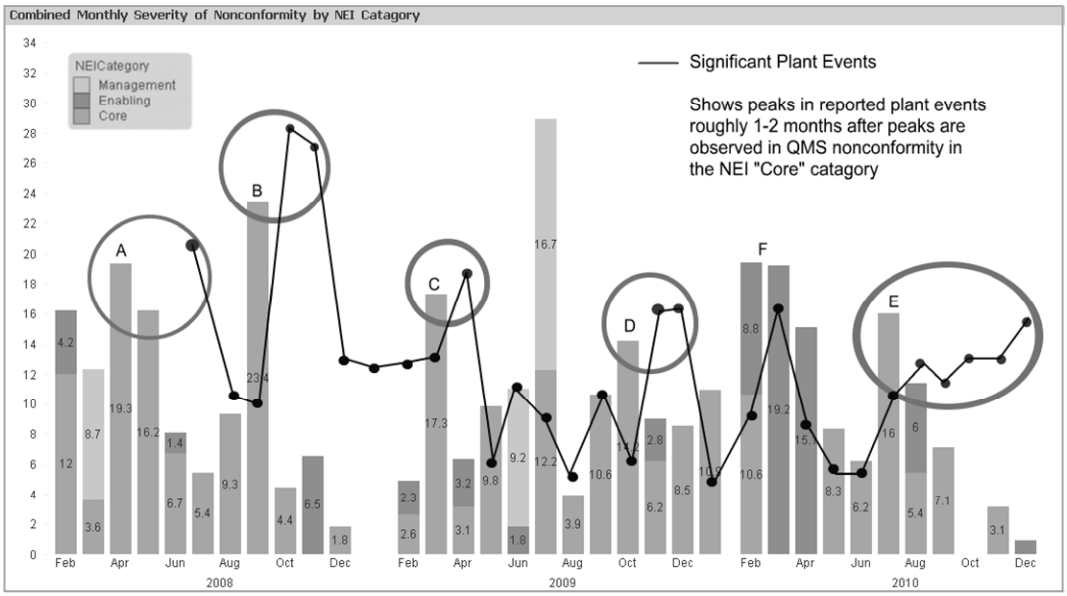

Figure 5.18: QMS performance measure vs. business performance (**Source:** Own)

5.10 Conclusion

This chapter expanded upon the following:

- Ø Current QMS Monitoring and Reporting Environment and its limitations.
- Ø The various data sources and levels of data collected over within an audit programme.
- Ø The data collection methods and the collection environment.
- Ø Data weighting criteria basis and methods.
- Ø Data Analysis results.
- Ø QMS deficiency location measurement, showing where within the QMS more deficiencies are occurring.
- Ø QMS performance measurement, which provides a quantitative reference from which to improve the business performance.
- Ø The research reliability and validity methodology

CHAPTER 6: CONCLUSION

6.1 Introduction

The research thus far corroborates the benefit and value that may be obtained by providing a quantitative QMS performance measurement. The benefit manifests itself in providing a firm reference for management to gauge improvement in implementation of QMS requirements, and in so doing, provides the foundation for business performance improvement.

The research shows that the Pareto analyses of the quantified process risk using the "cause" QMS theme, is able to provide management with direction as to where more urgent attention is required, and which QMS process deficiencies contribute more to the overall QMS implementation performance.

6.2 The research problem revisited

The problem that has been researched within the ambit of this study, reads as follows: The performance measurement capability of the quality management system at Eskom's Koeberg Power Station is insufficient. This diminishes management's ability to identify the business risk resulting from management system deficiencies, which impacts negatively on business performance.

The research proposes that more benefit can be derived by providing a quantitative reporting output. Feedback from various forums confirms that the performance measurement capability of the quality management system does not provide sufficient depth to support confident action. The research considered the entire audit value chain and proposed standardisation of grading methodologies, interface improvements and aggregation of the data outputs to arrive at an actionable QMS performance measurement.

6.3 The research question revisited

The research question, forming the crux of this research study, reads as follows: How can the performance measurement capability of the quality management system of Eskom's Koeberg power station be improved to assist management to identify business risk resulting from quality management system deficiencies, to improve business performance?

By decomposing the QMS into individual processes and linking QMS nonconformity to those process areas, aggregation and analysis of the data, results in a quantitative measure of the QMS performance. Fink (2006:82) notes the technique of decomposition is essentially a top-down approach to solving a complex problem. The quantitative measure of the QMS performance is then used as a reference to drive improvement.

6.4 The investigative questions revisited

The investigative questions researched in support of the research question, are listed below:

- *What quality management methods are currently used to improve business performance?* The literature showed that score cards, excellence models, awards are some of the methods used to improve business performance.
- *What performance measures are used for representing quality management system performance?* The literature showed audits and reviews are primarily used to measure QMS performance in the context of a specific audit and results primarily in a qualitative output.
- *What is the relationship between the quality management system performance measures and business performance?* The literature showed that excellence models, scorecards and awards are more prominent when making the link to business performance. No explicit QMS performance measures were noted.

- *How can QMS performance measurement provide insight into management decision making?* The research showed that when including severity and "cause and effect" data, management may be directed to the higher risk deficiencies where more urgent action is required.
- *How can the existing QMS performance measurements be used to improve business performance?* The overall QMS performance measure is used as a reference and motivation to improve QMS performance and hence business performance.

6.5 Key research objectives revisited

The identified primary research objectives of this research study, are listed below:

- **Primary objective:** The primary objective of this research study is to mitigate the research problem through the implementation of a feasible and viable problem solving mechanism.
- **Secondary objectives:** The secondary research objectives are:
  - *To identify which quality management methods are currently used to improve business performance.* Score cards, excellence models, awards are some of the quality methods used to improve business performance. These methods are however complementary to the QMS. ISO TC (2010:6), states that ISO 9004 (2009), is compatible with the main international and national Excellence/Award models. The document sates that models, scorecards and awards are not in competition, but provides complementary guidance on the path towards excellence.
  - *To determine which performance measures are used for representing quality management system performance.* Audits and reviews are primarily used to measure QMS performance. Ramly, Ramly and Yusof, (2007:1) state that the purposes of the audits can be divided into compliance audits and management audits, where compliance audits look for conformance to the audit criteria, while management audits look for conformance to the audit criteria and

the effectiveness of the process and opportunities for improvement in achieving organisation goals.

- *To show the relationship between the quality management system performance measures and business performance.* As noted previously, the literature showed that excellence models, scorecards and awards are more prominent when making the link to business performance. QMS performance measures were not linked directly to business performance measures.
- *To show how QMS performance measurement can provide insight into management decision making.* By extracting embedded "cause" information from QMS process nonconformities, aggregated analysis provides prioritisation as to where action is more urgently required.
- *To show how existing QMS performance measurement (audit) data can be used to improve business performance.* The potential to impact positively on business performance is achieved in two ways. Firstly by providing a definitive QMS performance measure from which to improve on, and, the potential to proactively act on areas of the organisation that show elevated QMS deficiency with a higher severity allocation.

6.6 Reliability and validity of the research

Blaxter, Hughes and Tight (2006:221) provide an overview of the expectations of a research project relating to its Significance, Generalisability, Reliability and Validity. The following (6.6.1 to 6.6.4) is adapted from the author's overview, with additional context provided to this research:

6.6.1. Significance of the research

Significance refers to the likelihood that a result derived from a sample could have been found by chance. The more significant a result, the more likely that it represents something genuine. In more general terms,

significance has to do with how important a particular finding is judged to be (Blaxter, Hughes & Tight, 2006:221). The researcher contends that the significance of this research lies in the unique QMS performance measure, and that the methodology with minor adaption, may be used by any organisation and thus not limited to the nuclear industry.

6.6.2. Generalisability

Generalisability relates to whether your findings are likely to have broader applicability beyond the focus of your study. (Blaxter, Hughes& Tight, 2006:221). The research is biased toward nuclear utilities management systems but may be generalised for use in any management system. This may be done by modifying the severity tags based on a business analysis, to accommodate a generic ISO 9001 based QMS.

6.6.3. Reliability

The concept of reliability has to do with how well you have carried out your research project. Have you carried it out in such a way that, if another researcher were to look into the same questions in the same setting, they would come up with essentially the same results (though not necessarily an identical interpretation). If so, then your work might be judged reliable. (Blaxter, Hughes& Tight, 2006:221). The researcher contends that due to the standardisation in QMS auditor certification and competency, the research outputs may be repeated within the same context and environment while being mindful of the identified uncertainties.

6.6.4. Validity

Validity has to do with whether your methods, approaches and techniques actually relate to, or measure, the issues you have been exploring (Blaxter, Hughes& Tight, 2006:221). The reserach methodology used herein in the opinion of the researcher contributes and builds up the various elements to achieve the research objective.

6.7 Findings and conclusions

This research showed that by introducing additional theming and severity data into the secondary audit findings data, it is possible to extract high level strategic direction information by the analysing the additional data. The dimensions and value of the QMS Performance measuring instrument are:

- Ø The benefits of a cause and effect theming philosophy.
- Ø The provision of a QMS process deficiency locator / identifier.
- Ø The provision of a quantitative measure of the management system performance.

6.7.1. The cause and effect theming philosophy

By assigning cause and effect themes to nonconformities, analysis of the collective nonconformities provides management with the current status of the QMS via the "effect" component of the theme, as well as the probable causes of those effects. This allows management to initiate action based on the "cause" information. The Pareto results of the "cause" themes below shows the areas where the larger return on investment may be obtained.

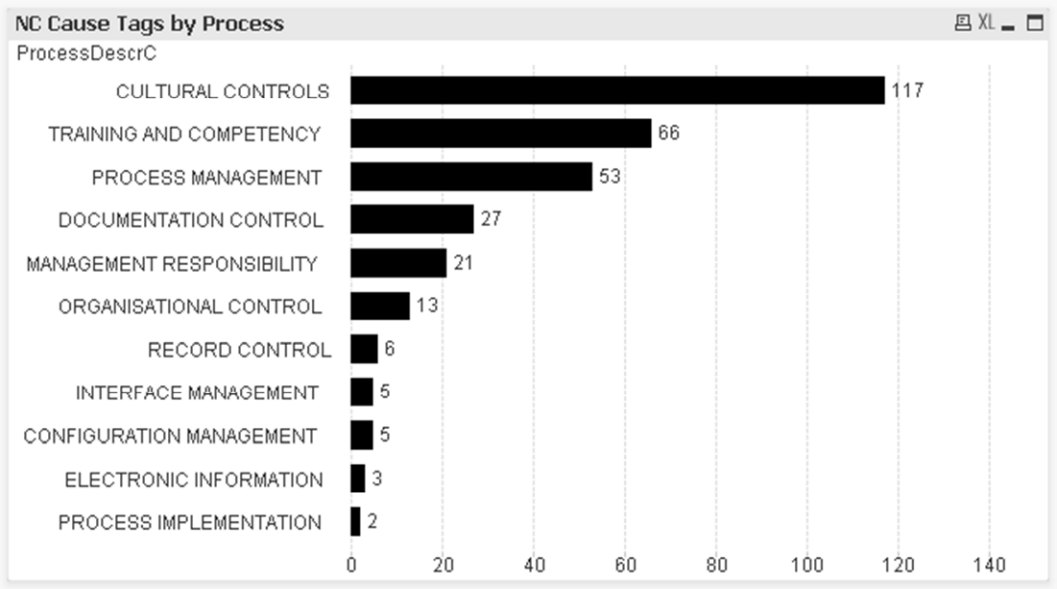

Figure 6.1 Nonconformity cause themes by process area (**Source:** Own)

6.7.2. QMS process deficiency locator / identifier.

The Pareto analysis result below shows the distribution of QMS nonconformities over a three year period. The collective severity of the nonconformities within the "Effect" process area provides management with an picture of where the bulk of the QMS deficiencies are occurring in the organisation, as well as a reference measure of business risk introduced via the QMS

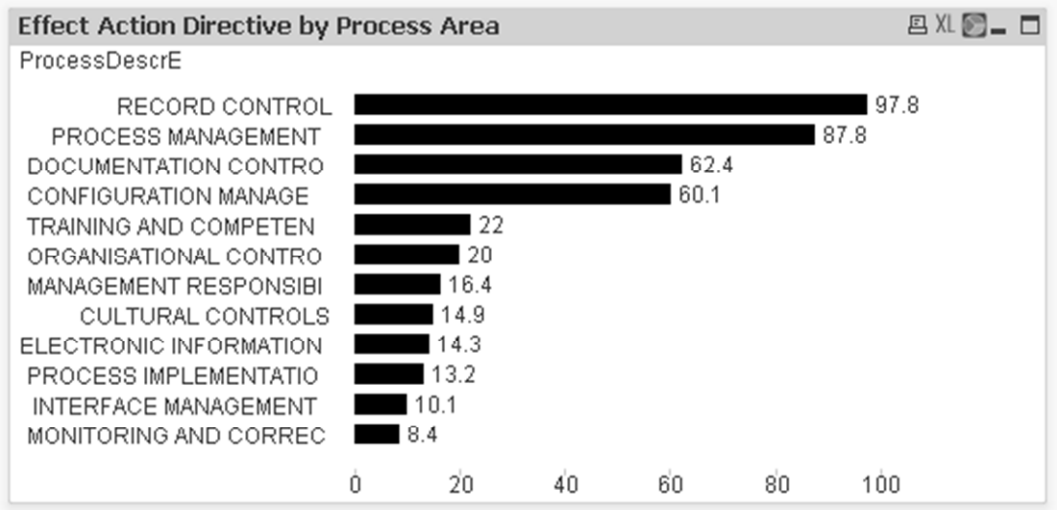

Figure 6.2: Nonconformity effect directive by process area (**Source:** Own)

6.7.3. Quantitative measure of the QMS performance.

To arrive at a quantitative QMS performance measure, the collective nonconformity data is analysed, processed and aggregated. Figure 6.3 shows the summary of the "severity informed" nonconformity data by year. The aggregation of the data shows the amount of QMS deficiency observed in each year. To provide a more conventional generic reference, the deficiency data shown in Figure 6.3, is converted into a positive percentage value. Management can thus invest attention and action on the "cause" data in order to improve on the 73.3% QMS performance seen in 2010. A value of 100% QMS performance would indicate that zero open nonconformity exists in the management system. The methodology to attain this value is expanded upon in Annexure G.

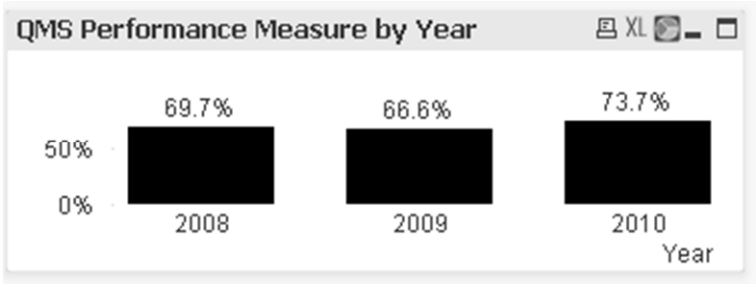

Figure 6.3: Collective QMS Performance Measure by Year (**Source:** Own)

6.8 Recommendations

To obtain the aggregated QMS performance value, a level of subjectivity is embedded in the inputs of various entry points to the model, which contribute to the uncertainty noted in the final QMS performance measurement. These include elements such as:

- Auditor bias, competency and experience.
- The quality and reliability of the theme listing (Annexure B).
- The understanding and application of the nonconformity specific severity grading.

Sufficient confidence is however claimed to allow management to act on the QMS measurement and Pareto analyses data. The subjective inputs in the model will decrease as uncertainties are reduced. Further research is thus recommended in the following areas:

- Refinement of the criteria used to grade nonconformities and a methodology for improving the understanding and application of the nonconformity specific severity grading.
- Reduction of the level of uncertainty in Auditor bias, competency, experience.
- Refinement of the QMS process theme listing, with exposure for influence being opened to a much wider audience.

6.9 Final conclusion and “real world” value

The research shows that measuring quality management system performance using quantitative analyses is obtained by deconstructing the elements that make up the QMS such as the process areas and nonconformity noted within those process areas, and applying the methods noted in this research.

The research also proposes an acceptable level of correlation in achieved between the QMS performance measure, and business performance. It also proposes that an elevated QMS risk value may be seen as a precursor to plant events which impact negatively on business performance.

The research also showed that by applying the methodology noted in this research, leading to overlaying QMS themes within audit data, and analysing that data, management is presented with two information sources to which they would respond in different ways. The extracted “effect” data when analysed, provides a measurement of the status that the effect QMS deficiency is having on the business. The “cause” data provides management with a target to which if action is introduced will reduce the negative results of the effects noted.

The individual monitoring activity elements (such as nonconformities and their associated process areas) when aggregated and analysed, culminate in a quantitative QMS performance measurement. By providing management with a quantitative reference in order to improve the overall QMS implementation compliance, the researcher claims that when improving compliance to the management system requirements, a positive impact will be seen in business performance.

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ANNEXURE A: Primary and Secondary Data

Due to the data sensitivity of the detail of the nonconformities as noted in paragraph 0 only the first 25 characters of the nonconformity are noted in the table.

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR37513	NC00018	2008/02/01	Low - 3	The process for the . . .	1e,8b	1d,10e
PR37424	NC00019	2008/02/14	High - 1	The CRACK process is not	1d,1e	1c,10n
PR37625	NC00020	2008/02/18	Medium - 2	The Training Record Form	10n,2d	2b
PR37625	NC00021	2008/02/18	Medium - 2	OTG has not established,	1b	1c
PR37625	NC00022	2008/02/18	Medium - 2	Some aspects of the LORT	1d	1e
PR37727	NC00024	2008/02/21	Medium - 2	The records of surveillance	3e	3b
PR38400	NC00023	2008/02/21	Medium - 2	Post decontamination . . .	1e,12f	10n
PR37424	NC00025	2008/02/28	Medium - 2	There is no programme for	1b	10i
PR37727	NC00026	2008/02/28	High - 1	The records of surveillan	3g,3e	10n
PR38009	NC00027	2008/02/29	Low - 3	The outage safety plan re	1e,3e	10n
PR38178	NC00028	2008/03/05	Medium - 2	There is no status board	8c	1b
PR30499	NC00029	2008/03/11	Medium - 2	There is no implementatio	1b	1b
PR30499	NC00030	2008/03/11	High - 1	There is a lack of formal	6g,6i	4d
PR30499	NC00031	2008/03/11	Medium - 2	There is non-compliance t	4d	6g
PR30499	NC00032	2008/03/11	Low - 3	There is non-compliance t	4c	4d
PR30499	NC00033	2008/03/11	Medium - 2	Configuration management	8d	2b
PR30499	NC00034	2008/03/11	High - 1	Non compliance to records	3a	1e
PR30499	NC00035	2008/03/11	Medium - 2	There is no official Empl	4g	10l
PR30499	NC00036	2008/03/11	Medium - 2	There is no Diversity Man	4g	10l
PR38403	NC00037	2008/03/13	Medium - 2	Equipment for the control	12n	10i
PR39534	NC00038	2008/04/01	Medium - 2	At the time of performing	4b	6f
PR39534	NC00039	2008/04/01	Medium - 2	RP procedure reviewers ha	8b	5f
PR38922	NC00040	2008/04/02	Medium - 2	Radiation shield testing	8d	8h
PR38922	NC00041	2008/04/02	Medium - 2	Management of Hot Spots i	1e	6f
PR39512	NC00042	2008/04/14	Medium - 2	Appointment of technicall	5i	1b

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR46294	NC00043	2008/04/25	Medium - 2	CA18579 Line-up process a	8c	10n
PR46294	NC00044	2008/04/25	Medium - 2	CA18580 There is no imple	1b	8d
PR46294	NC00045	2008/04/25	Medium - 2	CA18581 Records for react	3e	1e
PR46294	NC00046	2008/04/25	Low - 3	CA18582 Files of line-up	1e	10l
PR40097	NC00047	2008/05/20	Medium - 2	The FIN process is not be	1d	2d
PR40097	NC00048	2008/05/20	Medium - 2	There is no PN raised whe	1e	10l
PR40097	NC00049	2008/05/20	Medium - 2	The requirement to have a	1d	2d
PR40097	NC00050	2008/05/21	Medium - 2	Records are not maintaine	3a	10l,2d
PR40097	NC00051	2008/05/21	Medium - 2	There is no formalised tr	5g	5j
PR40097	NC00052	2008/05/21	Medium - 2	All procedures have not b	2b	10i
PR40097	NC00053	2008/05/21	Medium - 2	The management of control	3b	10i
PR40097	NC00054	2008/05/21	Medium - 2	Formalised training inter	5g,5f	5j
PR40097	NC00055	2008/05/21	Medium - 2	The work preparation proc	1d	6f
PR48620	NC00056	2008/06/06	Medium - 2	CA 19519. There is no DBT	12c	1b
PR40560	NC00057	2008/06/26	Low - 3	The Quarterly Radioactive	3e	3f
PR40560	NC00058	2008/06/27	Medium - 2	The annual authorisation	3f	3b
PR40560	NC00059	2008/06/27	Medium - 2	The Emergency Equipment K	1e	10i
PR40560	NC00060	2008/06/27	Medium - 2	Training requirements for	5g	5j
PR41489	NC00065	2008/07/23	Medium - 2	There is no appointed res	3e	6f
PR41489	NC00066	2008/07/23	Medium - 2	RP Dosimetry QRL is not b	3e	10i
PR41489	NC00067	2008/07/23	Medium - 2	The required minimum numb	10i	1e,10i
PR42789	NC00068	2008/08/08	Medium - 2	There were instances wher	11b	11i
PR42789	NC00069	2008/08/08	Low - 3	There was an instance not	4i	5i
PR42789	NC00070	2008/08/08	Medium - 2	Comments are not recorded	11g	1e
PR42789	NC00071	2008/08/08	Low - 3	The standardisation proce	1e	10i,1e
PR42789	NC00072	2008/08/08	Medium - 2	Control charts are not be	11g	1e
PR42789	NC00073	2008/08/08	Low - 3	Equipment calibration rec	3g,3d	10i,1e
PR47016	NC00090	2008/09/16	Medium - 2	The storage of original m	3j	11f
PR47016	NC00091	2008/09/16	Medium - 2	The lack of an integrated	3j,8d	4g
PR47016	NC00092	2008/09/16	Medium - 2	There is an over-reliance	11b	4b
PR47016	NC00093	2008/09/16	Medium - 2	The level of detail indic	1d,3g	1e,10i

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR47016	NC00094	2008/09/16	Medium - 2	There are outstanding upd	8e	1e,10i
PR47016	NC00095	2008/09/16	Medium - 2	There is a lack of consis	8h	1j
PR47016	NC00096	2008/09/16	Medium - 2	Incomplete records submit	3g	1j
PR47016	NC00097	2008/09/16	Medium - 2	The responsibility matrix	6f,12b	1e
PR47016	NC00098	2008/09/16	Medium - 2	The modification packages	10i	1e
PR47016	NC00099	2008/09/16	Medium - 2	The roles and responsibil	6e	10l
PR47016	NC00100	2008/09/16	Medium - 2	The verification of compl	10k	10i
PR47016	NC00101	2008/09/16	Medium - 2	The review of contractual	10k	10i
PR47016	NC00102	2008/09/16	Medium - 2	The contracts files maint	2b	8b
PR45031	NC00103	2008/10/29	Low - 3	The content of the obsole	2d	2b
PR45031	NC00104	2008/10/29	Low - 3	The content of the revers	2d	2b
PR45031	NC00105	2008/10/29	Medium - 2	The Classification Proces	2d	2b
PR44008	NC00109	2008/11/03	Medium - 2	Identification, processin	3b	1e,5j
PR44008	NC00110	2008/11/03	Medium - 2	The RFE training and auth	5c	5g
PR44438	NC00111	2008/11/14	Medium - 2	The Met Operations Manual	2b,2d	1e,10k
PR44438	NC00112	2008/11/14	Medium - 2	There is lack of accounta	7b	10d,10e
PR44438	NC00113	2008/11/14	Low - 3	There were inconsistencie	1g,12r	12r,10n
PR44038	NC00106	2008/12/01	Medium - 2	The implementation of the	1d	5f
PR44878	NC00137	2009/01/16	Low - 3	4.1.2 The Maintenance gro	5b	8b
PR44878	NC00138	2009/01/20	Medium - 2	The processing of the cat	3g	10i
PR44878	NC00139	2009/01/20	Low - 3	KAA-751 requires Group ma	5c,5e	5i
PR44878	NC00140	2009/01/20	Low - 3	The CRACK database is not	8e	5j
PR44878	NC00141	2009/01/20	Low - 3	The CRACK information pro	12g	5j
PR44878	NC00142	2009/01/20	Low - 3	The procedure referenced,	8b	2b
PR44878	NC00143	2009/01/20	Low - 3	During the processing of	8e	1e
PR44878	NC00144	2009/01/20	Low - 3	Group manager did not app	4i	1e,10n
PR45274	NC00145	2009/02/02	Low - 3	Training Audits are not b	5h	1e,10n
PR45806	NC00146	2009/02/16	Low - 3	Roles and responsibilitie	6f	10k
PR45830	NC00147	2009/02/17	Medium - 2	The RHM gas welding bottl	1e,10k	4d
PR46156	NC00150	2009/02/27	Low - 3	There were instances of i	10i,1e	10i
PR46233	NC00151	2009/03/03	Medium - 2	Routine monitoring of the	1j	12s

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR46336	NC00153	2009/03/05	Medium - 2	To be deleted. The Guide,	2a	5j
PR46428	NC00155	2009/03/09	Medium - 2	During a Clean Condition	10i	10c
PR46230	NC00156	2009/03/17	Medium - 2	CA18544 : NON CONFORMITY	12e	4b
PR46230	NC00157	2009/03/17	Medium - 2	CA 18545: NON CONFORMITY	11h	11i
PR46922	NC00158	2009/03/24	Low - 3	The KAM-038 log containin	3e	5j
PR48103	NC00159	2009/03/25	Low - 3	Incomplete records are in	11e,11f	4b
PR46826	NC00160	2009/03/30	Low - 3	Not all records for the o	3e	5j
PR46826	NC00161	2009/03/30	Low - 3	KLA-020 is outdated in th	2b	10n
PR46964	NC00162	2009/03/31	Medium - 2	CA 18766:The cleanliness	3b	5j
PR47121	NC00163	2009/04/01	Medium - 2	Appendix 2 of KAA-711 for	3d	3c,5e
PR47250	NC00164	2009/04/08	Low - 3	The Outage Safety Plan Ch	1e,8e	10n
PR47464	NC00165	2009/04/20	Medium - 2	NON CONFORMITY DESCRIPTIO	8b	2b
PR47464	NC00166	2009/04/20	Low - 3	NON CONFORMITY DESCRIPTIO	3f	5j
PR47464	NC00167	2009/04/20	Low - 3	Identified deficiencies s	7b	10i
PR47754	NC00171	2009/05/12	Medium - 2	The roles and responsibil	1e	10i
PR48073	NC00168	2009/05/12	Medium - 2	Items defined in KAA-641	1b	4g
PR48073	NC00169	2009/05/12	Medium - 2	The minimum information r	12q	9b
PR48073	NC00170	2009/05/12	Medium - 2	The process of hardness t	1e,1d	4d
PR48073	NC00172	2009/05/12	Low - 3	The shelf life extension	3e	5j
PR48073	NC00173	2009/05/20	Low - 3	There were discrepancies	8b	8d
PR48100	NC00174	2009/06/03	Medium - 2	Five documents within the	2g	2b
PR48100	NC00175	2009/06/03	Low - 3	Six of the controlled doc	2b	10i
PR48100	NC00176	2009/06/03	Medium - 2	Operating experience from	1d,7c	1b
PR48100	NC00177	2009/06/03	Low - 3	The process for Requests	1e,7c	10n
PR48100	NC00178	2009/06/03	Medium - 2	Some of the Generation re	1e,7c	9d
PR48227	NC00179	2009/06/05	Low - 3	The Process For The Revie	9d	2d
PR48227	NC00180	2009/06/05	Low - 3	Classification and defini	11d,2e	5j
PR48757	NC00181	2009/06/26	High - 1	In Departmentâ€☐ temporar	3c	5j
PR48757	NC00182	2009/06/26	Low - 3	The environmental conditi	12t	4b
PR48757	NC00183	2009/06/26	Medium - 2	Financial records are not	3j	4d
PR48757	NC00184	2009/06/26	Low - 3	Anomalies were noted rega	3b	5j

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR48757	NC00185	2009/06/26	Medium - 2	Records are not transmitt	3e	10i
PR49013	NC00186	2009/07/22	High - 1	Policies and Protocols re	9c	5j
PR49013	NC00187	2009/07/22	Medium - 2	The current process for c	3b,1d	2b
PR49013	NC00188	2009/07/22	Low - 3	There were instances note	2d	2b
PR49013	NC00189	2009/07/22	High - 1	Inadequate interfacing be	9b,7g	10i
PR49013	NC00190	2009/07/22	High - 1	The identification and st	3c	5j,10e
PR49013	NC00191	2009/07/22	Medium - 2	There is inadequate evalu	1e,1g	4d
PR49013	NC00192	2009/07/22	Low - 3	The Occupational Health I	11h,8d	1d
PR48506	NC00193	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2b	10i
PR48506	NC00194	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2e	5j
PR48506	NC00195	2009/07/24	Low - 3	NON CONFORMITY DESCRIPTIO	1e,2d	10i
PR48506	NC00196	2009/07/24	Low - 3	NON CONFORMITY DESCRIPTIO	9c,2a	1e,10i
PR48506	NC00197	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2d,1e	10n
PR48506	NC00198	2009/07/24	Low - 3	NON CONFORMITY DESCRIPTIO	2e	5j,10i
PR48506	NC00199	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	8d	9b
PR48506	NC00200	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	8d,8b	10l
PR48506	NC00201	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2b	10i
PR48506	NC00202	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	1e,2b	10i
PR48506	NC00203	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2b	2b,10i
PR48506	NC00204	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2b	5j
PR48506	NC00205	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2b	5j
PR48506	NC00206	2009/07/24	Low - 3	NON CONFORMITY DESCRIPTIO	3d	1b
PR48506	NC00207	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	6e	1b,5j
PR48506	NC00208	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	2e	5j
PR48506	NC00209	2009/07/24	Medium - 2	NON CONFORMITY DESCRIPTIO	1e,5f,2e	5i
PR49463	NC00211	2009/08/14	Low - 3	Procedures KAA-633, revis	2d	10i
PR49463	NC00212	2009/08/19	Low - 3	The administrative contro	8d	10i
PR49463	NC00213	2009/08/26	Low - 3	NON CONFORMITY DESCRIPTIO	7g,1e	5j,10i
PR49729	NC00214	2009/09/09	Medium - 2	Not all elements of the d	1e,8b	10i,10k
PR49729	NC00215	2009/09/09	Low - 3	The records requirements	3j,3e	5j,10i
PR49729	NC00216	2009/09/09	Low - 3	The records submission re	3j	5j,10i

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR49729	NC00217	2009/09/09	Medium - 2	Design engineering work i	2e	5j
PR49729	NC00218	2009/09/09	Medium - 2	Controlled documents asso	8d	10n,10i
PR50384	NC00219	2009/09/14	Low - 3	Oxygenation report is not	1e,3j	1e
PR50647	NC00220	2009/09/30	Low - 3	There were instances wher	3g	4e
PR50987	NC00221	2009/10/06	Medium - 2	The brazing procedure spe	2e	5j
PR50806	NC00222	2009/10/07	Medium - 2	Generation requirement fo	8d	10i
PR50806	NC00223	2009/10/07	Low - 3	The processing of spares	1g	10i
PR51115	NC00224	2009/10/19	Medium - 2	The implementation of ref	8d	9d
PR51115	NC00225	2009/10/19	Medium - 2	Items that awaiting to be	8d	5j,10i
PR51105	NC00226	2009/10/20	Low - 3	KAA-617 has not been main	2d,6f	2b
PR51105	NC00227	2009/10/20	Low - 3	Records requirements for	3e	10i
PR51105	NC00228	2009/10/20	Low - 3	The spares anomalies are	8d	1e
PR51454	NC00229	2009/10/23	Medium - 2	A CSR procedure, KAA-724	2b,10i	10i
PR50703	NC00230	2009/11/06	Medium - 2	An impact assessment of t	1e,1g	1e
PR51744	NC00231	2009/11/10	Low - 3	The limited systematic co	1d	1b
PR51224	NC00232	2009/11/19	Medium - 2	The QADP compiled by the	9c	5j
PR51224	NC00233	2009/11/19	Low - 3	Materials management does	1e,3d	5j
PR50788	NC00234	2009/11/30	Medium - 2	Not all EP training mater	5g,2b	5j
PR50788	NC00235	2009/11/30	Medium - 2	The EP Training procedure	4b	4b
PR49346	NC00236	2009/12/03	Medium - 2	The overall lead responsi	6f	6f,1b
PR49346	NC00237	2009/12/03	Medium - 2	NEPP 020, revision 4 has	2d,2e	10i
PR49346	NC00238	2009/12/03	Low - 3	Two LOPPs compiled by EPD	2d,2e	10i
PR49346	NC00239	2009/12/03	Medium - 2	Configuration control of	8e	10i
PR49346	NC00240	2009/12/03	Medium - 2	Not all the LOPPs for sys	2b	9c
PR52984	NC00241	2010/02/01	Medium - 2	NON CONFORMITY DESCRIPTIO	6i,6g	1e,4h
PR52984	NC00242	2010/02/01	Medium - 2	NON CONFORMITY DESCRIPTIO	4h,1g	4c
PR52451	NC00243	2010/02/02	Medium - 2	The process described in	1e	1e
PR52451	NC00244	2010/02/04	Low - 3	The current practice pert	1b	2b
PR52451	NC00245	2010/02/04	Medium - 2	KAA-569 process is not fo	1e	1e
PR52986	NC00246	2010/02/12	Low - 3	FRM (respiratory) trainin	3e	10i,5j
PR52986	NC00247	2010/02/12	Medium - 2	Certain RP respiratory re	3e	10i,5j

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR52826	NC00248	2010/02/17	Medium - 2	External SHE audit report	1e	10n,10i
PR52826	NC00249	2010/02/17	Medium - 2	The responsibilities and	1e,4d	10i
PR52826	NC00250	2010/02/17	Medium - 2	SHE Steering Committee Pr	5c	1e,10i
PR52826	NC00251	2010/02/17	Low - 3	OH&S and Environmental As	3b	5j
PR52826	NC00252	2010/02/17	Low - 3	Auditors performing inter	5c	1e,10i
PR52971	NC00253	2010/02/26	Low - 3	There is no evidence that	4e	1e,10i
PR52971	NC00254	2010/02/26	Low - 3	Design Engineering proced	2b	10i
PR52970	NC00255	2010/03/05	Low - 3	Procedure KAA-687 Rev 4,	2b	6f
PR52970	NC00256	2010/03/05	Low - 3	Records of KORC, KOSC and	3e	5j,10i
PR52970	NC00257	2010/03/05	Low - 3	The configuration control	8h	10i
PR52970	NC00258	2010/03/05	Low - 3	Not all personnel affecte	2b	5j,10i
PR52970	NC00259	2010/03/05	Low - 3	KAA-831 Rev 0, â€œKoeberg	8d,8b	10i
PR52970	NC00260	2010/03/05	Low - 3	The instructions recorded	1e,3g	10i
PR52972	NC00261	2010/03/29	Low - 3	The process for organisat	2b	10i
PR52972	NC00262	2010/03/29	Low - 3	There is no process for m	6b,6h	10i
PR52972	NC00263	2010/03/29	Medium - 2	Anomalies were noted with	6h	10i
PR52972	NC00264	2010/03/29	Medium - 2	Implementation of the nuc	3j,6e	6c
PR52972	NC00265	2010/03/29	Low - 3	The documented process fo	2d	10i
PR52972	NC00266	2010/03/29	Medium - 2	Organograms do not always	8b	6h
PR52972	NC00267	2010/03/29	Low - 3	Changes to the FOS have n	8d	6h
PR52972	NC00268	2010/03/29	Medium - 2	The records for the organ	3b	5j,10i
PR52972	NC00269	2010/03/29	Medium - 2	There are positions in th	6d	6f
PR52972	NC00270	2010/03/29	Low - 3	Records originating from	3e	10i,5j
PR52972	NC00271	2010/03/29	Medium - 2	Not all requirements in t	1e,9c	1e
PR52972	NC00272	2010/03/29	Low - 3	The documented process fo	1e	2d
PR52990	NC00273	2010/04/01	Medium - 2	Not all personnel or depa	9c,2b	5j,10i
PR52990	NC00274	2010/04/01	Medium - 2	KAA-668 is not in complia	2b	5j,10i
PR52990	NC00275	2010/04/01	Medium - 2	The Koeberg Control Offic	5c	1e,10i
PR52990	NC00276	2010/04/01	Medium - 2	In most instances during	1e,5e	1e
PR52973	NC00277	2010/04/16	Low - 3	Records of training inter	3b	5j,10i
PR52973	NC00278	2010/04/16	Low - 3	There is no evidence that	3e	5j,10i

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR52973	NC00279	2010/04/16	Medium - 2	There are no records avai	3e	5j,10i
PR52973	NC00280	2010/04/16	Low - 3	Electrical conductivity r	3g	10i
PR52973	NC00281	2010/04/16	Low - 3	There is no evidence that	3e	10i,5j
PR52973	NC00282	2010/04/16	Low - 3	There is no evidence that	3e	10i,5j
PR52974	NC00283	2010/04/29	Low - 3	The retention times speci	3b	5j,10i
PR52991	NC00284	2010/04/29	Low - 3	Documentation and Configu	8d	2d,2b
PR52991	NC00285	2010/04/29	Low - 3	KGA-046 does not specify	3b	5j,10i
PR52991	NC00286	2010/04/29	Low - 3	Koeberg Risk Profile repo	3b,3h	3b
PR52975	NC00287	2010/05/14	Low - 3	Electronic copies of TAF	3e	5j,10i
PR52975	NC00288	2010/05/14	Medium - 2	Certain project files rel	3e	1e,5j,10i
PR52975	NC00289	2010/05/14	Low - 3	The Facilities Control Ch	1e,2b	1e,10i
PR52975	NC00290	2010/05/14	Low - 3	Koeberg Grid Forum meetin	3e,3h	5j,3b
PR52975	NC00291	2010/05/14	Low - 3	Certain roles and respons	1e,6f	1e
PR54741	NC00292	2010/05/28	Low - 3	Records generated by Reli	3f	5j,10i
PR52977	NC00293	2010/06/21	Medium - 2	NON CONFORMITY DESCRIPTIO	8d,2d	2b
PR52977	NC00294	2010/06/21	Low - 3	NON CONFORMITY DESCRIPTIO	3f	5j
PR52977	NC00295	2010/06/21	Medium - 2	NON CONFORMITY DESCRIPTIO	3g	2b
PR52977	NC00296	2010/06/21	Low - 3	NON CONFORMITY DESCRIPTIO	3e	5j,10i
PR52978	NC00297	2010/07/05	Medium - 2	There were instances wher	3g	2b,4d
PR52978	NC00298	2010/07/05	Medium - 2	A number of maintenance p	8d	2b
PR54865	NC00299	2010/07/06	Medium - 2	NON CONFORMITY DESCRIPTIO	1e,8d	4d
PR 51107	NC00300	2010/07/14	Low - 3	NON CONFORMITY DESCRIPTIO	4d	10i
PR51107	NC00301	2010/07/14	Low - 3	NON CONFORMITY DESCRIPTIO	2e	5j
PR 51107	NC00302	2010/07/14	Low - 3	NON CONFORMITY DESCRIPTIO	4d	1e,10i
PR51107	NC00303	2010/07/14	Low - 3	NON CONFORMITY DESCRIPTIO	3d	6f
PR52979	NC00304	2010/07/16	Medium - 2	Organisational controls w	6h	2b
PR52979	NC00305	2010/07/16	Medium - 2	The Operability Determina	3e	10i,5j
PR52979	NC00306	2010/07/16	Medium - 2	The oversight role of the	1e,2b,2d	10i
PR52996	NC00308	2010/08/02	Medium - 2	There is lack of clarity	8d	6f
PR52996	NC00309	2010/08/02	Medium - 2	There is a lack of docume	1b,8e	1b
PR52996	NC00310	2010/08/02	Medium - 2	Effective configuration m	11i,8d,8g	4b

PR Number	NC No	NC date	Rating	Nonconformity	Effect Theme	Cause Theme
PR52981	NC00311	2010/08/06	Low - 3	The minimum training hour	1e,5f,5g	5i,4d
PR52981	NC00312	2010/08/06	Low - 3	Appendix 1, Fire fighting	2e	2b
PR52988	NC00313	2010/08/23	Medium - 2	The acceptance of certain	5c	4d
PR52988	NC00314	2010/08/23	Medium - 2	Records associated with t	3e	10i
PR52988	NC00315	2010/08/23	Medium - 2	The KAA-743 process, â€œI	8e	10i
PR57014	NC00316	2010/09/09	Medium - 2	The authorised turbine fo	2b	10i
PR57173	NC00317	2010/09/16	High - 1	Plant surveillances data	3e	1e
PR57173	NC00318	2010/09/16	High - 1	Completed surveillance re	3e	10i,5j
PR57173	NC00319	2010/09/16	Low - 3	Contradictions between KA	8b	2e
PR57173	NC00322	2010/11/11	Medium - 2	Some of plant surveillanc	3e	1e,10i
PR57173	NC00323	2010/11/11	Low - 3	Records of outage 217 wer	3d,3e	10i,1e,5j
PR52995	NC00325	2010/12/22	Low - 3	GGM0907, Koeberg Accident	2b,2d	10i

ANNEXURE B: QMS Process Themes Listing

	10 March 2012 Revision 1 Mtech	
1	**a**	**PROCESS MANAGEMENT**
1	**b**	Process has not been adequately defined or documented
1	**c**	The sequence Interactions between various processes have not been adequately determined or documented (GS-R-3 5.2)
1	**d**	Process not effective (required process outputs not consistently achieved)
1	**e**	Process not fully implemented
1	**f**	Process documentation not consistent with existing implementation documents (GS-R-3)
1	**g**	Monitoring and reporting on the performance of the process is not performed(GS-R-3)
1	**h**	Process is not carried out under controlled conditions, eg using approved current procedures, instructions, drawings or other appropriate means(GS-R-3)
1	**i**	Processes contracted to external organizations (outsourced process) are not identified within the management system. (GS-R-3)
1	**j**	The organization did not retain overall responsibility when contracting any processes(GS-R-3)
1	**k**	Process outputs (products) were not clearly identified. (GS-R-3 5.4)
1	**l**	Process measurement criteria were not established(GS-R-3 5.4)
2	**a**	**DOCUMENTATION CONTROL (Procedures, drawings, etc)**
2	**b**	Documentation has not been controlled (reviewed / approved / authorised) as required
2	**c**	Documentation change control process has not been implemented
2	**d**	Documented procedures do not reflect current practice
2	**e**	General documentation management process (KAA-500/KSA-011) Non-Compliance
2	**f**	No procedure or written guidance
2	**g**	It has not been ensured that document users are aware of and use appropriate and correct documents (GS-R-3)
3	**a**	**RECORD CONTROL**
3	**b**	Records have not been properly identified, authenticated or classified
3	**c**	Non complainant storage conditions of records
3	**d**	Records are not easily retrievable (GS-R-3)
3	**e**	Records have not been transmitted as per QRL
3	**f**	Records identified in documentation/procedure are not captured in the QRL (or visa versa)
3	**g**	Records are incomplete(GS-R-3)
3	**h**	Records required to demonstrate that the process results have been achieved are NOT specified in the process documentation (GS-R-3)
3	**i**	The media used for the record has not been such to ensure that the records are readable for the duration of the retention times specified for each record(GS-R-3)
3	**j**	Records are not traceable to associated items and activities
4	**a**	**MANAGEMENT RESPONSIBILITY**
4	**b**	Planning by managers ineffective (resource needs such as capital, equipment and information not properly identified)
4	**c**	Management direction not effectively communicated (such as goals, priorities, expectations and initiatives)
4	**d**	Management oversight tools not effectively used (such as benchmarking, independent reviews,

		monitoring of corrective actions, self assessment)
4	**e**	Inadequate Eskom supervision and intervention of turnkey and other projects
4	**f**	Excessive project slippage (due to management)
4	**g**	Management did not ensure that measurable objectives for implementing the goals, strategies and plans are established (Business planning) (GS-R-3)
4	**h**	Management did not ensure that the implementation of the plans is regularly reviewed against their objectives and that actions are taken to address deviations from the plans where necessary (GS-R-3)
4	**i**	An individual reporting directly to senior management has not been appointed with specific responsibility and authority for the coordination, reporting and resolving conflicting requirements of the QMS(GS-R-3)
4	**j**	Management review not implemented.
5	**a**	**TRAINING AND COMPETENCY**
5	**b**	Staff not suitably qualified or certified to perform tasks
5	**c**	Required authorisations not in place; authorisation invalid
5	**d**	Required initial or ongoing training not scheduled or attended
5	**e**	Accreditation process not followed
5	**f**	Experience levels negatively impacting on performance
5	**g**	Training program not in place or fully complied with
5	**h**	An evaluation of the effectiveness of the training actions taken were not conducted. (GS-R-3 4.3)
5	**i**	Senior Management did not ensure that individuals are competent to perform their assigned work(GS-R-3 4.4)
5	**j**	Individuals do not know the importance and/or understand the consequences of their activities and how their activities contribute to safety in the achievement of the Org objectives. (GS-R-3 4.4)
6	**a**	**ORGANISATIONAL CONTROL**
6	**b**	Funtional Organisational Structures (FOS) not in place or available for review
6	**c**	FOS's (Functional Organisational Structures) and Organograms not clearly defined or documented
6	**d**	Job profiles and descriptions have not been authorised
6	**e**	Interfaces between different organisations have not been clearly defined or documented
6	**f**	Roles, responsibilities and accountabilities of key individuals and groups are not clearly stated or communicated
6	**g**	Performance management not implemented as required
6	**h**	Organisational change management not implemented as required
6	**i**	Performance criteria are not established and / or used.
6	**j**	Increased use of contractors to perform key organizational activities for long periods of time.
7	**a**	**MONITORING AND CORRECTIVE ACTION**
7	**b**	Corrective Actions have not been effectively implemented or adequate to prevent recurrence.
7	**c**	Operational Experience not effectively used to prevent problems
7	**d**	Inadequate root cause analysis
7	**e**	CA/Findings not addressed in a timely manner
7	**f**	Failure to deal with the findings of independent external safety reviews
7	**g**	Lack of independent review
7	**h**	Completions (effectiveness) of CA's were not verified.

8	**a**	**CONFIGURATION MANAGEMENT**
8	**b**	Lack of configuration control (related to e.g. design, documents, materials, maintenance, operating [excluding plant status])
8	**c**	Lack of configuration negatively impacting on plant status control
8	**d**	Inadequate consideration of configuration management in processes /procedures and practices
8	**e**	Changes that affect configuration were not recognised and or processed.(NQA-1 requirement 3, 601.1)
8	**f**	Measures to ensure changes are recognised and or processed were not included in the configuration management requirements. (NQA-1 requirement 3, 601.1)
8	**g**	Configuration not maintained for the life a the plant. (NQA-1 requirement 3, 601.2)
8	**h**	Measures were not established and or implemented to ensure that proposed changes to the configuration are evaluated. (NQA-1 requirement 3, 601.6)
9	**a**	**INTERFACE MANAGEMENT**
9	**b**	Interfaces not adequately managed (complex)
9	**c**	Communication anomalies affecting interfaces between entities
9	**d**	Interface not adequately defined / documented
9	**e**	Internal customer's needs not fully considered
9	**f**	No measurement of internal and or external customer expectations or requirements
10	**a**	**CULTURAL CONTROLS**
10	**b**	Strong safety culture not being re-inforced (nuclear / conventional)
10	**c**	Inadequate use of error-prevention tools and techniques
10	**d**	Management does not hold people accountable for their actions
10	**e**	Individuals do not take responsibility/accountability for their actions
10	**f**	Individuals do not demonstrate questioning attitude by challenging existing conditions
10	**g**	Alignment of station processes with world best practice
10	**h**	Poor housekeeping
10	**i**	Lack of ownership of safety and/or quality
10	**j**	Quality culture not embedded or visible
10	**k**	Safety and or quality issues being ignored in making business decisions
10	**l**	Lack of corporate oversight
10	**m**	Lack of inclusion of all role players
10	**n**	Lack of, or inadequate enforcement of rules
11	**a**	**ELECTRONIC INFORMATION (IM incl docs and records)**
11	**b**	Data control accountability lacking (including line groups w.r.t Information Management IM interface)
11	**c**	Software control anomalies
11	**d**	Classification of software or IM hardware anomalies
11	**e**	Data security and integrity is compromised due to : access control, revision control, or lack of verification anomalies
11	**f**	Archiving practices leading to poor retrievability of data
11	**g**	Poor Data quality
11	**h**	Database configuration issues
11	**i**	Information is not managed as a resource (GS-R-3 4.2)
12	**a**	**PROCESS IMPLEMENTATION (includes outage and projects)**
12	**b**	The planning stage of work management is not used as an opportunity to identify critical factors that may influence the performance of tasks

12	**c**	Risk assessment not performed or inadequately performed to identify all risks and hazards
12	**d**	Pre or post -job briefings inadequately performed
12	**e**	Supervisors do not provide adequate direction or support during planning, organising and co-ordinating of tasks
12	**f**	Safe and reliable work practices were not followed in performance of the task
12	**g**	Negative Plant Performance Impact
12	**l**	Classification of SSCs anomalies (find a better location? Or not - we mostly see anomalies at the implementation level)
12	**n**	Equipment Calibration anomalies or noncompliance
12	**o**	Quality Control anomalies or noncompliance
12	**p**	plant status control anomalies or noncompliance
12	**q**	Procurement / Contracts anomalies or noncompliance
12	**r**	In Service Inspection (ISI) anomalies or noncompliance
12	**s**	Project / Contractor implementation anomalies or noncompliance
12	**t**	Work environment anomalies or noncompliance (room temperature, humidity, etc)
12	**u**	Equipment malfunction leading to anomalies or noncompliance (air conditioner failure, etc)
12	**v**	Work package, Permits to work (PTW), Temporary Alteration (TA) anomalies or noncompliance

ANNEXURE C: Specific severity grading criteria

Source: KAA-832 (2009:25)

A **High** rating is typically assigned to those nonconformities where:

- Ø The auditee does not comply with legal or regulatory requirements
- Ø There are safety (OH&S) act contraventions and health of people and plant is at risk
- Ø There is a major equipment damage or defects and/or operational nonconformities relative to the subject being monitored that will have serious plant health and/or financial impact
- Ø There is an important contravention of an Eskom or Generation policy, standard, directive or Environmental, Safety or Quality programme
- Ø There is a repeat of a high or medium rated nonconformity from previous audits.

A **Medium** rating is assigned to those nonconformities where:

- Ø There is a risk of load loss and/or discontinuity of supply in the station
- Ø There is a risk of lack of reliability (i.e. through a lack of continuous monitoring)
- Ø There is a risk of a unit trip
- Ø There are defects or operational nonconformances relative to the audit subject that may have moderate impact on plant health and/or have financial impact
- Ø There is a repeat of a low rated nonconformance from previous audits.

A **Low** rating is assigned to those nonconformities where:

- Ø There are housekeeping issues (cleanliness, demarcation of work areas, administrative discipline, data capturing and records)
- Ø There are minor defects or defects of` operational nonconformances relative to the audit subject that may have minimal impact on plant health and/or financial impact in the short term

ANNEXURE D: KNPS events reported 2008 to 2011

Year	Month	Severity Code	No of Events
2008	Jan	P	36
2008	Jan	S	3
2008	Feb	P	33
2008	Feb	S	2
2008	Mar	P	24
2008	Mar	S	1
2008	Apr	P	16
2008	Apr	S	3
2008	May	P	13
2008	Jun	P	16
2008	Jul	P	19
2008	Jul	S	3
2008	Aug	P	11
2008	Sep	P	10
2008	Oct	P	27
2008	Oct	S	1
2008	Nov	P	26
2008	Nov	S	1
2008	Dec	P	14
2009	Jan	P	13
2009	Feb	P	15
2009	Mar	P	14
2009	Apr	P	19
2009	May	P	5
2009	May	S	1
2009	Jun	P	11
2009	Jul	P	9
2009	Aug	P	4
2009	Aug	S	1
2009	Sep	P	10
2009	Oct	P	7
2009	Nov	P	16
2009	Dec	P	16
2010	Jan	P	6
2010	Feb	P	10
2010	Mar	P	17
2010	Apr	P	8
2010	Apr	S	1
2010	May	P	5
2010	Jun	P	5
2010	Jul	P	11
2010	Aug	P	13
2010	Aug	S	1
2010	Sep	P	11
2010	Sep	S	1
2010	Oct	P	14
2010	Nov	P	13
2010	Nov	S	1

Year	Month	Severity Code	No of Events
2010	Dec	P	16
2010	Dec	S	1
2011	Jan	P	13
2011	Feb	P	14
2011	Mar	P	26
2011	Apr	P	22
2011	May	P	16
2011	May	S	3
2011	Jun	P	8
2011	Jun	S	1
2011	Jul	P	3
2011	Aug	P	7
2011	Aug	S	1
2011	Sep	P	7
2011	Sep	S	1
2011	Oct	P	6
2011	Oct	S	1
2011	Nov	P	10
2011	Dec	P	7
2012	Jan	P	10
2012	Feb	P	4
			694

ANNEXURE E: Validity of measurements

Figures 6.4 and 6.5 depict the 2 out of 3 alignment of raters to support the validity potential of the research.

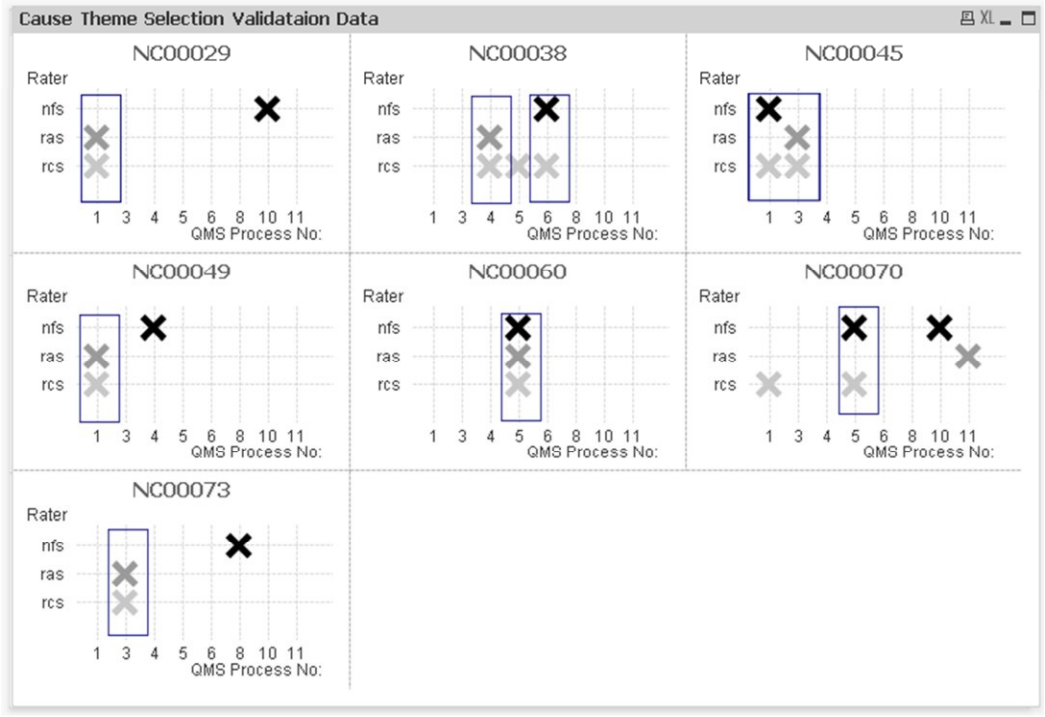


Figure 6.4: Cause Theme Validation Results (**Source**: Own)

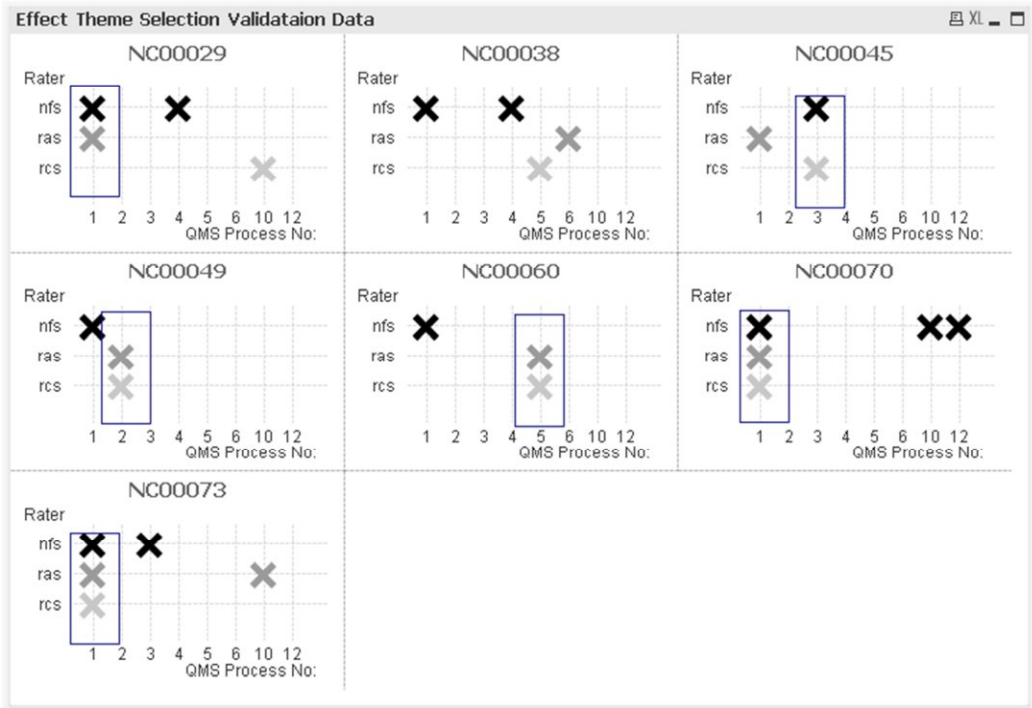
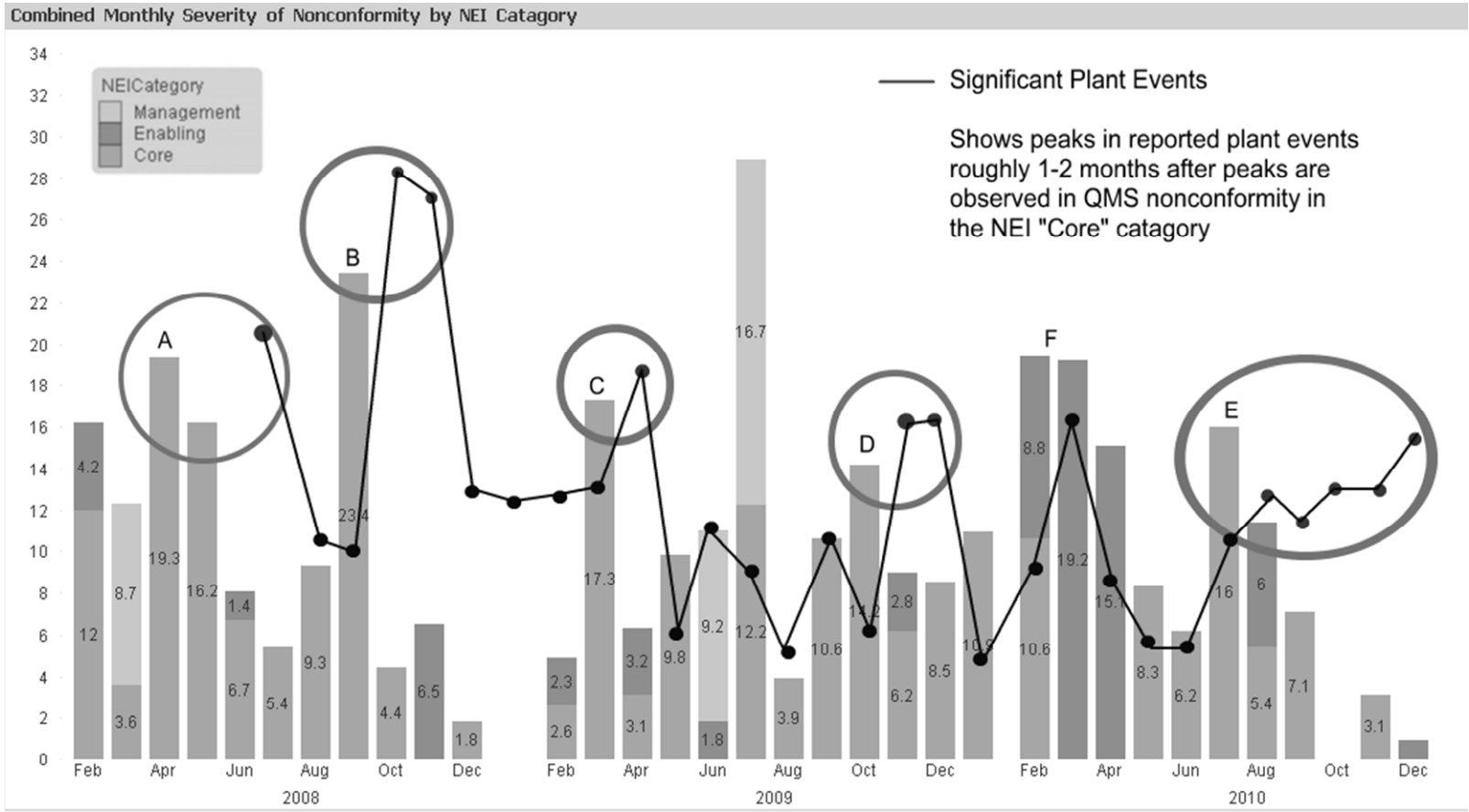


Figure 6.5: Effect Theme Validation Results (**Source**: Own)

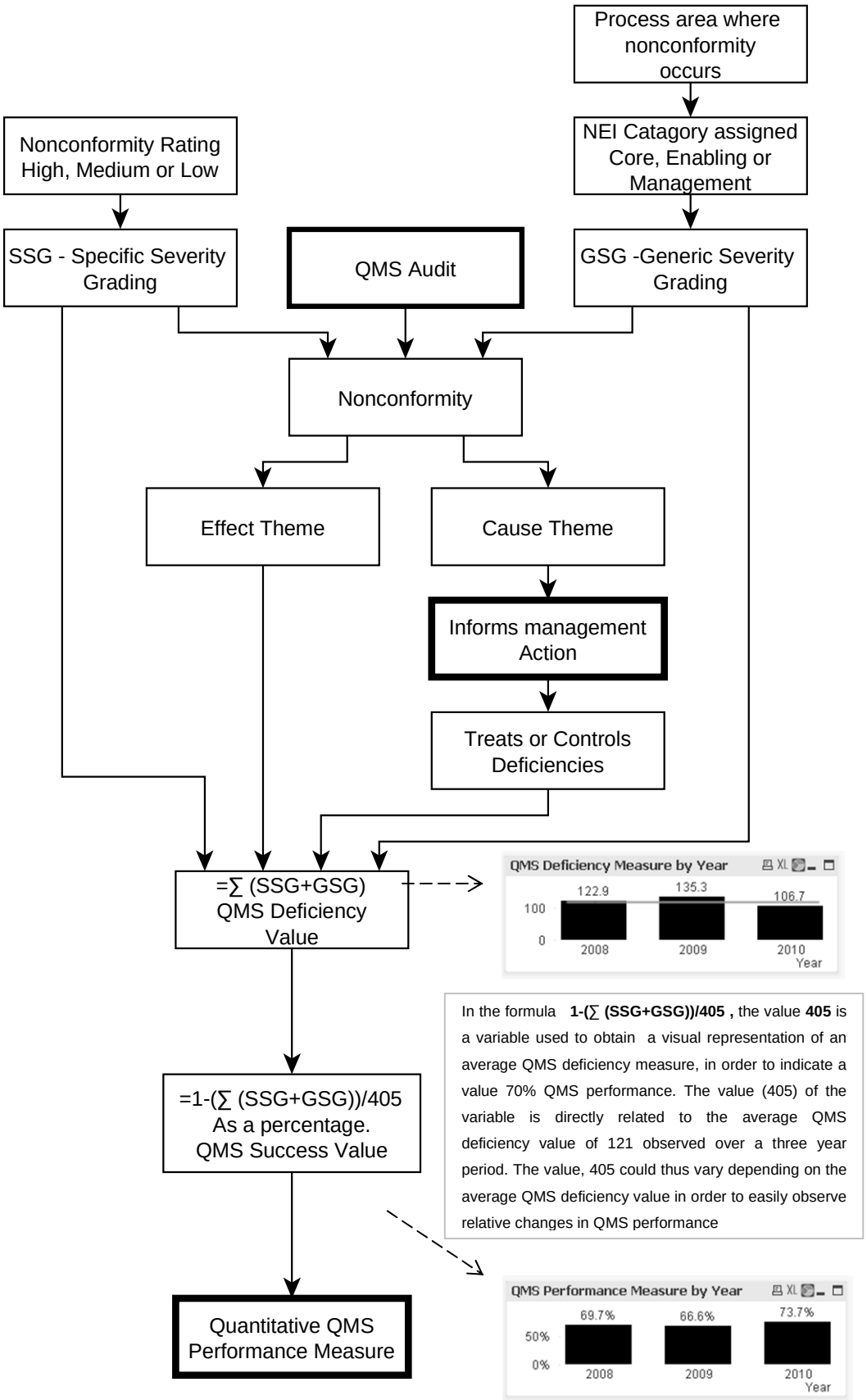
ANNEXURE F: Nonconformities vs. plant events relationship

(**Source**: Own)



ANNEXURE G: QMS performance measure methodology

(Source: Own**)**



ANNEXURE H: QMS measurement data processing scripts

(**Source**: Own)

Data Upload Script

```
Directory;
LOAD[QA Num],
[PR Num],
OrgArea,
[Project Name],
[Planned Start],
[Project Manager],
[Overall Score],
Status,
[No Non Conf],
[Report Status]
FROM
[Audits and Findings 2008-2010r.xls]
(biff, embeddedlabels, tableis [Reports Final Status QADB 21 Fe$]);

Directory;
LOAD[NC No],
       [PR Num],
Rating,
Statusasncstatus
FROM
[Audits and Findings 2008-2010r.xls]
(biff, embeddedlabels, tableis [NC's  Final Status QADB 21 Feb $]);



Directory;
LOAD//[PR Num],
[NC No],
NCdate,
Year (NCdate) asYear,
Month (NCdate) asMonth,
//Status as ncstatus,
//Rating,
[Non-conformity]
FROM
[Quantifying QMS Heath Questionaire rev1a.xlsx]
(ooxml, embeddedlabels, tableis [Full List 2008_2010]);

Directory;
LOADRating,
RatVal
FROM
[Audits and Findings 2008-2010r.xls]
(biff, embeddedlabels, tableisRatingVal$);
```

QMS Themes Metadata Script

```
Directory;
LOADProcessArea,
Theme,
Pnum,
ThemeDescr,
[36-188],
ISO,
[GS-R-3],
[NQA-1],
```

```
IBI,
NEI
FROM
[Questionaire Themes rev 1.xlsx]
(ooxml, embeddedlabels, tableisQMSThemes);

Directory;
LOADPAWeight,
//NEICategory will cause a conflict
//NEICategory,
ProcessArea
FROM
[QMS Process Areas.xlsx]
(ooxml, embeddedlabels, tableis Sheet1);
```

QMS Themes Metadata Script

```
Directory;

//lookup table to link process area to process number

MAP_QMS:
MappingLOAD * Inline[
Map_ID,Map_Value
1,PROCESS MANAGEMENT
2,DOCUMENTATION CONTROL
3,RECORD CONTROL
4,MANAGEMENT RESPONSIBILITY
5,TRAINING AND COMPETENCY
6,ORGANISATIONAL CONTROL
7,MONITORING AND CORRECTIVE ACTION
8,CONFIGURATION MANAGEMENT
9,INTERFACE MANAGEMENT
10,CULTURAL CONTROLS
11,ELECTRONIC INFORMATION
12,PROCESS IMPLEMENTATION
];

MAP_QMS_W:
MappingLOAD * Inline[
Map_ID,Map_Value
PROCESS MANAGEMENT,1
DOCUMENTATION CONTROL,0.3
RECORD CONTROL,0.3
MANAGEMENT RESPONSIBILITY,0.3
TRAINING AND COMPETENCY,0.6
ORGANISATIONAL CONTROL,0.3
MONITORING AND CORRECTIVE ACTION,0.3
CONFIGURATION MANAGEMENT,1
INTERFACE MANAGEMENT,0.3
CULTURAL CONTROLS,0.3
ELECTRONIC INFORMATION,0.3
PROCESS IMPLEMENTATION,1
];

//lookup table to link QMS tag to to QMS tag description

MAP_Theme:
MappingLOAD * Inline[
Map_ID,Map_Value
1a,PROCESS MANAGEMENT
1b,Process has not been adequately defined or documented
1c,The sequence Interactions between various processes have not been
adequately determined or documented (GS-R-3 5.2)
```

1d,Process not effective (required process outputs not consistently achieved)
1e,Process not fully implemented
1f,Process documentation not consistent with existing implementation documents (GS-R-3)
1g,Monitoring and reporting on the performance of the process is not performed(GS-R-3)
1h,Process is not carried out under controlled conditions, eg using approved current procedures, instructions, drawings or other appropriate means(GS-R-3)
1i,Processes contracted to external organizations (outsourced process) are not identified within the management system. (GS-R-3)
1j,The organization did not retain overall responsibility when contracting any processes(GS-R-3)
1k,Process outputs (products) were not clearly identified. (GS-R-3 5.4)
1l,Process measurement criteria were not established(GS-R-3 5.4)
2a,DOCUMENTATION CONTROL (Procedures, drawings, etc)
2b,Documentation has not been controlled (reviewed / approved / authorised) as required
2c,Documentation change control process has not been implemented
2d,Documented procedures do not reflect current practice
2e,KSA-011 / KAA-500 Non-Compliance
2f,No procedure or written guidance
2g,It has not been ensured that document users are aware of and use appropriate and correct documents (GS-R-3)
3a,RECORD CONTROL
3b,Records have not been properly identified, authenticated or classified
3c,Non complainant storage conditions of records
3d,Records are not easily retrievable (GS-R-3)
3e,Records have not been transmitted as per QRL
3f,Records identified in documentation/procedure are not captured in the QRL (or visa versa)
3g,Records are incomplete(GS-R-3)
3h,Records required to demonstrate that the process results have been achieved are NOT specified in the process documentation (GS-R-3)
3i,The media used for the record has not been such to ensure that the records are readable for the duration of the retention times specified for each record(GS-R-3)
3j,Records are not traceable to associated items and activities
4a,MANAGEMENT RESPONSIBILITY
4b,Planning by managers ineffective (resource needs such as capital, equipment and information not properly identified)
4c,Management direction not effectively communicated (such as goals, priorities, expectations and initiatives)
4d,Management oversight tools not effectively used (such as benchmarking, independent reviews, monitoring of corrective actions, self assessment)
4e,Inadequate Eskom supervision and intervention of turnkey and other projects
4f,Excessive project slippage
4g,Management did not ensure that measurable objectives for implementing the goals, strategies and plans are established (Business planning) (GS-R-3)
4h,Management did not ensure that the implementation of the plans is regularly reviewed against their objectives and that actions are taken to address deviations from the plans where necessary (GS-R-3)
4i,An individual reporting directly to senior management has not been appointed with specific responsibility and authority for the coordination, reporting and resolving conflicting requirements of the QMS(GS-R-3)
4j,Management review not implemented.
5a,TRAINING AND COMPETENCY
5b,Staff not suitably qualified or certified to perform tasks
5c,Required authorisations not in place; authorisation invalid
5d,Required initial or ongoing training not scheduled or attended
5e,Accreditation process not followed
5f,Experience levels negatively impacting on performance
5g,Training program not in place or fully complied with
5h,An evaluation of the effectiveness of the training actions taken were

not conducted. (GS-R-3 4.3)
5i,Senior Management did not ensure that individuals are competent to perform their assigned work(GS-R-3 4.4)
5j,Individuals do not know the importance and/or understand the consequences of their activities and how their activities contribute to safety in the achievement of the Org objectives. (GS-R-3 4.4)
6a,ORGANISATIONAL CONTROL
6b,FOS not in place or available for review
6c,FOS's (Functional Organisational Structures) and Organograms not clearly defined or documented
6d,Job profiles and descriptions have not been authorised
6e,Interfaces between different organisations have not been clearly defined or documented
6f,Roles, responsibilities and accountabilities of key individuals and groups are not clearly stated or communicated
6g,Performance management not implemented as required
6h,Organisational change management not implemented as required
6i,Performance criteria are not established and / or used.
6j,Increased use of contractors to perform key organizational activities for long periods of time.
7a,MONITORING AND CORRECTIVE ACTION
7b,Corrective Actions have not been effectively implemented or adequate to prevent recurrence.
7c,Operational Experience not effectively used to prevent problems
7d,Inadequate root cause analysis
7e,CA/Findings not addressed in a timely manner
7f,Failure to deal with the findings of independent external safety reviews
7g,Lack of independent review
7h,Completions of CA's were not verified.
8a,CONFIGURATION MANAGEMENT
8b,Lack of configuration control (related to e.g. design, documents, materials, maintenance, operating (excl plant status))
8c,Lack of configuration negatively impacting on plant status control
8d,Inadequate consideration of configuration management in processes /procedures and practices
8e,Changes that affect configuration were not recognised and or processed.(NQA-1 requirement 3, 601.1)
8f,Measures to ensure changes are recognised and or processed were not included in the configuration management requirements. (NQA-1 requirement 3, 601.1)
8g,Configuration not maintained for the life a the plant. (NQA-1 requirement 3, 601.2)
8h,Measures were not established and or implemented to ensure that proposed changes to the configuration are evaluated. (NQA-1 requirement 3, 601.6)
9a,INTERFACE MANAGEMENT
9b,Interfaces not adequately managed (complex)
9c,Communication anomalies affecting interfaces between entities
9d,Interface not adequately defined / documented
9e,Internal customer's needs not fully considered
9f,No measurement of internal and or external customer expectations or requirements
10a,CULTURAL CONTROLS
10b,Strong safety culture not being re-inforced (nuclear / conventional)
10c,Inadequate use of error-prevention tools and techniques
10d,Management does not hold people accountable for their actions
10e,Individuals do not take responsibility/accountability for their actions
10f,Individuals do not demonstrate questioning attitude by challenging existing conditions
10g,Alignment of station processes with world best practice
10h,Poor housekeeping
10i,Lack of ownership of safety and/or quality
10j,Quality culture (complex)
10k,Safety and or quality issues being ignored in making business decisions
10l,Lack of corporate oversight

```
10m,Lack of inclusion of all role players
10n,Lack of or inadequate enforcement of rules
11a,ELECTRONIC INFORMATION (IM incl docs and records)
11b,Data control accountability issues (incl line vs. IM interface)
11c,Software control anomalies
11d,Classification of software or hardware anomalies
11e,Data security and integrity is compromised due to :  access control,
revision control, or lack of verification anomalies
11f,Archiving practices leading to poor retrievability of data
11g,Poor Data quality
11h,Database configuration issues
11i,Information is not managed as a resource (GS-R-3 4.2)
12a,PROCESS IMPLEMENTATION (includes outage and projects)
12b,The planning stage of work management is not used as an opportunity
to identify critical factors that may influence the performance of tasks
12c,Risk assessment not performed or inadequately performed to identify
all risks and hazards
12d,Pre or post -job briefings inadequately performed
12e,Supervisors do not provide adequate direction or support during
planning, organising and co-ordinating of tasks
12f,Safe and reliable work practices were not followed in performance of
the task
12g,Negative Plant Performance Impact
12l,Classification of SSCs anomalies (find a better location? Or not  -
we mostly see anomalies at the implementation level)
12n,Equipment Calibration anomalies or NC
12o,Quality Control anomalies or NC
12p,plant status control (duplicate in configuration)
12q,Procurement / Contracts anomalies or NC
12r,ISI anomalies or NC
12s,Project / Contractor implementation anomalies or NC
12t,Work environment anomalies or NC (room temperature, humidity, etc)
12u,Equipment malfunction leading to anomalies or NC( air conditioner
failure, etc)
];



LOAD[NC No],
[Effect Theme],
//    SubField ([Effect Theme], ',',) as [Effect Themes],
//     ApplyMap ('MAP_Theme',[Effect Theme])as Effect_Theme_Descr,

//    MAY still be used if new data is added!!!!!!!!!!

[Cause Theme]
//    SubField ([Cause Theme], ',',) as [Cause Themes],
//    ApplyMap ('MAP_Theme',[Cause Theme])as Cause_Theme_Descr

//    MAY still be used if new data is added!!!!!!!!!!

FROM
[Quantifying QMS Heath Questionaire rev1a.xlsx]
(ooxml, embeddedlabels, tableis [Full List 2008_2010]);



Directory;
LOAD[NC No],
CauseSep,
//KeepChar ([CauseSep],'1234567890')as ProcessNumC,    (included line in
formula below)

//access and aply lookup table for themes above top
ApplyMap ('MAP_Theme',CauseSep)asCause_Theme_Descr,
```

```
//access and aply lookup table for themes above top
ApplyMap ('MAP_QMS',(KeepChar ([CauseSep],'1234567890')))asProcessDescrC

FROM
EffectCauseSep.xlsx
(ooxml, embeddedlabels, tableisCauseSep);

Directory;
LOAD[NC No],
EffectSep,
//KeepChar ([EffectSep],'1234567890')as ProcessNumE,    (included line in
formula below)

//access and aply lookup table for themes above top
ApplyMap ('MAP_Theme',EffectSep)asEffect_Theme_Descr,

//access and aply lookup table for themes above top
ApplyMap ('MAP_QMS',(KeepChar ([EffectSep],'1234567890')))asProcessDescrE
//ApplyMap ('MAP_QMS_W',(ProcessDescrE)) as QMSWeight
FROM
EffectCauseSep.xlsx
(ooxml, embeddedlabels, tableisEffectSep);

Directory;
LOADQMSttc,
QMSttcVal
FROM
QMSProcWeight.xlsx
(ooxml, embeddedlabels, tableis Sheet2);
```

```
//start here
//LOAD [NC No],
//     [Effect Theme],
//     SubField ([Effect Theme], ',',) as [Effect Themes],
//KeepChar ([Effect Themes],'1234567890')as procesNoE,
//     [Cause Theme],
//     SubField ([Cause Theme], ',',) as [Cause Themes]
//KeepChar ([Effect Themes],'1234567890')as procesNoC
//FROM
//[Quantifying QMS Heath Questionaire rev1a.xlsx]
//(ooxml, embedded labels, table is [Full List 2008_2010]);
```

NEI Severity Metadata Script

```
Directory;
LOADOrgArea,
NEILinkasNEICategory,
SfetyWeight,
QMSWght
FROM
[NEI Process Areas.xlsx]
(ooxml, embeddedlabels, tableisOrgNEILink);

Directory;
LOADNEICategory,
NEIProcess,
// NEIWeight,
NEICode,
NEICodeTitle,
```

```
NEICodeDetail
FROM
[NEI Process Areas.xlsx]
(ooxml, embeddedlabels, tableisNEIDetail);
```

Events Data Upload Script

```
Directory;
LOADEvent,
EventEdate,
Year (EventEdate) asYearES,
Month (EventEdate) asMonthES,

//EventSeverity,
Eseverity
FROM
[Events vs CA status.xlsx]
(ooxml, embeddedlabels, tableis Events);

Directory;
LOADCA,
Castatus,
CAEdate,
CADdate,
CAComplDate
FROM
[Events vs CA status.xlsx]
(ooxml, embeddedlabels, tableis [QA CA Status]);

//Directory;
//LOAD CA,
//     [PR Num],
//    CADescr

//FROM
//[Events vs CA status.xlsx]
//(ooxml, embedded labels, table is Sheet3);
```