UNIVERSITY OF SUNDERLAND

THE ROLE OF ISO 55000 IN ENSURING EFFICIENT ASSET MANAGEMENT IN SMALL AND MEDIUM-SIZED ENTERPRISE (SMEs)

IBIFURO C. IHEMEGBULEM

Computer Engineering BTech (Nigeria), Computer and Network Engineering MSc (UK), Engineering Management MSc (UK).

A Thesis Submitted in Partial Fulfilment of the Requirements of the University of Sunderland for the Degree of Doctor of Philosophy

October 2024

ABSTRACT

The fast rate of change in today's business world has resulted in companies facing a vast array of challenges which threaten their survival; the strategic objective of continuous survival and meeting stakeholders' needs in light of assets at their disposal. Though SMEs are usually faced with financial and non-financial difficulties but managing engineering assets optimally are crucial for organizations to stay competitive in today's global market. Asset Management is used to find how organisation handle the management of its engineering asset throughout the life cycle to achieve a strategy; Engineering asset have financial worth which mirrors economic value; the management of this value is significant to the organisation. Asset management has progressed from being a maintenance dominated field towards a more strategic, holistic, and standardized direction. Establishing an effective AM can increase an organization's repute and productivity, prevent asset failures, enhance facilities and investment decisions, and also meet regulatory responsibilities.

In the context of these challenges, this doctoral research explores the role of ISO55000 in ensuring efficient asset management in small and medium sized enterprise. The literature and prior studies was based on Asset management, maintenance strategy and SME competitiveness reveal a positive correlation between 'efficient asset management strategy' and 'SME survival'. There are however, concerns about the appropriate strategies and extent to which successful SMEs can accrue the benefits from adopting an efficient framework like ISO55000 in their asset management processes. These concerns led to the thesis overarching aim of *promoting the adoption of an ISO55000-based framework, which better reflects the challenges faced by SMEs.* The study revealed contextual understanding of research, ontological and epistemological philosophy as basic theory building. The study adopts quantitative research strategy and a deductive approach with questionnaire as research method. Data were collected from 8 different SMEs with target of 25 responses from staff members per SME in order to achieve a target of 200 questionnaire responses. 128 online questionnaires we duly completed and collated using the google survey form. The data were further analysed using Factor analysis, Hypothesis testing, chi-square test and multiple regression on IBM Statistical Package for the Social Sciences (SPSS). The results reveals four factor solutions: the Development of comprehensive Asset Management Strategy[F1], organisational needs and ISO55000 compliant structure [F2], risk management, monitoring and control strategy [F3] and Operational issues and evaluation [F4], for the ease of adoption of ISO55000 in SMEs Asset Management (RO1-RO4). The relationship between these factors was tested through two hypotheses, which reveal that

the efficiency of assets will improve with the adoption of ISO55000 ($H_{0.1}$) and that the implementation of ISO 55000 contributes to effective management of SMEs ($H_{0.2}$). These quantitative results led to the development of a four stepped-ISO55000 driven holistic framework, which show the needs for SMEs to: (1) input *Defined stages in organisational maintenance strategy, plans for addressing organisational constraints and Asset management configurations* into the Asset maintenance process, which transforms into a comprehensive Asset management strategy. (2) Input *Defined company's success measures, Implement Plans for Addressing Company's ISO 55000 needs and compliant structure, and Increased ISO awareness campaign* into the Asset maintenance process which transforms into the ability to meet organisational needs and ISO55000 compliant structure. (3) *Use KPIs in maintenance, Implement Accessible Asset Management policies, Centralised Asset Management, Implement Plan for Risk management* and *increase belief in the maintenance strategy and the existing maintenance plan* within their Asset maintenance process, which transforms into an Improved Risk management, monitoring and control strategy. (4) Input *Defined performance evaluation and Plans for Addressing SME Problem, lack of ISO certification* into the Asset maintenance process, which transforms into an ability to Resolve Operational Issues and improve performance evaluation problem. The Combination of these four steps will result in *Ease of Adoption of ISO55000 ($H_{0.1}$) and Creation of ISO Compliant structure for Effective SMEs Asset Management ($H_{0.2}$).*

This study makes contribution to knowledge by providing greater insights into understanding Asset Management, ISO55000 and ways of leveraging on the strengths and weaknesses faced by SMEs in this highly competitive business environment. The developed framework will help increase SMEs resilience and responsiveness. Validation of the holistic framework was limited due to study time; hence, areas for further research would include testing the proposed framework by involving a wider range of participants.

ACKNOWLEDGEMENT

My deepest gratitude and sincere thanks to Almighty God whose grace, guidance and favour is responsible for all my life's achievements; especially for letting me live to see this thesis completed. This thesis could never be finished without the support and assistance of my supervisory team: I wish to express my sincere appreciation to my director of studies Prof David Baglee for enthusiastic supervision and reassuring guidance throughout the entire period of this research work. His constructive comments, unyielding support and patience are highly appreciated; I am forever grateful Sir.

My appreciation goes to Barrister Golden Chioma who have always supported me and whose examples have taught me to work hard for the things that I aspire to achieve. I would like to thank my family for their warmth love, support and prayers during my academic journey. I must mention my friend Doctor Abbi for helping in the data collection and other participants that contributed in data collection, for their time and interests in this subject. I highly appreciate the moral support from my Research colleagues and the Graduate Research School (GRS) team at University of Sunderland. To all the others who have been part of my research project and academic journey I appreciate you all. Many thanks to everyone.

DEDICATION

This thesis is dedicated to Almighty God my pillar, source of inspiration, wisdom and strength throughout this program and on His wings only have I soared. I dedicated my thesis to Barrister Golden Chioma, for his kindness, commitment and endless support; his selflessness will always be remembered.

Table of Contents

ABSTRACT ..... **I**

ACKNOWLEDGEMENT ..... **III**

DEDICATION ..... **IV**

LIST OF FIGURES ..... **VIII**

LIST OF TABLES ..... **IX**

LIST OF ABBREVATIONS ..... **X**

CHAPTER ONE **1**

INTRODUCTION **1**

1.1 INTRODUCTION 1

1.2 THE CRITICAL IMPORTANCE OF SMES IN TODAY'S ECONOMY 3

1.3 BACKGROUND OF ASSET MANAGEMENT AND ISO55000 4

1.3.1 Assets and Asset Management *4*

1.3.2 Introduction of ISO 55000 Standards *5*

1.4 MOTIVATION FOR THIS STUDY 6

1.5 RESEARCH QUESTIONS, HYPOTHESES, PURPOSE AND CONTRIBUTION TO KNOWLEDGE. 6

1.5.1 Research Question(s) *6*

1.5.2 Research Hypotheses *7*

1.5.3 Purpose and Aim of study. *7*

1.5.4 Delimitation of Study *7*

1.5.5 Originality *7*

1.6 STRUCTURE OF THESIS: RESEARCH OUTLINE 8

1.7 SUMMARY OF CHAPTER 9

CHAPTER TWO **10**

LITERATURE REVIEW **10**

2.1. INTRODUCTION TO CHAPTER 10

2.2 SMES: ITS DEFINITION, IMPORTANCE, ACTIVITIES AND RELEVANCE IN TODAY'S WORLD 11

2.2.1 Globalization of SMEs *12*

2.2.2 Importance of innovations in SMEs *14*

2.2.3 Business Success or Failure Factors in SMEs *15*

2.2.4 Background: Improvement activities on the part of SMEs *16*

2.2.5 Top management Involvement in Innovation *17*

2.3 ASSET MANAGEMENT AS A DRIVER FOR SME SURVIVAL: EVOLUTION, MEASUREMENT AND IMPLEMENTATION. 17

2.3.1 The Concept of Assets, Asset Classification and Asset Life Cycle *18*

2.3.1.1 Asset Life Cycle *19*

2.3.1.2 Asset Database *21*

2.3.1.3 Asset Information Management *22*

2.3.2 Background of Asset Management: definition, scope and importance *22*

2.3.2.1 Asset Management Requirements *25*

2.3.2.2 Framework for Asset Management *25*

2.3.2.3 Implementation of Asset Management Principles *26*

2.3.2.4 Asset Management Maturity *27*
2.3.3. Asset Maintenance *28*
2.3.5 Maintenance of assets: Organizational Responsibilities *30*
2.3.5.1 Organizational Responsibilities: Performance management Monitoring Asset performance: *31*
2.3.5.2 Organizational Responsibilities: Risk assessment and management *32*
2.3.5.3 Organizational Responsibilities and Asset Maintenance Strategies *33*
2.3.6 Asset Management and SMEs *36*
2.4. INTERNATIONAL ORGANIZATION OF STANDARDIZATION (ISO): A SOLUTION FOR SME ASSET MANAGEMENT 38
2.4.1 Pre-ISO Standards: EAM and PAS 55 ..... *38*
2.4.2 Introduction of ISO 55000 Standards *40*
2.4.2.1 Introduction of ISO 55000 Standards: Content *43*
2.4.2.2 Introduction of ISO 55000 Standards: Scope *43*
2.4.3 ISO5500 and Asset Management Policy *45*
2.4.3.1 ISO5500 and Asset Management Policy: Decision making criteria *48*
2.4.3.2 ISO5500 and Asset Management Policy: Risk Management *49*
2.4.4 Alignment of ISO 55000 with other standards: its differences and similarities *50*
2.4.5. Implementation of ISO 55000: Benefits and Hindrance *52*
2.4.5.2. Benefits of the implementation of ISO 55000 ..... *53*
2.4.5.3 Factors that will affect Implementation of ISO 55000 ..... *54*
2.5. IMPACT OF INTERRUPTIONS ON ASSET 55
2.6. HYPOTHESES DEVELOPMENT FROM KEY RESEARCH GAPS IN PRIOR STUDIES - LINKING ISO55000 ADOPTION TO IMPROVED SMES ASSET MANAGEMENT 56
2.7. SUMMARY OF CHAPTER 57

CHAPTER THREE 59

RESEARCH METHODOLOGY 59
3.1 INTRODUCTION 59
3.2 RESEARCH METHODOLOGY: PHILOSOPHICAL JUSTIFICATION FOR CHOICE OF RESEARCH DESIGN AND METHODS FOR THE STUDY 60
3.3 RESEARCH STRATEGY: TECHNIQUES FOR COLLECTING PRIMARY DATA 63
3.3.1 Quantitative research Questionnaire Design - Quantitative Data in this study *66*
3.3.2 Identification, recruitment and sampling of participants - questionnaires *68*
3.4 PROCEDURES FOR QUANTITATIVE DATA ANALYSIS TO ACHIEVE RESEARCH OBJECTIVES 69
3.5 ADDRESSING ETHICAL AND OTHER METHODOLOGICAL ISSUES 70
3.5.1. Addressing ethical issues in this study *70*
3.5.2 Major Limitations of the choice of Methodology for the study *72*
3.5.3 Piloting of Questionnaires schedules to inform main study *72*
3.6 SUMMARY OF CHAPTER 73

CHAPTER FOUR 75

DATA ANALYSIS 75
4.1 INTRODUCTION 75
4.2. PRESENTATION OF THE RESULTS: 75
4.2.1. Presentation of the results from the statistical analysis of the questionnaire survey *75*
4.2.2. Development of questionnaire measures and scales: Exploratory Questionnaires Survey of Customers data preparation for analysis. *76*

4.2.3 Factor Analysis: Exploratory Questionnaires 76
4.2.3.1 Factor Analysis Steps..... 77
4.2.3.2 Factor 78
4.2.1.3 Hypothesis Testing 85
4.2.1.4 Presentation of Chi-square test of quantitative data 90

CHAPTER FIVE 95

DISCUSSION OF FINDINGS 95
5.1 INTRODUCTION..... 95
5.2.1 Factor solution 1: Implementation of ISO55000 in SMEs through the Development of comprehensive Asset Management Strategy. 96
5.2.2. Factor 2 Developing comprehensive Asset Management Strategy to address Organisational constraints in terms of long-term training and vision[i19] 100
5.2.1 Factor solution 2: Implementation of ISO55000 in SMEs by addressing organisational needs and ISO55000 compliant structure has five (5) loaded items..... 108
5.2.3 Factor 3: Implementation of ISO55000 in SMEs through risk management, monitoring and control strategy has loaded items; Maintenance philosophy[i6], plan[i7] and use of KPI[i9] etc..... 116
5.2.4 Factor 4: Implementation of ISO55000 in SMEs by addressing Operational issues and evaluation has loaded items; 118
5.3 ADDITIONAL INSIGHTS FROM SUBSEQUENT CHI-SQUARE ANALYSIS OF QUESTIONNAIRE 121
5.4 SUMMARY OF CHAPTER 125

CHAPTER SIX 127

CONCLUSIONS AND RECOMMENDATIONS 127
6.1 INTRODUCTION..... 127
6.2. A holistic framework: Comprehensive Asset Management Strategy, organisational needs and ISO55000 compliant structure, risk management, monitoring and control strategy and Operational issues and evaluation. *..... 127*
6.3 Implications of the developed holistic framework - the significance of findings in the context of the contributions to knowledge. *..... 131*
6.4. Extent of validation of the holistic framework: Inability to see the proposed model implemented and results monitored throughout the limited study time. 132
6.5. Contributions to knowledge..... 133
6.5.1 Specific contributions to knowledge 133
6.6. Conclusion 134
6.6. Recommendation for future research at the post-doctoral level..... 134

PUBLICATIONS 136
My PhD Research Journey: The Intrigues, Rigour and Sense of Fulfilment..... 137

REFERENCE LIST 140

APPENDICES 154
PARTICIPANTS INFORMATION SHEET AND CONSENT FORM FOR THE QUESTIONNAIRE 162

LIST OF FIGURES

Figure 2.1: The asset life cycle phases and examples of variations……20
Figure 2.2: History of Asset Management……..25
Figure 2.3: Types of Assets as defined by PAS 55…….40
Figure 2.4: Relationships between key terms…….42
Figure 2.5: Asset management system……...45
Figure 3.1: A 5 step Procedure for Quantitative data analysis……...71
Figure 4.1: Scree plot for component extraction criterion……..83
Figure 5.1: Mix maintenance strategies……..98
Figure 5.2: How maintenance is triggered……100
Figure 5.3: Objectives of Asset management……...103
Figure 5.4: Support for Asset management objectives……104
Figure 5.5: Improvement of Asset management activities……...106
Figure 5.6: Barriers for Implementing Asset Management……..107
Figure 5.7: Organizational internal audits……108
Figure 5.8: Factor solution 1 models……109
Figure 5.9: Challenges faced in maintenance……...110
Figure 5.10: Factors contributing to organizational success……...112
Figure 5.11: ISO 55000 elements needed……...114
Figure 5.12: Factor solution 2 models……117
Figure 5.13: Factor solution 3 models……119
Figure 5.14: Problems faced by SMEs……...120
Figure 5.15: Asset management Evaluation……...121
Figure 5.16: Factor solution 4 models……122
Figure 6.1: Holistic Framework for ISO 55000 adoption in SMEs……..130

LIST OF TABLES

Table 2.1: Benefits of ISO 55000 Implementation…….55

Table 3.1: Preselected theme used in questionnaire design……69

Table 3.2: How specific ethical Issues were addressed in this study……..73

Table 3.3: Sample distribution by Industry……74

Table 4.1: Communalities……...80

Table 4.2: Factors loading for the rotated factors……...82

Table 4.3: Component Transformation Matrix……...83

Table 4.4: Total Variance Explained by Extracted factors…….84

Table 4.5: KMO and Bartlett's test of the Suitability of the data for factor analysis…….85

Table 4.6: Multiple regression, model summary, ANOVA and coefficients HO_1 …… 87

Table 4.7: Analysis of Variance (ANOVA)……87

Table 4.8: Coefficient result…….....88

Table 4.9: Multiple regression, model summary, ANOVA and coefficients HO_2 ……89

Table 4.10: Analysis of Variance (ANOVA)……...90

Table 4.11: Coefficient result……...90

Table 4.12: Chi-Square test…….91/92

Table 5.1: Chi-Square crosstab analysis of frequencies of participants for company size in terms of employee size that adopted ISO 55000……123

Table 5.2: Summary of level of significance from the Chi-Square test…….....123

Table 5.3: Chi-Square Crosstab analysis of frequencies of participants for companies that adopted ISO 55000……123

Table 5.4: Summary of level of significance from the Chi-Square test…….....124

Table 5.5: Chi-Square Crosstab analysis of frequencies of participants……124

Table 5.6: Summary of level of significance from the Chi-Square test…….....125

Table 5.7: Chi-Square Crosstab analysis……125

Table 5.8: Summary of level of significance from the Chi-Square test…….....126

Table 6.1: Publications……...137

LIST OF ABBREVATIONS

AIMS	Asset Information Management System
AM	Asset Management
AMS	Asset Management System
BSI	British Standards Institution
CBM	Conditioned Based Maintenance
CM	Corrective Maintenance
CMMS	Computerized Maintenance Management System
EAM	Engineering Asset Management
ERP	Enterprise Resource Planning
IAM	Institute of Asset Management
ISO	International Organization of Standardization
KPIs	Key Performance Indicators
MTBF	Mean Time between Failures
OECD	Organization for Economic Co-operation and Development
PAS	Publicly Available Specification
PM	Preventive Maintenance
PM	Productive Maintenance
RCM	Reliability Centered Maintenance
ROI	Return on Investment
ROFA	Return on Fixed Assets
SAMP	Strategic Asset Management Plan
SMEs	Small and Medium-Sized Enterprise
SSIsi	Small-Scale Industries
TBM	Time-Based maintenance
TPM	Total Productive Maintenance

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Market volatility is a challenge to businesses as they encounter series of issues; surviving and meeting stakeholders' needs becomes essential. Increase in client's demands and expectations with the present financial challenge meant that organizations must re-think how to plan and design, operate and maintain vast assets, which is the most important component of improving business performance. Global market dynamics require continuous improvement and managing assets optimally, which is essential for organisations to remain competitively relevant.

Asset managers and regulators act quickly and aggressively to maintain operations and protect stakeholders' investment to ensure business stability. Breakdown acted as a catalyst for creativity and innovation as businesses adopt a pre-emptive strategy to working asset, effectively overcoming the numerous challenges. While anticipating unpredictable changes, businesses are to protect valuable assets and optimise asset management processes. Asset management is a combination of processes and policies, which organisation uses to maximize its investment; these assets enable organisations to meet their objectives and the finest way to manage these assets to maximize value.

Engineering Asset Management (EAM) is a comprehensive approach to overseeing engineering assets, which include equipment, plants, inventories etc. EAM comprises a wide range of disciplines, focusing on both operational and strategic considerations while incorporating aspects of management, economics, and information technology (Brunette, 2014). The primary objective of EAM is to manage the entire life cycle of engineering physical assets to achieve the business objectives, especially for businesses with extensive investments in plant equipment or infrastructure. EAM optimizes the technical concerns of asset reliability, maintenance, safety and asset performance with the necessary financial and managerial skills; it significantly impacts the competitive capability of business and its productivity and sustainability. The fundamental objective of EAM is to certify the productive utilization of assets, thereby contributing value to the overall economy. According to Amadi-Echendu et al. (2010), EAM relies on information systems to capture data that are crucial for informed decision-making and its effective implementation is critical for all stakeholders involved. Most literature on EAM tends to emphasis on two main features: Technology and communication tools are essential for managing asset-related data effectively, and decision-making techniques involved in optimizing the management of engineering assets. Asset management (AM) require

a more efficient and effective strategy through long-term planning, guaranteeing that standards are defined and achievable for accessible resources. It promotes business decisions and delivers long-term business benefits, creating awareness of the impact of assets to economic growth. Organizations should understand the asset they own, describe how it performs and establish the finance required to meet the obligations placed upon it. This raises the strategic question of not only how these assets should be managed but also when they should be managed in order to optimise gains from them. These inspired the development of Asset management field and different rules, theories and guides on how this strategic question can be best answered.

Asset management activities are governed by Standards; ISO 55000 is an asset management standard that manages assets by looking into concepts, design, build, commission, operations and end of life-disposal phases. The International standard for asset management includes three documents ISO 55000 – Overview, principles and terminology, ISO 55001 – Management System Requirements and ISO 55002 – Management systems – Guidelines for the application of ISO 55001. The standard is designed for facilitating effective and efficient management of assets and for organisations to acquire value from its assets. ISO 55000 offers a structured approach to Asset Management (AM) that require organizations to be transparent and accountable, from top management to shop floor staff; the whole organization should be accountable for asset care, not only maintenance reliability staffs.

The purpose of this research is to determine the Role of ISO 55000 in ensuring efficient Asset Management in Small and Medium-Sized Enterprise (SMEs). The issue of Ensuring Efficient Asset Management in Small and Medium-Sized Enterprise today with the high rate of SME collapse and failures has become topical to government, industry, stakeholders and regulators. It further raises the critical issue of the strategic role ISO 55000 could play in improving asset integrity and performance which in turn will improve the survival rates and profitability of the Small and Medium-Sized Enterprise (SMEs). Although some prior studies have suggested that assets should be managed throughout its lifecycles beginning from project idea, purchase, finance, human resource, investment, maintenance, operation, disposal, etc., others have shown that holistic Asset Management should include people, practices, organisational structure, information systems and work design. Responding to industry's yearning for a guideline in optimising management of physical assets, the Institute for Asset Management (IAM) collaborated with International Standards Organization (ISO) in coming up with ISO 55000 series. The question of the extent to which a comprehensive Asset Management framework

such as ISO55000 can be adjusted to capture the challenges faced by SMEs and ensure industry-wide standards in Asset Management remains. To address this study questionnaire survey was used in order to achieve the overarching aim of promoting the adoption of ISO55000, by developing an improved ISO55000-based Asset management framework which better reflect the challenges faced by SMEs.

The remaining part of the chapter is divided into four sub-sections. Section 1.2 provides insights into the critical importance of SMEs in today's economy, their role in evolution at various stage of economic development, the numerous challenges SMEs continue to face (such as financial support, business opportunities, etc.) with a view towards understanding the factors that determine the durability of SMEs; in order to ensure that they remain fit-for-purpose. Section 1.3 presents, an overview of Asset Management and ISO55000, Asset Management Requirements, links with SME and the importance of ISO55000 for improved Asset management. The key findings from existing literature and prior studies, the research gaps to be addressed by this study, the research questions and related objectives, to underpin the rationale and motivation for the study are presented in Section 1.5. This section also addresses the significance and implications of the study and highlights its major limitations, with the view of identifying the contribution to knowledge this study makes. Finally, Section 1.6 provides a summary of the chapter, including an outline of the structure for the thesis.

1.2 The critical importance of SMEs in today's economy

SMEs are key component of a broad economy; its importance depends on their role in social stability evolution at diverse phases of economic development. SMEs do not only contribute to output, but they also fulfil common objectives, attract significant foreign reserves into the country and provide employment, which makes them the backbone of private sector around the globe (Al Mahrouq 2010). Most organisations playing a meaningful role in global economy (Islam et al. 2011) are considered SMEs and represents above 95% of private firms, 1/3 of investments universally and more employment in the economy (Cansız 2008). Based on European Union 2015-2016 data, SMEs represent 57.4% of the value added tax and 66.8% of employment created in the whole union. SMEs are an important force for economic development.

SMEs in the UK are over 99% of the business populace, they are projected to be 5.5 million, which makes them the heartbeat of UK economy. The European economy estimates 349756 SMEs in 2008 and in 2009 over 348550 SMEs existed in Portugal, which translates to 98% of

the total numbers of companies operating within the non-financial business sector and approximately 60% of the turnover (Statistics Portugal, 2010; 2011). SMEs are the key generators of employment and income, and drivers of innovation and growth. In the present economic decline; manufacturing, wholesale/retail trade and other sectors contribute most to growth in SME's value in non-financial business sector. It is therefore encouraging that 2011/12 saw the utmost level of company start-ups since the previous recession with over 450,000 new businesses registered (Holmes 2010).

Despite the significant contribution to economic growth, SMEs continue to face several challenges including financial support, business opportunities, businesses diversification, unskilled manpower, and onerous regulatory requirements for sustaining good business practices. Without enough and sustainable financial capital, SMEs will not realize full growth (SME-RC 2012). New SMEs have an unstable existence and many hardly outlive their first year; only a minority will still be operating five years later. The high rate of failure among SMEs makes financial institutions and investors very sceptical in their dealings with them. Nevertheless, environmental changes in SMEs also prompt more uncertainty because resources for obtaining information about the market and updating the business processes are limited.

For this reason, this thesis will investigate the challenges facing SMEs. Understanding the factors that determine the durability of SMEs will allow the development of best practice, and this vital information can then be communicated to entrepreneurs and SMEs owners. The lack of efficient asset management practices by SMEs exposes them to a lot of financial distress; inefficient asset management declines the growth and potential of any business especially for company that intends to expand or invest in lucrative projects (Mathuva 2009). Poor Asset Management makes it extremely difficult for SMEs to conduct strategic operational plans and therefore fails to meet their operational targets.

1.3 Background of Asset Management and ISO55000

This section introduces the issues around asset management, its requirements and its role with regards to SMEs. Subsequently, an introduction to ISO 55000, its role, benefits and components is presented to set the context and philosophical underpinning on which this thesis is built.

1.3.1 Assets and Asset Management

Assets are physical items such as plant, machinery, building, pipes, tools, equipment, real estate etc. that are used to serve business purpose; they demand the support of people, services and

resources of many types including operators, maintainers repair facilities, consumables, spare parts, documentation and training. To ensure that these supports are provided and budgeted for Asset Management is needed. Assets are about delivering business value not just efficiently or effectively running, organisations must be able to identify, track, classify, and assign ownership for the most essential assets to ensure they are adequately protected. Utilisation of asset, improves industrial performance, which makes industries think of ways to plan, maintain and operate their asset.

Successful business makes AM a critical component of their activity, an effective implementation of asset management requires that, the organization reassess its process of doing business; for example, the organization must concentrate on the life cycle of asset rather than on the initial capital cost; this needs series of changes in certain management methods, organizational structure, and the total approach to asset decisions.

Asset Management maintains an anticipated service level for what firms expect their assets to produce at the lowest life cycle cost possible. Lowest lifecycle cost as a phrase describes efficient cost for overhauling, rejuvenating or replacing an asset. Growth in AM requires real commitment to change-management, investment in resource training and reward, consideration of life cycle costing perspectives, enhancement of data collection and storage, as well as the adoption of structured approaches (Kiwelu 2009).

1.3.2 Introduction of ISO 55000 Standards

ISO 55000 is a written set of rules published by an international standard writing body (International Organization for Standardization). The rules describe practices that are universally recognized and accepted for assuring that organizations constantly understand and meet the demand of their clients. The purpose of ISO 55000 is to link management requirements with asset management system. The study acknowledge common practices across global cooperation which applies to extensive range of asset, diverse cosmopolitan background and organizations when drafting ISO 55000. ISO 55000 gives a clear prioritization scale in ensuring that limited scarce resources are directed where they can make the most impact. Against the backdrop of the numerous benefits of ISO 55000, this study seeks to explore how ISO55000 can drive effective asset management in Small and Medium-Sized Enterprise (SMEs) and how they can tap into its benefits.

1.4 Motivation for this Study

Although the principles of asset management have been broadly accepted and have been effectively adopted by several organisations, but others are still at an initial stage of its implementation. The ability for SMEs to improve manufacturing processes regularly and retains sustainability as organisations; company owners, operators and maintainers of assets are further charged with the responsibility of guarantying the successful performance of their assets to meet the expectations of stakeholders. Organisations that can meet stakeholders demand become attractive to prospective clients and better positioned to ensure competitive advantage; hence, organisations are under pressure to improve their operations, productivity, and asset quality, while satisfying customers.

Management is an intricate activity that can be affected by internal and external factors that must be tackled in a holistic manner. However, the lack of appropriate tools and techniques for SMEs to implement ISO55000, do not allow them to benefit from reduced insurance premiums, improved productivity due to a tailor-made asset management strategy. ISO55000 is the first international asset management standard, which provides terminology, requirement and guidance for implementing, maintaining and improving an effective asset management system. ISO55000 has not been adapted by most SMEs due to the perceived complexity and inherent barriers within SMEs. Where ISO55000 (asset management) has been successfully adopted is a demonstration of leadership and commitment from top decision makers.

1.5 Research questions, hypotheses, purpose and contribution to knowledge.

This section presents the key research questions, developed hypothesis, purpose of this study and key contributions.

1.5.1 Research Question(s)

Considering the issues presented above, this study seeks to answer the following research questions:

1. What are the current practices employed by SMEs to maintain and sustain the management of their assets?
2. Can a new approach to ISO55000 be developed to suit SMEs?
3. Which ISO 55000 elements are the most important for SMEs?
4. What impact will the adoption and implementation of ISO5500 elements give to SMEs?

1.5.2 Research Hypotheses

Considering the critical issues that arise from the review of prior studies, this research proposes the following hypotheses to be tested in this study:

Hypothesis 1: The efficiency of assets will improve with the adoption of ISO55000.

Hypothesis 2: The implementation of ISO55000 contributes to effective management of SMEs.

1.5.3 Purpose and Aim of study.

The purpose of this study is to explore how ISO55000 can drive effective asset management in Small and Medium-Sized Enterprise (SMEs) and enhance the performance of business and equipment by ensuring consistent, efficient performance to prevent loss or breakdown. The aim of this research is:

- To determine the critical factors that limits the success and growth of small businesses.
- To contribute towards providing functionally sustainable asset management system in SMEs, to enable them meet both present and future needs brought on rapid development.
- To develop a new approach to implement an effective and efficient method through which SMEs could adopt and implement ISO 55000 in Asset Management.
- To develop a conceptual framework that can be used to identify capabilities needed in the management of assets.

1.5.4 Delimitation of Study

The scope of this study is narrowed to SMEs operating engineering asset and due to the resource constraints of SMEs scope of asset management focus on critical asset with high impact on business operations. Though SMEs have less complex asset portfolios, the implementations of ISO55000 are scaled to align with available resource. The choice of methodology and sample size limits the study; quantitative data were gathered to respond to research questions, which enabled researcher in determining factors from empirical to descriptive data. Only 8 SMEs were selected base on their interest in study and problems with asset management implementation.

1.5.5 Originality

The research provides a new perspective on how asset managers can create value for their organisations by investing in ISO 55000. This study proposes a framework that seeks to identify the true impact of ISO 55000 in SMEs by examining the benefits of asset management.

The recent penetration of ISO 55000 in industrial practice highlights the need to assess the benefits of standard in asset management. This research goes some way towards examining and analysing the current practice and prospects of implementing ISO 55000 in SMEs. Findings from this study will provide useful input for the policy makers, academics and asset management practitioners.

1.6 Structure of thesis: Research outline

To achieve these research objectives, this study is divided into 6 chapters. A summary of each chapter's content is given as follows:

Chapter One: This chapter introduces background, purpose, significance of study research question and research objectives teased out from the gap in literature. It presents a brief introduction to Asset Management and the role ISO55000 plays in efficient Asset Management. Motivation for this study is presented and followed by contribution to knowledge.

Chapter Two: The main purpose of the chapter is to provide a critical theoretical underpinning for the thesis, it stated the research aim, questions and objectives by understanding the research problem and the research gap(s) from existing literature and prior studies. This is achieved by ensuring the literature review is built around the main themes and sub-themes associated with Asset Management, tools currently available to large scale companies and SMEs, the scope and theoretical underpinnings of standards like ISO55000 and its potential role and benefits in relation to SMEs. This provides a theoretical link between the themes and the purpose/overarching question of the thesis; and ultimately, leads to the statement of the thesis' specific research questions and objectives.

Chapter Three: Methodology chapter critically evaluates philosophical aspect of the research and method used in justifying the appropriate research design and answering key research questions. Described the questionnaire structure and collects quantitative information; it also presents how ethical issues in the research are dealt with.

Chapter Four: Analysis the quantitative data collected, rigorous exploratory factor analysis through dimension reduction (using IBM SPSS Version 24).

Chapter Five: Discussion; in-depth discussion of the results and findings from the analysis.

Chapter Six: Recommendation and Conclusion chapter presents how ISO55000 could be edited to reflect the challenges faced by SMEs and from these, key conclusions are drawn. A personal reflection by this researcher on learning outcomes gained throughout the duration of

this doctoral research program and challenges experienced during this research are used to conclude this study.

1.7 Summary of Chapter

This chapter presents a background for the research and sets the tone for how the issues in the thesis would be explored. Section 1.2 presents the insights into the critical importance of SMEs in today's economy, their role in evolution at diverse phases of economic development, the several challenges SMEs continue to face challenges. On this foundation, the relevance of ISO5500 and Asset management in SMEs was presented which led to the key research questions, developed hypotheses and contribution of this study. The next chapter discusses the literatures on Asset management, various Asset management tools available, SMEs with emphasis on their current challenges, debates on the appropriateness of ISO55000 in SMEs all of which provides further deeper justifications for the research question of this study.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction to chapter

Globally the asset management industries are exploiting every feasible advantage to keep pace with competition. Universal competition compels companies to consider client demands by increasing product varieties, decreasing delivery times, reducing costs and increasing product quality; while businesses are under pressure to also reduce costs, meet production targets and performance, conform to regulatory standards and boost return on investment. This will in return ensure companies gain competitive advantage throughout the asset life cycle; the management of assets can be a challenging task so much so that optimizing their usage is critical, and engineering companies, processes, and tools must be more product quality oriented. Asset management means operating a group of assets throughout its whole technical lifecycle, guaranteeing a suitable return, with a define service and security standards.

As the growth of large firms begins to reduce, the position of SMEs becomes more significant mostly in developing countries (Philip 2011). SMEs account for most businesses and are also key contributors to job creation and economic development globally. Despite the position of SMEs in the economy, it is financial constraint and this has an overwhelming impact on its operation and development. Without essential infrastructure and technology it becomes impossible to drive the economy as expected and improve innovation. Innovation support organisations in sustaining competitive advantage, generate capital investments, job creation and technological evolution (Stam & van Stel 2011); organisations introducing new processes, products and ideas should be able to appropriate value from its innovation.

SMEs encounters several problems with their business and this can fluctuate their growth; non-availability of machineries can paralyse operations and become a possible hindrance for manufacturing SMEs wanting to survive. ISO 55000 merge with suitable business strategies improves the financial and non-financial performance of the organisation. As business size increases, it becomes tough for organization to perform functions of control and supervision. The BSI (British Standards Institution) endorse the involvement of SMEs in innovative strategy as ISO 55000, they gain some privileges of large companies despite the size and advantages of SMEs (British Standards Institution, 2019).

The primary aim of this literature review chapter is to critically detail factors that ensure that SMEs benefit from ISO55000 concepts and practices for asset management. In order to do this,

the benefits of ISO55000 standard, certification, management system, and asset management in terms of performance, concepts, practices and philosophies of Small and Medium-Sized Enterprise (SMEs) and the research efforts focused on ISO55000 are reviewed. The remaining part of the chapter is divided into five sections. Section 2.1 presents SMEs definition, importance, activities and relevance in today's world, in the context of Globalization of SMEs, Importance of innovations in SMEs, Business Success or Failure Factors in SMEs and its improvement activities and Top Management Involvement in Innovation. Section 2.2 presents Asset Management as a driver for SME survival: Evolution, Measurement and Implementation. This is achieved by discussing the Concept of Assets, Asset Classification and Asset Life Cycle, Asset Management definition, scope and importance, Maintenance of assets and Organizational Responsibilities, Asset Maintenance within SMEs and in Subsection 2.2.5 Asset Management Problems and SMEs. Section 2.3 discuses International Organization of Standardization (ISO) as a Solution for SME Asset Management. It also discusses the PRE-ISO Standards such as PAS 55 and EAM, ISO5500 and Asset Management Policy, Alignment of ISO 55000 with other standards and the Benefits and Hindrance Implementation of ISO 55000. Section 2.4 Hypotheses development from key research gaps in prior studies - linking ISO55000 adoption to improved SMEs Asset management. Finally, Section 2.5 provides a summary of the chapter and link to the next chapter on research methodology for achieving the specific research objectives.

2.2 SMEs: its definition, importance, activities and relevance in today's world

SMEs are non-subsidiary businesses that employ less than a set number of employees. Universally there are diverse definitions for SMEs, which makes it challenging to compare in different countries, especially when the benchmark is not the number of employees, but the economics of business, annual turnover and total assets. SMEs in the UK are organisation with 250 registered employees and a turnover of less than £43 million. In Europe the upper number limit is 250 employees, some countries set at 200 while in United States SMEs are firms with less than 500 employees. SMEs financial asset define them in European union, as they must have an annual turnover of EURO 40 million or less and a balance sheet valuation not exceeding EURO 27million (OECD 2010). Despite their huge contributions, it is difficult to give a universally acceptable definition of the term SMEs as its definition and meaning differ in individual countries. There are three broad subcategories generally being used to define SMEs. These are:

- Firms with 10 or less staff are categorised as *Micro entities*.
- Small companies refer to firms with 50 workers or less, whilst
- Medium-sized enterprises describe firms with up to 250 employees.

In China, manufacturing firms with 2000 staff or less, or with an annual turnover of 300 million RMB Yuan or less, or having 400 million RMB Yuan or less in total assets is SMEs; While in India the term Small-Scale Industries (SSIsi) is preferred to 'SMEs' and they have chosen investment in assets as the basis to be categorised as Small-Scale Industries or not (Saini & Budhwar 2008). The Small Business Administration of the USA, classes small business based on criteria like, ownership structure, revenue, industry or sector, and number of employees (Burns 2016). They are reliable for creating employment, economic growth and social development, but face several challenges daily. SMEs have a very large impact on the development quality of a specific geographic area. The more presence of SMEs in the economy of a particular area, the more important for SMEs in achieving sustainability (Philip M 2011). Given their importance in all economies, they are essential for economic recovery. Most SMEs primary interest is survival without concern for competitiveness and growth. As a result, they invest neither in modernisation nor in growth and survive in traditional market niches, small-scale trade being the most important case in point (Stella K 2011).

2.2.1 Globalization of SMEs

Globalization is significant for all companies, large and small; exporting, licensing and franchising, contractual arrangements, joint ventures, and strategic alliances and fully owned foreign direct investment (FDI), and mergers and acquisitions are ways companies can be global. With SMEs having scarce resources at their disposal, exporting and importing continue to be the most common means of globalization (European Commission survey, 2015). In European Union (EU), 25 million SMEs hire about 100m persons and contribute to half of their GDP. Study shows that 26% of all EU SMEs exported their goods or services in 2019 (European Commission, 2020 a); 23% exported to other EU Member States, 9% exported to European countries outside the EU, 4% exported to North America, 4% exported to the Middle East and Africa, 3% to Latin America and the Caribbean, 3% to China and 4% to the rest of Asia and the Pacific (European Commission, 2020).

Global diversification is an essential strategy for businesses as importation and exportation act as entrance to foreign trade (Al Mahrouq 2010); in 2012 the Turkish SMEs made an export of 62.6% and import of 38.5% as trade transactions (Turkstat 2013). According to Statistics

Portugal (2011), there is a decrease in the number of SMEs up to the tune of 0.3%; a situation that paints a picture of economic crisis. However, 10% of exporting SMEs in Portugal contributed over 30% in turnover, which reflects the highest percentage of fall of approximately 8%.

Conversely in Italy, Japan and France, the number of SMEs accounted for 99% of the total number of enterprises while in the United States, there were more than 2000 million SMEs, accounting for 98% of total number of enterprises although America is famous for its large enterprises (Liu, Li & Zhang 2012). In the case of Turkey, statistics show Small and Medium-Sized Enterprises (SMEs) constitute 99.9% of total number of enterprises, 76% of employment, 53% of wages and salaries, 63% of turnover, 53.3% of value added at factor cost and 53.7% of gross investment in tangible goods (Turkstat 2013). In the UK however, SMEs provide 59.1% of private sector jobs and are responsible for 48.7% of private sector turnover. In large and industrialized economies such as Germany, United States of America and the emergence of South Korea as a global partner, SMEs account for as high as 64% of industrial employment which implies that the performance of SMEs has a major impact on the performance of the wider economy.

Presently there is a gap for participating SMEs in global markets, compare to large companies that export their products. Majority of SMEs are not benefiting from global marketplace, this situation has not substantially changed over the past decade. International trade-fairs are openings for SMEs to network and be recognized by other companies; information that can promote long-term decision-making on prospects offered by global market can be gathered (Bettis-Outland et al., 2010). Networking amongst SMEs assist them to achieve markets hierarchy, integrate into different complementary skills and technologies (Williamson & De Meyer 2012). In several places like China, networking aid innovative SMEs to balance the size-related advantages of big companies (Leeet al. 2010; Zeng et al. 2010). Links with diverse companies will increase opportunities to establishing and strengthen business associations that may lead into global value chains (Measson & Cambell-Hunt, 2013). Gaining access to foreign client and potential partners in order to enlarge business globally can be a challenge to SMEs as time and resource becomes a constraints. Government supports are valuable for SMEs to improve their trade in global market (Monreal-Pérez & Geldres-Weiss, 2019). Companies are allowed to exploit certain assets in foreign markets, accrue international market power and reach a global scale. Partnering with other SMEs could come with risks of know-how leak to

possible competitors, which can be reduced with cautious knowledgeable asset management.

2.2.2 Importance of innovations in SMEs

Global markets allow companies to increase competitiveness and promote advance development; it also permits them to expand their technological capacities from overseas, while offering access to inexpensive inputs. With markets becoming more competitive, SMEs will benefit in sustaining themselves through novel product in order to compete with big companies. Innovation is fundamental, and achieving competitive power (Gonzalez-Loureiro et al., 2012) lean towards new products, unique management and marketing techniques, including reliable technologies (Popescu, N.E. 2014). SMEs are focusing on making innovation the key driver for sustainable competitive advantage (Dadfar et al. 2013), they are known as dominant contributors to innovations playing a fundamental role in the economies of countries all over the globe. Innovation allows organizations to meet consumer's need, stay ahead in the competition, capitalize on strategic market opportunities, and align organizational strengths with market opportunities (Rujirawanich et al., 2011).

The process of modifying, improving, refining the consolidation of product plants is innovative; Innovation can be the radical creation of a new plant or major change in a production line (Aurel Mihail Titu et al, 2015); SMEs market are major players in delivering innovative solutions, which makes it important for SMEs to improved business quality by identifying business needs based on client demands. Innovative SMEs have a high tendency to test and generate new processes, which contributes significantly to improvements in productivity, competitiveness, and technological progress in their sector and the economy as a whole (OECD 2010; Pederzoli *et al.* 2011). The implementation of new practices seems to be high among SMEs; thou these new practices might not guarantee immediate benefits or performance enhancements. Studies like Dadfar et al. (2013) have revealed that enhancement programs will not produce concrete and optimistic outcomes except they align with the company's strategic orientations.

SMEs are more flexible than larger companies, which allow them to respond quickly to changes from the market (Revilla & Fernandez, 2012; and Thomä & Bizer 2013). SMEs are expected to pursue new opportunities outside its immediate environ; which support organizational and technical competences. Competition demands that companies exceed performance concurrently in various areas deprived of compromise and SMEs exposure to intense global

market competition can fuel innovation (Neuhäusler 2012).

2.2.3 Business Success or Failure Factors in SMEs

High failure rates and poor performance levels overwhelm SMEs; this intensify the need for value creation to guarantee business sustainability. SMEs have similar challenges in most countries whether developing or developed, but the level of problems vary from country to country, industry to industry and depend on organisations characteristics. SMEs face challenges mainly during their emerging phase; but better adapt to fluctuations in market and new client requirements. Theses challenge are mostly lack of adequate and timely fund, limited knowledge and investment, non-availability of appropriate technology, low production capacity, unproductive marketing strategies, lack of capacity to recognize new markets.

The management process in SMEs is mostly characterized by extremely personalized choice, biases, and attitudes of the companies' entrepreneur or owner. Lack of human resources management involves non-availability of skill workers and experienced managers (European Central Bank, 2019), which drives them to outsource goods and services. With limited skilled workforce handling global operation, it will be difficult as expertise is required for staffs to handle communication, logistics and documentation particularly with foreign clients (Mendy & Rahman, 2019). Due to scarce resources some SMEs could struggle in handling the intricacy of customs documentation and bureaucracy linked to export (Arteaga-Ortiz & Fernández-Ortiz, 2010); which also impact on compliance costs leading to delays, huge inventories and working capital (OECD, 2018). SMEs often do not have the huge budget for training employees as big companies, which makes them encounter difficulties in identifying reliable foreign partners.

Financial limitations are modern SMEs barrier; Bank-based finance accounts for about 90% of SMEs financing needs (European Commission, 2020b), failure to obtain these loan creates difficulty in exportation. Financial barriers have always been the most problems for SMEs; shortage of funds can hinder necessary investments for an operation, new products and marketing strategies. SMEs are mostly at disadvantage position when insuring assets and obtaining loans from banks due to low assets compare to big companies. Constrained by scarce resources, SMEs are open to intense competition in global markets, from big multinational companies and current local companies; the size of a company can be linked to the financial barriers experienced by SMEs (European Commission, 2011). Insufficiency of resources and inability to protect the company's assets may impede the opportunities for SMEs to effectively

partake in global market (OECD, 2018). SMEs wanting to globalize their operations are often confronted with governmental barriers by home and foreign government policies in relation to export / import and companies. Government should be able to support and sustain SMEs financially as lack of finance could be a hindrance in accessing global market. SMEs can become competitive globally when they surmount their financial barriers and gain adequate fund (Jinjarak and Wignaraja, 2016).

2.2.4 Background: Improvement activities on the part of SMEs

Improvement is a significant factor for SMEs to implement in its innovative activities and essential as part of their growing process (Sidik, 2012). Companies are continuously looking for techniques to provide an effective business strategy that can improve their market. Organizations should stress on improving response time e.g. evaluating product enhancement methods, reducing set-up time, improving production technique, introducing improved production design and reorganising dealings with contractors. The process is based on the elimination of waste and entails the reduction of non- value-added activities that tend to impose expense on production (Mishra, 2020). These activities can be reduced through implementation of maintenance and quality management systems; SMEs are encouraged to support these activities with synergy from management and staff to boost the worth of the company. Trainings for workers on the usage of technology and its management are to be encouraged by managers or owners of SMEs; Improvements in business;

- Decreases losses and improves business performance.
- Decreases operational costs.
- Adds value to the products and services.
- Allow innovation in a structured manner.
- Will help SMEs in expanding their global reach to audience around the world.

Businesses should invest in continuous improvement, as it is vital for any company wanting to succeed and be competitive; it aims to realize better efficiency and to optimize performance. Continuous improvement also encourages staffs to contribute in implementing process that improves the business.

SMEs should develop competitive strategy that could address competition from local and global companies; it is vital for SMEs to create well-defined market niches, in which they can

still hold competitive advantage. Managers must deal with a high form of intricacy that affects several of their companies' assets, product line and dealings with business partners. The difficulty in overcoming obstacles found in areas of competition, technology, markets, production capacity, product range, level of entrepreneurs' skills and product quality assurance contributes to SMEs mortality rate (Ropega J 2011). Most SMEs have chosen to embark on a renewal of production technologies as well as improvement programs that have yielded positive results in larger firms (e.g. ISO standards).

2.2.5 Top management Involvement in Innovation

Top management play an essential role in strategic decisions and outcomes (Wang &Tao, 2019), they influence relationships within the corporate social network. Top management set directions and organizational cultures that nurture or impede innovation, which become the foundation of the organizations performance (Lee & Trimi, 2021). When organisations aim at innovation, the managers' ability to make inform decision that guide and direct workers enhances participative leadership which in turn increases staffs' trust, commitment and inspires them to do their tasks. Top management need to motivate staffs' prospects by boosting their competitiveness, providing necessary resources.

Top managers must share same vision of innovation with their organisation; create an atmosphere that adopts technological change, new businesses through valuation and promotion of innovative thinking by determining market and customer needs. Top management should choose project leaders with competence to lead, direct and back sustainable innovation (Sauer & Kauffeld, 2015). Irrespective of organisation size, top managers are important to business operations and drive support for innovation (Zheng et al., 2019); top managers should boost learning opportunities; encourage commitment to learning and risk-taking (Yang 2012).

2.3 Asset Management as a driver for SME survival: Evolution, measurement and implementation.

As previously stated, the significant issues around SMEs and their survival raises the question on how they can be sustained given the critical importance SMEs play for the economy vis-a-visa, improved social elements and provision of employment. The management of SMEs isn't easy as changes can easily occur as businesses continually to evolve. Proactive management averts time loss and improves business while saving substantial money, besides its in SMEs business's interest. Asset management is a systematic approach used in managing company assets to a dynamic and profitable business. Though SMEs own fewer assets, these assets are the glue that keeps the business operational. Asset support organizations in conducting its

business, they have value and could depreciate over time. SMEs need to keep track of how many assets they own, their condition and where they're located. Staff responsible for tracking assets should be made aware of what the company owns, its location and condition as the absence of that information could lead to economic loss, managerial liabilities, or tax/legal concern. Assets require continual monitoring as it's very easy for items to fall through the cracks and become lost, it could also be theft either from within or outside the company. As business begins to expand, industrial changes occur but one thing that won't change is the need for Asset management, the benefits of improving SMEs business with asset management include;

- **Increased productivity:** decreases wasted time and allows company to evade oversights and delay while completing routine tasks.
- **Better forecasting:** when assets are accurately tracked and their condition, it's easier to track future costs related to those assets.
- **Maintenance and repair costs**; it enable management to understand the costs in replacing assets that have outlived their usable lifespan. With a quality barcode system, a quick scan is all it takes to pull up a report on an asset's maintenance record and determine any upcoming costs associated with that item.
- **Reduced duplicate purchases;** Management not knowing what assets they already have and which need to be purchased result to incredible waste, this happens because inventory of asset and parts are not properly done. Ordering for items already in possession result to waste and leads to needless wait times as staffs delay completing tasks until the new item arrives.

2.3.1 The Concept of Assets, Asset Classification and Asset Life Cycle

Engineering asset includes aircraft, airport, manufacturing plant, rail/road network or an electricity/water utility. Asset improves most aspects of peoples living and enhances the joy of living. Asset ranges from intellect and talent in human beings, land, mineral resources and natural endowments, hardware and software tools and systems, and other physical artefacts. Assets are usually engineered towards achieving something valuable. Dictionary define asset as ...*an item of property owned by a person or company, regarded as having value and being available to meet debts, commitments, or legacies* (Oxford 2014). The definition consists of three very important words an object (property) to which a legal entity ("person or company") attributes a value ("debt"). Value is frequently calculated in term of economic and finance, the

definition focuses on value of asset, objective to improve and maintain with the expertise in handling them, PAS 55 defines physical assets as *machinery, buildings, plant, vehicles, property, and other items that have value to organizations* (BSI 2008a). The definition is eligible by stating: *Value can be tangible or intangible, financial or non-financial, and includes consideration of risks and liabilities. It can be positive or negative at different stages of the asset life.* Barry (2011) and McGlynn & Knowlton (2011) categorized physical assets into the following groups:

- Plant and production comprising of mining, petroleum, textile, chemical, electronics, semi-conductor, food
- Real estate and facilities consisting of land, clinics, offices, retail space, warehouses, schools, accommodations
- Infrastructure comprising of, electricity/gas distribution, railways, highways, telecommunication, water
- Mobile Assets comprising of airlines, trucks, ships, railroad vehicles, military fleets
- Information technology consisting of service desk, computers systems, software routers, networks, auto-discovery, etc.

As the dependence on engineering assets for enhance livelihood begin to increase, managing these assets becomes imperative, so they sustain quality of life in a world of limited resources. Certifications, instruction, and training are skills for managing assets. Well-managed assets can realize huge value but using outdated approaches can result in underperformance and losses.

2.3.1.1 Asset Life Cycle

Request for resourceful production and asset preservation motivated the need for reliable operation, machine design and maintenance. Asset lifecycle indicates its economic lifetime within an organisation; a broad understanding of asset throughout the whole lifetime is vital. Asset life cycle requires three phases, supply of the asset, operations and decommission; main phase of the asset life cycle is the investing phase, which is based on business necessities and decisions e.g. plan, buying, installation and commissioning of the asset. The aim is either for replacement of aged engineering assets or increase manufacturing capacity.

ISO 55000 defines Asset life as; *the period from asset creation to asset end-of-life* (ISO 2014a), the life cycle of any asset is important for understanding AM (IAM 2015). Asset output declines considering the service it renders throughout the valuable life of the asset.

Guaranteeing the performance of the asset is the core job of engineers. Every activity that continue to re-establish or improve the use of spare-parts, are part of maintenance. Maintenance task are divided into inspection, repair and availability. IAM (2015) suggests the more the asset system complexity, the more it becomes difficult to pinpoint the phases of lifecycle; the challenge is the difficulty in implementing maintenance strategies, modifications and fluctuating functional demands and replacements during the asset's life.

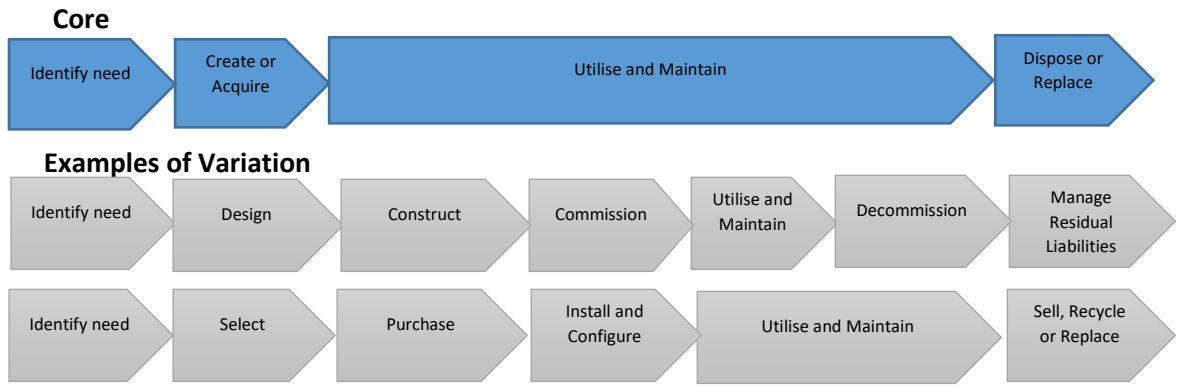


Figure 2.1: The asset life cycle phases and examples of variations

As shown in Figure 2.1 above, Asset life cycle starts by identifying the need, planning, designing and selecting the suitable solution. The subsequent process is the acquisition, which includes the request for proposals, comprehensive purchasing and warranty agreements. Asset configuration, commissioning and or Installation and other related processes are the following phase. Asset operation and maintenance period is the lengthiest; assets create value at this stage and require maintenance for continual performance. In this phase, it is usual to concentrate on improving productivity using tools like Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), Six Sigma and Lean manufacturing. Disinvestment of asset happens when they are no longer in operation or maintenance can't revive, then followed by decommissioning. The disposal of machinery after its productive life involves considerations of safety and ecological issues, followed by replacement phase (McGlynn & Knowlton 2011).

Operators are to ensure equipment operate at topmost levels thereby reducing finance and maintenance costs low; information (data) is to be collated during active lifecycle of the equipment for management and control. Lifecycle strategy must emphasis on active identification and mitigation of asset lifespan (Ruitenburg et al., 2014). Asset management is upholding an anticipated level of service for what you want your assets to provide at the lowest life-cycle cost. Lowest life-cycle cost refers to the best appropriate cost for rehabilitating, repairing or replacing an asset. The principle benefits of an asset management life cycle

comprise of:

- Improving consumer satisfaction by managing service delivery and products to mandatory standards.
- Return on Investment (ROI) optimization
- Having enduring plan, asset assurance and performance sustainability
- Enhancing health and safety performance
- Developing business control and risk management processes.
- Increasing business reputation by targeting stakeholder's value, workers satisfaction, operational procurement system and reliable advertisement of products/services.
- Sustainable development is considered when managing asset life cycle.

2.3.1.2 Asset Database

Due to the complexity of handling physical asset; a central method for managing performance and maintenance data is required. Organisations are to develop integrated IT system (database) to store and analyse data; it is necessary to ascertain what should be captured in the database, the process to capture the data. Responsive IT systems boost the swiftness and accuracy of asset management; IT system, data and database development are beyond the scope of this research.

Asset performance and condition data includes input, output, wear, temperature, vibration and run-time; the development of systems to manage this data are the critical factors driving the asset management changing practices. Asset database can support organizations to know their assets location, their allocation process, and their performance. Machine self-diagnostics, sensors with automatic controls, metering and monitoring systems, digitized field notes and repair archives are the different avenues through which these data can also be collected. Asset data should be useable and integrated into computerised maintenance management system (CMMS) (Wireman T 2013). The second view professes that data does not equal knowledge and that there is no deficiency of asset data. The argument is gathering accurate data in the exact format and analysing it successfully should be priority.

The various database should provide asset management support such as inventories, supply chain, Computerized Maintenance Management Systems, spares inventories, and enterprise resource planning. The mutual purpose is efficient information system with database integration. New technologies (ISO 55000) and services are assisting in this quest; it is

expensive and necessitates management guidance and executive supervision. Large datasets give basic information to maintenance improvement, processes, and capital investment decision-making. It is worth mentioning that though precise data produces accurate information but does not necessarily translate into making good decisions. Some studies had design models and tools efficient in handling limited quality data (De Jonge 2014); reliable standard (ISO 55000) can be used to resolve issues associated with data quality for management and exchange of asset information (Braaksma, Klingenberg & Van-Exel 2011).

2.3.1.3 Asset Information Management

Asset management system are developed based on transmitted and reliable information; despite the large volumes of available data organisations still experience Information management problems. The capacity for information to be translated without relative knowledge, data ambiguity and complications with the exchange of data are challenges face with poor information quality (Braaksma 2012). Asset information is used in hierarchy to structure account for failure modes, failure occurrences and failure causes.

2.3.2 Background of Asset Management: definition, scope and importance

The first step in defining Asset Management (AM), is to define management as an organization, supervision, or direction; the skill application or careful manipulation, treatment, control or use (of a thing or person), or in the conduct of something (Oxford 2014). This implies that the focus of management is on a particular purpose; thus AM drive could be visible in various methods, and management should be carried out at various organizational levels. Many researchers have defined Asset management as a planned and comprehensive processes (e.g. monetary, maintenance and operations) to achieve lifetime efficiency from assets while considering risk involve (Woodhouse 2013).

The term “Asset Management” is defined as the “systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan” (BSI & PAS55-1 2008). This definition is calculatedly extensive and is applied to range of organizations. Organizations might have their own understanding of AM, based on its previous and type of assets it manages. As a basic concept, AM is progressively gaining attention within the field of organizational strategy.

AM also manages the financial and physical assets of a company mainly to enhance the return on investment. AM is an orderly practice of asset maintenance, enhancement for equitable price (Trojanová & Pitoňák 2014). Asset Management also manages a group of assets over the whole technical life cycle guaranteeing a suitable return and ensuring defined service and security standards. Asset management plays a key role in the detection and evaluation of decisions leading to long-term economic success and best possible earnings. For asset management to live up to these expectations, it has to deal with a number of challenges .e.g.;

- Arrangement of strategy and operations with investor values and goals
- Balancing of reliability, safety, and financial considerations
- Profiting from performance-based rates

Asset Management is really a matter of understanding the risks first followed by developing and applying the correct business strategy and the right model to solve the problem, all supported and delivered by the organization, processes and technology. Asset Management focal point is placed on creating clear centralized accountabilities and responsibilities for effectively optimizing huge asset investment. SMEs tend to lack physical asset that banks can use as collateral (Rassenfosse 2012). AM activities are to be planned, implemented and controlled through suitable decision and management procedures. When originated from the main objectives of a company, AM substantially influences the operational and sustainability performance of a company; asset life cycle requires an established asset management framework.

The objective of asset management is for companies to manufacture at lower rates than their competitors, with higher return on fixed assets. AM permits the use of analytical methods in managing assets throughout its life cycle; top management cooperation and support is essential. Assets are managed for organisations to discern what they have, location, who is using it and what is it worth? Fundamentally to know in what way it relates to other assets. Awareness of resource permits one to make correct forecasts, leading to consistent and effortless decision-making. Forecasting allows management to assess the advantage of maintenance agreements, bulk purchases.

Especially under today's competitive climate, how to plan and design, operate and maintain the growing large assets is not only one of the key problems of improving business performance, but also the foundation and the most important components .e.g. smart grid. Asset Management

(AM) was developed on the earlier principles of Terotechnology that emphasize on engineering, economics modules, and management etc. that relates to physical assets. Decision-making in asset management are no longer based on individual evaluation but are data–driven, holistic system, risk and life cycle decision procedures that unite with organizations strategic plan. Asset Management encompasses aspects of engineering, operations research, organizational issues, human factors, while assets are not just mechanical, but also civil, electrical, electronic and software related. Amadi-Echendu et al. (2010) claim that *asset management tend to be broad in scope, covering a wide variety of areas ...constituting a multiplicity of spheres of activity*, and considered in terms of the engineering asset on the one hand, and the processes for managing the asset on the other hand (Amadi-Echendu et al. 2010). Nelson (2011) explained the history of Asset Management with its beginning in the 1900s in US, when urban centres witnessed increasing needs to provide larger population with water and sanitary services - described below. The idea of Asset Management (AM) has acquired acceptance in developed countries such as Australia, USA, UK, and several newly stable environments such as Kuwait. Countries are progressively accepting and executing AM principles as their regions redevelop.

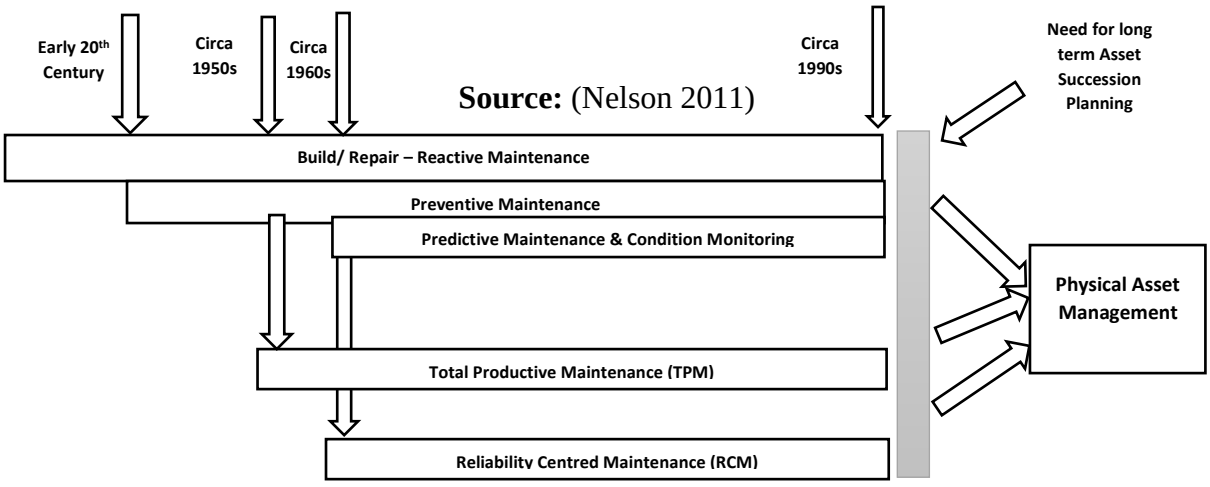


Figure 2.2 History of Asset Management (Nelson 2011).

2.3.2.1 Asset Management Requirements

Awareness of companies' operations and maintenance activities in their plant should be based on AM requirements (Alfatih, et al., 2015). Formation of guidelines for acquiring assets and consistent internal practices throughout the organization is seriously significant for an efficient AM system. Total cost of ownership and return on investment analysis confirms impact of AM to profitability instead of overhead; risk of operating cost is definitely an obstacle to generating mindshare. Factors to consider in AM are;

1. Organizational commitment
2. Leadership direction
3. Improvements
4. Planning
5. Support services
6. Operations
7. Performance evaluations

There was an industry-wide consensus within engineering circles on the need to explore AM comprehensively, focusing on lifecycle, strategy validation, risk, and human factor.

2.3.2.2 Framework for Asset Management

Asset management framework is the group of products and processes that must be tackled in order to provide the most efficient cost effective services and drives the relationship between operations, maintenance and capital planning (Almeida, et al., 2021). It specifies the asset management information systems scope and information requirements to support asset management decision-making. It enhances decision-making by connecting firm's strategic goals to its asset management policy, asset management objectives and strategy. It is recommended that firms develop a complete business model for all its assets and confirm it covers all life cycle phases and organisational tasks. The asset management framework identifies three things that must to be in place (EL-Akruti 2012):

1. **Decision Making***:* decision-making motivates firms to address its important objectives and ensure that the service needs are provided. A complete framework that allows organisation to choose direction and compatible asset management activities that best suit its goals must be set out (Woodhouse J 2010). This address "*The What, Why and How*" of asset management. It serves as *asset management policy* and *asset*

management strategy and objectives. Asset competence is examined, and the output forms a set of *Asset Strategies* – listing what needs to be done on each of the equipment. (Burns 2010)

2. **Monitoring and Appraisal**: this offers a feedback circle amid asset mediation, state and its performance. There should be difference between Asset performance monitoring and performance of the device that manages the asset; which is essential in ensuring successful results and support decision-making process.
3. **Enablers***:* decision-making success depends on the organisational competence (such as its workers), and the asset information and technology support tools available to boost business processes. The state and performance of asset is the yardstick majority of firm's base their success on, with only few firms measuring the outright result of management approach. Proper success measurement should cover reliability, availability, maintenance and maintainability, logistic support (and safety) requirements.

2.3.2.3 Implementation of Asset Management Principles

Implementation or introduction of new asset management (ISO 55000) necessitates structural reform of policy, set targets and anticipated outcomes including having strategic plan (Mikolaj et al., 2012). Organizations overseeing assets are to initiate an integrated system of asset management in order to improve business; this might requires logical systems, enhance practices, new information, different ways of communication in the organizations. Principles to consider;

- Authorization of a developmental scheme for assets, monitoring of present state of the assets and possible needs for assets.
- Choose suitable process for implementing asset management plan
- Examination of asset information and data for resourceful decision making
- Responsibility for assets structure
- Continuous assessment and monitoring of efficiency of asset planning
- Initiating strategies to accomplish business goals and measure performance of services.

Performance asset management indicators that should be monitored are as follows:

- Indicator of monetary influence of maintenance and repairs (Trojanová & Pitoňák 2014).

- Yearly maintenance and repairs costs.
- Indicator of technical condition and remaining life of the asset (Stenstr¨om et al., 2013).

AM is implemented through an asset management program and typically includes a written asset management plan. Objectives of Asset management should be described based on its significance to the organization for instance:

- Expertise of staff and maturity of the organization
- Asset portfolio and its performance as a whole
- Competence and efficacy of asset management activities and plans
- Services delivered to clients;
- Information adequacy to sustain asset management system
- Maturity of asset management system processes;

Organizations objective and strategic plan should be in line with asset management objectives.

2.3.2.4 Asset Management Maturity

Asset Management (AM) Council defines AM maturity as "the ability of an organization to foresee and respond to its environment through the management of its assets, while continuing to meet the needs of its stakeholders'. AM maturity explains the ratio to which a company is performing AM practices and gaining commensurate benefits. Industries use AM maturity assessments to measure the current AM state, the result becomes useful in exploring improvement opportunities. Maturity is calculated with a collection of criteria on a 5- point scale however presently no standard criteria for assessment (Port & Callaghan, 2011; Botha 2014). Maturity assessments can be used to assess compliance with standards such as ISO 5500 (Botha, 2014; Smith, 2012).

AM maturity requires that an organization deliver outcomes such as customer service, profit, safety and assurance, with the assigned resources and within the requisite delivery period. Asset management maturity is dynamic and should be able to respond to both the changing business environment and changing stakeholder needs in a manner that aligns with the other functions of the organization. AM maturity can be considered as the extent to which asset management is aligned and integrated into an organization. After addressing the Background of Asset Management: definition, scope and importance, it is important for Asset maintenance strategies

to be explored

2.3.3. Asset Maintenance

Although manufacturing equipment is built to ensure successful operation through the expected service life, deterioration starts as soon as it is commissioned. In addition to deterioration, other breakdowns may also occur, particularly when the equipment is operated beyond its design limits or due to operational errors. Equipment downtime, lower production becomes the outcome. These outcomes affect negatively on the operating cost, and productivity among other significant performance requirements (Muchiri et al. 2011).

Maintenance is an effective technique that guarantees an appropriate level of reliability during the life cycle of an asset. Maintenance is concerned with retaining assets using proactive and corrective methods with aim of how swiftly equipment can return to operating condition after breakdown. Improving maintenance is a strategic task; its operations are complex, particularly if the supplier has to manage various assets at different sites. Thus, the use of monitoring technology to monitor asset health is suggested; an advanced monitoring will result in higher asset availability (Lightfoot et al., 2011). Well-organized maintenance possess commercial objectives, which requires decrease in downtime, cost and evade consequences associated with unavailable assets. Equipment maintenance and system reliability are important factors affecting the organisation's capacity to provide quality and timely services to customers. Reliability is a significant feature in the assessment of industrial equipment. Maintenance supports plant objectives within the objectives of the organisation. Important factors to be considered in asset management are:

Asset usage: Assets are to function in their best condition despite been under extreme workload; an intense workload deteriorates asset life (Panegossi & Silva, 2021). This expose asset to untimely failures except there is regular mediation with proper reinstatement activities. All assets do not undergo same stress despite been under same intense workload; only those with no in-built severance go through critical stress. Workloads have significant influence on asset therefore its usage should be assess and measured.

Failure History: is the consistency of asset failure throughout its lifecycle; historic computation of failure through Availability of asset, MTBF and Reliability of component or system etc. during normal operation, system gives precise data failure history. Only sustainable analytical assets and expert decision for non- sustainable asset are considered for this computation.

Asset Condition: considers the valuable life remaining and the asset age; Assets should be classified and evaluated at class level rather as singular part of an equipment. Condition-monitoring methods and deteriorating model are chosen based on asset class. For non-availability of data, expert decisions form the finest choice; the asset age is not the best indicator of its ability to provide satisfactory service. Maintenance of age-based asset do not guarantee expense reduction (Sandu, et al., 2022). All these factors therefore raise the question of when and how best to trigger the time asset maintenance is due in firms. This leads to Condition and Performance assessment.

Condition and Performance Assessment

An asset condition can be used to detect possibility of failure; '***Condition'*** implies the state of an asset in asset management framework. 'Condition of an asset' is defined as the 'readiness of a machinery to serve its function'; this comprises of operational readiness of the asset and its physical integrity (Marlow & Burn, 2008). It is expensive and complex to evaluate the condition of a complex system especial as majority of these systems are exposed to various loading conditions, built with diverse material type and age. Even as the condition of an asset deteriorates, some assets are still able to fulfil its purpose adequately; thus expense on an asset should not only be based on its structural condition but also on results obtained by assessing the asset performance (Jorge, et al., 2021). Since assessing the condition of assets is capital intensive it should be done if its benefits outweigh the costs; this can also be done through physical observation of each component that can be very challenging; example is an underground network due to inaccessibility and quantity of component. The physical observation procedure is usually cost intensive thus increasing the difficulty in carrying it out.

Performance is assessing the performance of engineering assets against set goals and objectives. In order to assess the progress of an asset, performance is measured in a quantifiable way for effectiveness and efficiency. Performance measurement provides the needed information for management to make effective decision (Jorge, et al., 2021). Performance cannot be managed without measurement, as measurement can only indicate the present status of performance.

Performance can also be a management tool essential in monitoring activities of the assets; selecting performance indicators that is suitable for management is crucial in asset management (Lavy S, 2010). Performance indicators impacts on operational practices and maintenance of finance; therefore, using the right performance indicator with consideration to organization's

strategic policy and plan allows organisation to assess the scope for improvement. When considering performance indicator to be adopted by organisations, the strategic value to shareholders' and management decision-making influence are to be considered and this should be justified benefit against the cost. Poor 'condition' of the assets or poor operational practice could result in breakdown of the asset; when checking condition and performance of an asset, its failure consequences and understanding of its risk needs to be considered (Almeida, et al., 2021).

Companies invest in assets to meet their business objectives and manage their risk around safety, financial, and environmental events. Assets generate huge amounts of data daily base on their own specific purpose, these data can keep management informed to help make smarter decisions or become vulnerable to blind spots and risk (Wetzer, et al., 2019). Management requires the ability to understand what these data means in order to establish which information is important to the health of the assets, then the decision of which assets are most critical to the business and most importantly what asset strategy to manage it all.

2.3.5 Maintenance of assets: Organizational Responsibilities

The selection and implementation of a suitable maintenance strategy have overwhelming benefits to asset life span and performance such as:

- Significant Asset life optimization,
- Significant Improvement of service and performance of assets
- Significant improvements in the perceptions of asset service and safety standards by the general public, and
- Significant reduction in long-term life cycle cost.

The importance of asset maintenance planning ensures cost-effective and timely execution of projects thereby assisting the organization in achieving long-term cost-effective and productive asset portfolio management (Ferreira LA 2012). Asset managers' influence the maintenance activities, processes and systems for their firms especially for high priority assets. These assets of high priority includes asset that could pose health and safety concerns or key to operations, while assets of low value and short lifespan may be classified as low priority assets. Consideration should be given to the resources when allocating maintenance tasks (Parnell G.S. 2011). Asset managers must regularly review maintenance program to make decisions on asset maintenance and ascertain if plans implemented are yielding the desired results. Resources for

maintenance should be assessed regularly with service delivery observance as recommended by asset managers to certify that assets are better maintained. Service providers are to maintain their organization's assets as stated by the standards in place; asset managers must confirm asset management activities or maintenance are proper if they are outsourced (Edwards 2010). One challenging aspect of well-organized asset management system development is the splitting of departments and contradictory operational influences; this is important as it harvests some of the major organizational performance benefits. A well-defined asset management system provides channel of cooperation across functional divisions. It guarantees accountability at all levels of the asset existence both in and out of operational tolerances (e.g. overhauls, maintenance and fault corrections). Common features of good asset management practice in organizations include:

Leadership and accountability - an influential supporter of asset management that is also part of the Top Management Team manages the organization.

Expert – Burns (2010) suggests an expert should monitor targets, make-decision and support maintenance activities

Cooperation - Regular assessment meetings should be held to evaluate performance cost and mediation points. The combination of the above will lead to asset management success through introduction.

The asset management function establishment that supports the development and implementation of asset management within the organization is a basic feature of best practice. Staffs responsible in the management of asset need to differentiate operations, maintenance or financial activities to meet stakeholder's demand of cost/ risk minimization, performance optimization, and that all activities are tackled and controlled unilaterally (Lloyd 2010).

2.3.5.1 Organizational Responsibilities: Performance management Monitoring Asset performance:

Asset performance must regularly and properly be appraised and evaluated to determine if service delivery or expected results are realized; organizations should supports continuous improvement of their asset (Ferreira LA 2012). To ensure asset goals are achieved companies should:

1. Monitor and manage Asset-related risks, contingency plan must be in place for

efficient service delivery

2. Identify or establish standards (ISO 55000) that is suitable for their asset
3. Set benchmarks base on service delivery goals

It is essential for asset managers to create performance targets, mindful of resources available; when evaluating asset's performance, the Usage, Functions, economic performance, service need and condition of asset should be put in consideration (EL-Akruti 2012). Management processes must be established and maintain to consistently record, monitor and assess performance; results will be used to improve performance. Performance should be measured against organizations own established targets or benchmarks, asset standards to ascertain if assets are underperforming, being managed efficiently, or expensive to own or operate.

Methods for monitoring asset performance and asset management systems should be integrated into companies planning framework; framework should be updated when there is a change. It is the duty of asset managers to guarantee that implemented systems meet asset management requirements (Burns 2010). Asset management maturity evaluation must be conducted by organizations to ascertain:

1. User satisfaction and Operational performance of their asset
2. Organizational Performance by using Applicable KPIs (Key performance indicators)
3. Expected target against operations and equipment's
4. Asset management systems maturity

Policy objectives, service standards and resources availability should be the driver when establishing KPIs and its target for assets; KPIs could be monetary or non-monetary, qualitative or quantitative (Alegre, 2016). Proper appraisal of asset performance, KPIs used by company, its objectives should be compared against other like assets when determining KPIs and targets. Organizations are to provide information and performance data of an asset through its asset information management system (AIMS). Necessary changes to organization's asset management and risk management processes must be resolved for organization's asset base to accomplish service delivery objectives, within available resources; competing priorities should be considered by Asset managers when making informed decision (Plant Services 2010).

2.3.5.2 Organizational Responsibilities: Risk assessment and management

Accidents at workplace usually happen abruptly and surprisingly, triggering injuries and damages; unsafe activities and environment, organizational elements, error-Induced conditions create accident. Risk assessment comprises of threat identification, appraisal of preventive

measures and purpose, and estimates of threat exposure and penalties; with these factors in place organizations can control intolerable risk (Edwards 2010). Efficiency of risk management strategies is to be assessed on a routine basis. Asset lifecycle risk should be examined when risk management strategies are developed such as:

- Asset Operations
- Physical breakdown of Asset
- Economic value of the Asset
- Health and safety of the Asset
- Stakeholder's consideration.

Operation of critical assets for business stability should continue while attending to breakdown, emergency and incidents. Defects in design and process plan jeopardize production thereby causing economic risk (Gah, et al., 2021); Carrying out maintenance tasks can be risky, causing risk to equipment, business and persons involve in the operations; Application of suitable strategy prevents risk.

2.3.5.3 Organizational Responsibilities and Asset Maintenance Strategies

The purpose of Strategy is to aid SMEs with the philosophy of increasing product value and simultaneously decreasing manufacture cost. Maintenance strategy addresses ways and plans needed to achieve the expected maintenance task and all features of maintenance management (Knackstedt 2011). Differentiating the component condition from the component importance is the standard way to classify maintenance strategies. Irrespective of how fantastic equipment design is, the equipment overtime deteriorates as machinery operate and undergo stress. Maintenance is therefore required to stop or slow down the process of asset deterioration and to preserve the integral asset value for the economic advantage of the company (Ayu & Yunusa-Kaltungo, 2020.). Asset maintenance should be enhanced as this reduce operational cost, improve quality product and increases the productivity of manufacturing plants, which is the economic focus (Jung, et al., 2019). Managers should define a vibrant manufacturing strategy.

The early phase in the development of maintenance strategy is the Corrective Maintenance (CM), which is centred solely on the breakdown repairs; this takes place when a fault is detected, then it is repaired or replaced (Khayal & Suleiman, 2024). Following is Preventive Maintenance (PM), maintenance functions are fixed with the aim of detecting and/or

anticipating potential failures before it occurs. Another strategy widely used was Time-based maintenance (TBM) that is done at fixed and scheduled intervals either for inspections or maintenance works; it is mainly based on the service history of a component (Amin, 2016). Reactive strategies on the other hand are initiated when event activates replacement actions, while proactive strategies is implemented when future concern for replacement and operational decisions are based on the predicted development of failure rates in order to reduce cost and evade other undesirable outcomes (Mutlu Öztürk & Öztürk, 2019). The manufacturers of the equipment either give these time intervals or they are based on the experience of the operator. "Proactive strategies are stated to be generally more justifiable for assets with high consequence of failure". The progression continues to Productive Maintenance (PM), which involves the formation of a maintenance plan that reflects maintainability (M) and reliability (F). Due to many different applications and mechanisms of production assets, advance strategies such as Reliability Centred Maintenance (RCM) and Total Productive Maintenance (TPM) may be appropriate for one asset, but it might not be suitable strategy for another asset. For a proper strategy to be applied, top management acquaintance of assets and broad cognisance of factors relating to asset maintenance and accessible resources guides decision-making. The details of these aforementioned maintenance strategies:

TPM is a complete tactical maintenance philosophy designed to tackle maintenance of equipment struggling to attain faultless production operations; the underlying philosophy of TPM is continuous improvements (Cuatrecasas & Torrel 2010). TPM needs the collaboration of the entire company to increase factory productivity within reasonable cost. The first establishment to feature TPM plant is a Japanese business "Nipondenso" and it improved the outcomes for the company. Essential to the development of TPM is the training and growth of the personnel in relevant modules to form a proficient workforce within the company. TPM concentrate on the whole lifecycle of machine, guaranteeing lesser breakdowns, reduction of costs. For TPM strategy to progress, financing vital areas must be done; apart from training cost, aged asset may need new parts or replacement (Gupta et al. 2011). The outcomes of implementing TPM inspires individual and economic growth with crucial modifications within the organisation such as:

- Manufacturing of goods without the decline in quality
- Staff with several skill set
- Decrease in maintenance expenditure

There are areas where companies tend to experience hurdle when implementing TPM despite being said to enhance total efficacy of the company. Hurdles include:

- Scarce resource (capital, time, expertise level)
- Staff resistance to change
- Panic of job loss between staffs

When implemented TPM poses changes on skill development, administrative conduct and responsibilities including use of information technology in most organisations (Choy & Siam 2011).

Reliability Centred Maintenance (RCM) incorporates all other strategies and directs resources precisely to critical points taking into account the operational importance of the device (regarding facility availability), as well as its condition. RCM is a practice aimed at system function, breakdown linked to functions and the effects of major functional system breakdown (Telang 2010). RCM does not only consider the condition of the system components, but also the chances of equipment failure and system impact should a failure occur; implying it's an improvement over preventive maintenance. RCM is also a great tool for the ranking of replacement and refurbishment activities, because bad equipment conditions lead instantly to the query of whether it is more economical to do more maintenance or replace the equipment. RCM concentrate on fit-for-purpose levels and incorporating breakdown and performance data into its support mediation decisions.

Computerised Maintenance Management System (CMMS) serve as a maintenance database that can be used with TPM and RCM as a strategy to gather data, it boost maintenance success and assist management in decision-making. CMMS offered features includes:

- Monitoring inventories (spare parts and consumables)
- Delivering work orders
- Monitoring maintenance (preventive)
- Recording past and present machine data, equipment warranty and specifications,

In optimizing maintenance function, increasing maintenance period will decrease the faults that affect production interruption (Allin, et al., 2019). Maintenance and reliability purpose is to guarantee assets availability when needed. Reliability forecast and prevents breakdowns, for machines to perform their designed functions and enhance reliability is a tactical task.

Implementing comprehensive asset management strategy is a crucial element that is lacking for most SMEs; its benefit involves having strategic target, commitment, staff proficiency and awareness of asset, asset condition, risks, costs and performance.

It is compulsory for an asset management strategy to include the diverse plan for achieving objectives of service delivery (such as costs, benefits and risks assessments), asset upgrades, purchase and disposal over a range of time (Kusuma & Muttaqin, 2022). Asset managers should consider their organization's existing asset base condition, capacity, capability and usage, available resources, funding constraints and competing service and asset priorities (Burns 2010). Some key elements Asset managers should consider include:

1. The unique environment the firm exists in terms of laws, policy, and accountability requirements
2. The framework design and the firm's management structure;
3. Market (External) factors and their risk;
4. Delivery options for the Private sector and needs of Stakeholder;
5. Skills needed by staff and adaptive learning within the organization
6. The plans for asset lifecycle management throughout the lifespan, including upgrades, delay acquisition or assets disposal;
7. The criticality of service delivery operations and enhanced cost effectiveness;

The strategy should commensurate with the size, functions and level of the organization and continually assessed and reviewed by senior managers for the strategy to remain relevant. Asset maintenance is a continuous practice for the improvement of the availability, safety, reliability and durability of physical assets; it is the duty of Managers therefore to determine the appropriate vibrant strategy to employ (Lima, 2019).

2.3.6 Asset Management and SMEs

The management of SMEs isn't easy; changes can easily occur as businesses continually to evolve and company asset are the glue that keeps the business operational. Asset support SMEs in making profit; as business starts to expand industrial changes occur but one thing that won't change is the need for asset management (Rødseth, et al., 2020). Asset support organizations in conducting its business, they have value and could depreciate over time; businesses need to keep track of how many assets they own, their condition and where they're located. Asset management is analytical in managing a dynamic and profitable business though SMEs own fewer asset. Staff accountable for tracking assets should be made aware of what the company

owns, its location and condition; absence of that information could lead to economic loss, managerial liabilities, or tax/legal concern (Pedersen & Schjølberg, 2020). Asset require continual monitoring as it's very easy for items to fall through the cracks and become lost, it could also be theft either from within or outside the company. SMEs usually want staffs to take on several roles concurrently, it becomes challenging for staffs to keep up with preventive maintenance schedules, software updates, audits, and depreciation.

Maintenance represents a huge percentage of operating costs of an organisation, an area of greater emphasis to assist industries in meeting their objectives but it's an area not deprived of challenges (Hodkiewicz MR 2013). Company maintenance departments face several problems in their efforts to enhance processes to realize maximum equipment uptime and availability. Despite having advanced condition-monitoring programs, many operations stay trapped in a reactive maintenance cycle. Base on that, most maintenance teams execute at least 70% of all maintenance activities in an unplanned manner (Patidar, et al., 2017). Unpredicted component failures usually come from recurring problems that were constantly patched, hence allowing the root-cause undetermined and delaying the problem to be tackled. This act leads to a negative impact on mean time between failures (MTBF). Migrating amid work locations, collecting parts from the stockroom, manually recording workflow information, and hands-on diagnostics are classic time-wasters, which is difficult. It is predicted that maintenance personnel on average devote less than 30% of their time on concrete productive tasks. Issues also occur from failure to automatically capture significant workflow and component-level health information, such as periods of operation, equipment condition and maintenance history (Ferreira LA 2012). Manual data collection is not cost effective and hardly sustainable over long periods. In order to implement a proactive approach that facilitates longer equipment service lives, systematic collection and integration of equipment health information is essential. Operating against this fact limits organizations' ability to make extensive infrastructure and information systems purchases, which requires implementing and supporting a conventional maintenance management system.

Asset management tools (built-in barcode scanners) allow company to track assets and collect data especially those in different location; and which ease the conduct of routine asset audits to ensure that your information is accurate (Allin, et al., 2019). The accurate value of an asset won't be its initial purchase price, as the value depreciates over time. Accurate depreciation is vital both for accounting and tax purchases.

2.4. International Organization of Standardization (ISO): A Solution for SME Asset Management

The International Organization of Standardization (ISO) was formed in Geneva, Switzerland, in 1946 to develop international, industrial, and quality standards as a model for quality assurance standards in design, development, production, installation, and service. ISO coordinates efforts made by groups of technical experts representing individual national standard institutes to develop consensus-based voluntary technical standards on variety of issues (Chiarini, 2017). The mission of ISO standards is to promote international cooperation, especially business and trade, by facilitating communication on technical issues between industry, government, consumers, and other stakeholders and allowing consistency of products and services within and across national boundaries. ISO scope of disciplines includes economics, engineering, supplier chain, human resources and information systems; organisations might need personnel with multiple expertise and fit communicators depending on the context these organisations operate.

2.4.1 Pre-ISO Standards: EAM and PAS 55

EAM addresses the value contribution of AM; it is an important part of daily management, particularly the investment of equipment in many organizations. PAS 55-1 (PAS55-1 2008) defined EAM as an optimization strategy of AM concerning performance, risk, and expense modeled over the life cycle (EL-Akruti, 2012). The diagnostic methods used need to be reviewed regularly and require update with new techniques, models that are more reliable and robust for predicting the condition of physical assets. Monitoring and analyzing asset behavior detect the fundamental fault or symptoms with greater efficiency. Hastings (2010) viewed EAM as a sequence of events to help organizations achieve their goals.

The British Standards Institution (BSI) first published PAS 55 (publicly available specification) as businesses request support in executing and modifying asset management; 4 years later it was reviewed to include global consensus with best practices in handling physical assets. PAS 55 was universally accepted as a program that guarantees consistency; enhance performance and flexibility (Woodhouse 2013). PAS 55 specifications is mainly for optimal management of physical assets; Asset management needs to be categorized considering asset type, life cycles along with cross-functional activities. PAS 55:2008 formally defines AM as the: *systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycle for the purpose of achieving its organizational*

strategic plan. PAS 55 optimize the management of physical assets.

PAS 55 is subdivided into two: PAS 55-1 describe AM requirement specifications while PAS 55-2 functions as guidance tool for PAS 55-1. The specification is formed around Plan-Do-Check-Act cycle; for an efficient asset management strategy to be implemented successfully, PAS 55-1 demands a disciplinary approach, which allows company boost their worth as well as distributes its planned goals effectively by managing life cycle assets. Furthermore, PAS 55-1 specifies that its specification is appropriate to asset intensive company with critical outflows.

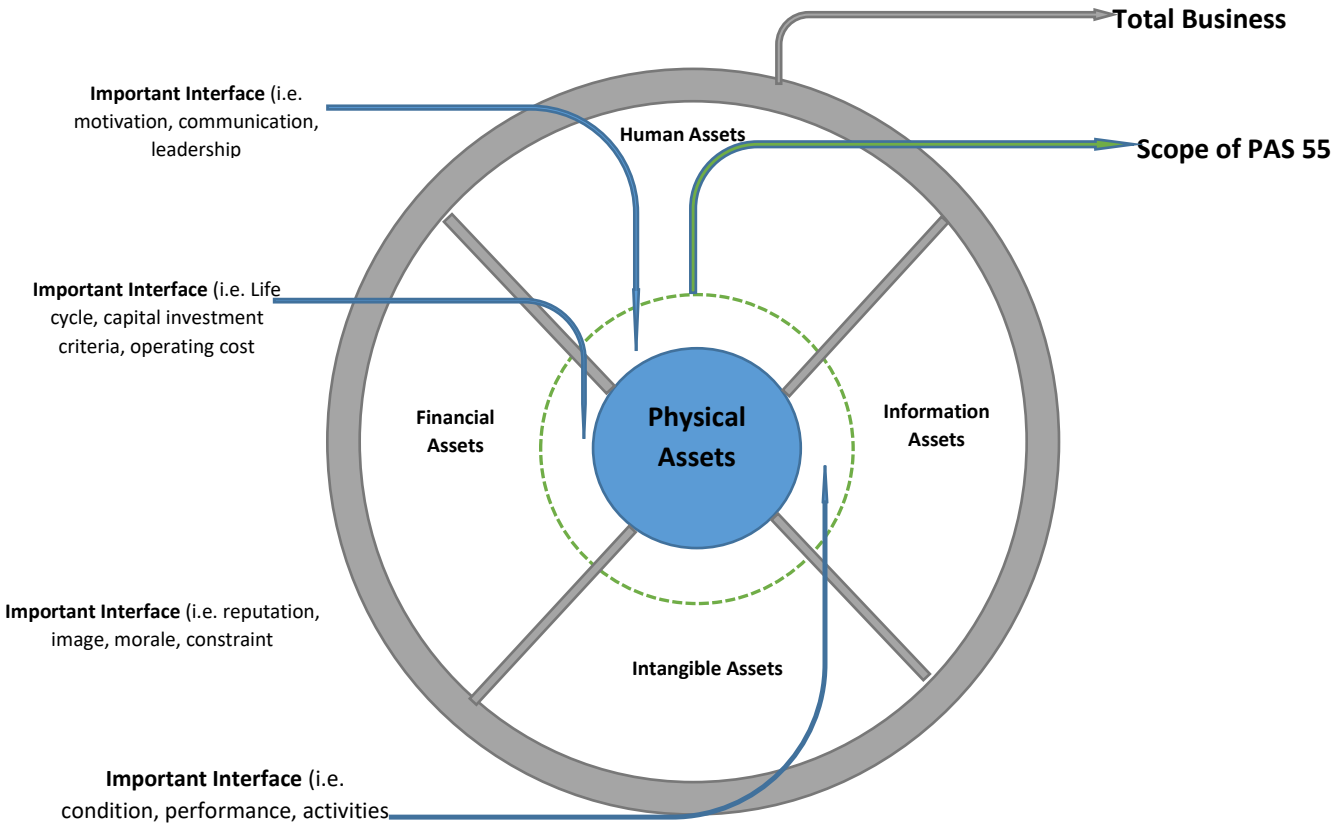


Figure 2.3: Types of assets as defined by PAS 55

Adopted from British Standards Institution (2008a, VI)

PAS 55 serve as requirement checklist for organization's management system, AM improvement and control; its requirements are inextricably linked together (see figure 2.3 above). PAS 55 documents should be read in its entirety to get full understanding when implementing asset management (Ratnayake, 2013). The development of ISO 55000 Standard was as a result of the acceptance and implementation of PAS 55 in industries (manufacturing,

transport,) as Asset management standard.

2.4.2 Introduction of ISO 55000 Standards

The publication of the ISO 55000 standards stimulated enthusiasm concerning the coalescence of different perspective for a subject matter that is *cross-*, *inter-*, *multi-*, and *trans-* disciplinary (ISO 2014). ISO 55000 standards defines asset as an "*item, thing or entity that has potential or actual value to an organization"* (ISO 2014a). ISO 55000 as a framework for asset management system, it assists business to proactively manage the lifecycle of their assets, from acquisition to withdraw. ISO 55000 permits a company to identify assets that are critical to fulfilling its investor requirements, business goals and demonstrates the management of its asset. ISO 55000 is an innovation with international set of standards produced to give guidance in asset management best practice. Innovation aids companies to preserve their competitive edge, contributing to increase in capacity and making extra capital investments, productivity, technological advancement, employment, and growth. It is not sufficient for a company to introduce something new and useful; the company must thrive in devoting the value of its innovation. It supports optimization of asset and reduces the overall cost of ownership while assisting to meet the necessary performance and safety requirements (Woodhouse 2013). ISO 55000 specifies requirements for establishing, implementing, maintaining and improving an organization's asset management system and can be applied to any company where physical assets are central to their business. It is vital for organizations to efficiently manage the variety of asset, which it depends on, which is as important as ever, regardless if it is motivated by:

(I) Delivering reliable services and structure
(II) Operational safety for service user
(III) Sustaining licenses based on compliance with regulations.

Organizations are to identify need for asset, which begin during the analysis stage of a project in the industry; the needed asset are to be specified in broad. ISO 55000 standard is applicable to any sector or asset intensive company with technical specifications. ISO 55000 standard contains 3 interrelated series; ISO 55000, ISO 55001 and ISO 55002 Asset management. Overview, principles, and terminology are all embedded in ISO 55000; requirements for the management systems are contained in ISO 55001; ISO 55002 states rules for the application of ISO 55001 (ISO55000 2014).

ISO 55000 is proposed for companies that intend to enhance the realization of value from their

asset base; it's for companies with the desire for asset management system improvement through sustaining, planning, establishing, implementing and reassessing their asset management activities (BSI 2014). The implementation of ISO 55000 frameworks therefore provides companies the benefits of excellent asset management and by extension, the assurance of overall accomplishments of its objective continuously and consistently. BSI (2014) suggests certain key factors to be taken into account when a firm is designing its Asset management improvement plan. These are:

- Stakeholders and company's expectations.
- The monetary constraints,
- Company purpose and nature;
- Regulatory needs and standards; and
- Company's operational environment;

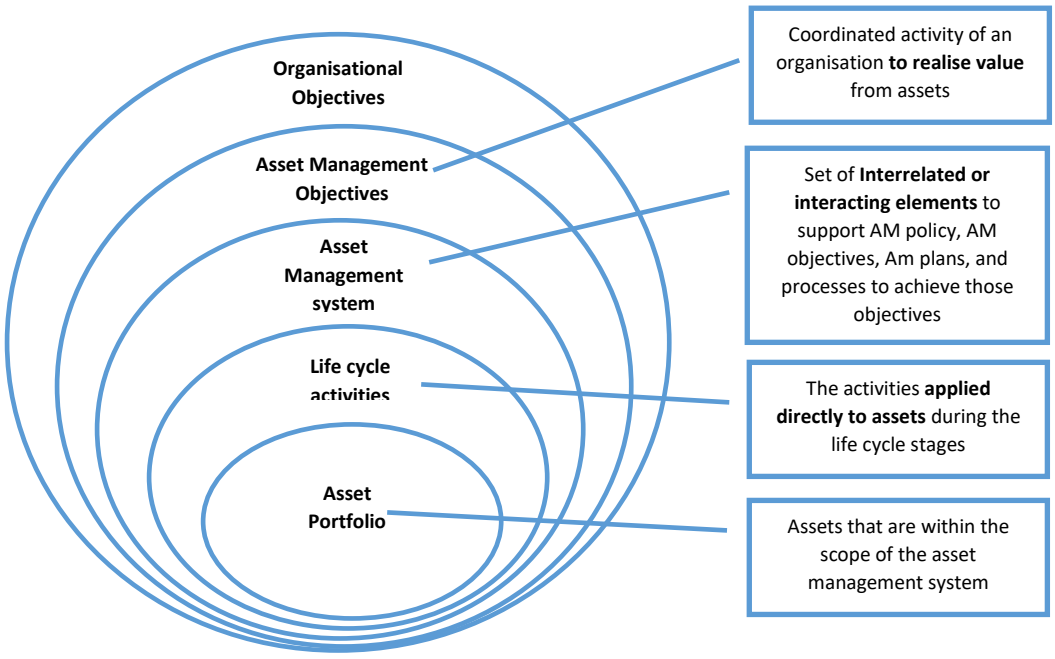


Figure 2.4: Relationships between key terms
Source: ISO55000 (2014)

As shown above in the ISO 55000 diagram to the right, Asset Management objectives are a coordinated set of activities that help your organization realize the amount of value delivered from the asset. They are subdivided into interacting elements that allow the organization to achieve those Asset Management objectives.

AM as a discipline is growing and there is awareness that it is less about "doing things to asset",

but more about "using asset to deliver value and achieve the organization's explicit purposes". The characteristic of an asset seem to be consistent across with a well-defined set of universal requirements that should be manage properly; thus giving rise to the added adjectives "value" in qualifying AM. ISO 55000 standard gave a different view of how AM family describes AM. It defines AM as *coordinated activity of an organization to realize value from its asset* (ISO 2014a). This study will identify with ISO 55000 definition of AM.

According to IAM (2015), "as the thinking is common to the use of asset in whatever form they take. It is up to the organization to choose how to manage those asset to derive best value...." ISO 55000 qualifies the definition with three summaries (ISO 2014a):

- Stability of cost, performance and risk shows organization achievement of value
- Application of fundamentals in asset management system is refer as Activity
- Implementation, planning and approach have a connotation in "Activity" as regards to Asset management.

BSI (2014) suggests the successful realization of Asset value through comprehensive management of manufacturing company's opportunities, cost, performance and risks is predicated on effective control and governance of asset. This is more so critical given the continuously growing challenges and risks companies face in their quest to conform to the requirements of their regulatory and legislative environment. ISO 55000-framework document in its 2.2 subsection states benefits of asset management to be the following (BSI 2014):

- Better decision-making process and better management of organizational costs, opportunities, performance and risks, which are key to improving asset investment decisions.
- Cost reduction while not compromising asset value or company's objectives thereby improving its return on investments (ROI).
- Meeting statutory, legislative and regulatory standards while also meeting the expected standards policies and processes in asset management.
- Better demonstration of company's CSR (Corporate Social Responsibility).
- Better reviewing and improvement Asset management procedures, processes and performance, which are indicators of company's efficiency and effectiveness.
- Reductions of Monetary losses, liabilities, and negative environmental effects while at the same time leading to better health and Safety standards, and better company image;

both of which are important in risk management.

- Efficient management of a firm's short and long-term outcomes, performance and expenses leading to improved organization operations and sustainability.
- Better customer satisfaction levels and knowledge and confidence of stakeholders; both of which lead to better organizational brand and reputation.

Findings from prior studies reveal the broad participation of experts across diverse industries is the fundamental reason why ISO55000 has been successfully implemented in different industries and variety of cultures (Woodhouse, 2013). Therefore, such studies conclude that the ISO 55000 series implementation results improved organizational competitiveness.

2.4.2.1 Introduction of ISO 55000 Standards: Content

PAS 55-2008 was the foundation on which ISO 55000 was created; achieving corporate goals are significant factor this standard offers to organization. ISO 55000 contained three standards:

ISO 55000; provides critical overview, concepts and terminology;

ISO 55001; specifies the requirements for an effective Asset Management System;

ISO 55002; offers interpretation and guidance for such a system to be implemented.

Continuous improvement is an essential element within asset management; this is highlighted in ISO 55002 (2014, p.6) by stating that "compliance with all the requirements of ISO 55001 should be considered as achieving only the minimum starting point for an effective asset management system and should not be seen as the final goal". The introduction and definitions of key terms reside in ISO 55000; Requirements for a management system is defined in ISO 55001 and Guidance on the interpretation and application of the ISO 55001 requirements is define in ISO 55002. Asset life cycle, organizational context, leadership, plans, relevant support, implementation, performance evaluation and improvement are all element in ISO 55001.

2.4.2.2 Introduction of ISO 55000 Standards: Scope

The most significant change is the target scope of application for the standards. ISO 55000 is aimed for any asset type specifying how it should be applied to management of physical assets. AMS in figure 2.5 below explains the needs and expectations of stakeholders; organizational policy and strategy can be translated into clearly defined objectives and plans of the organization.

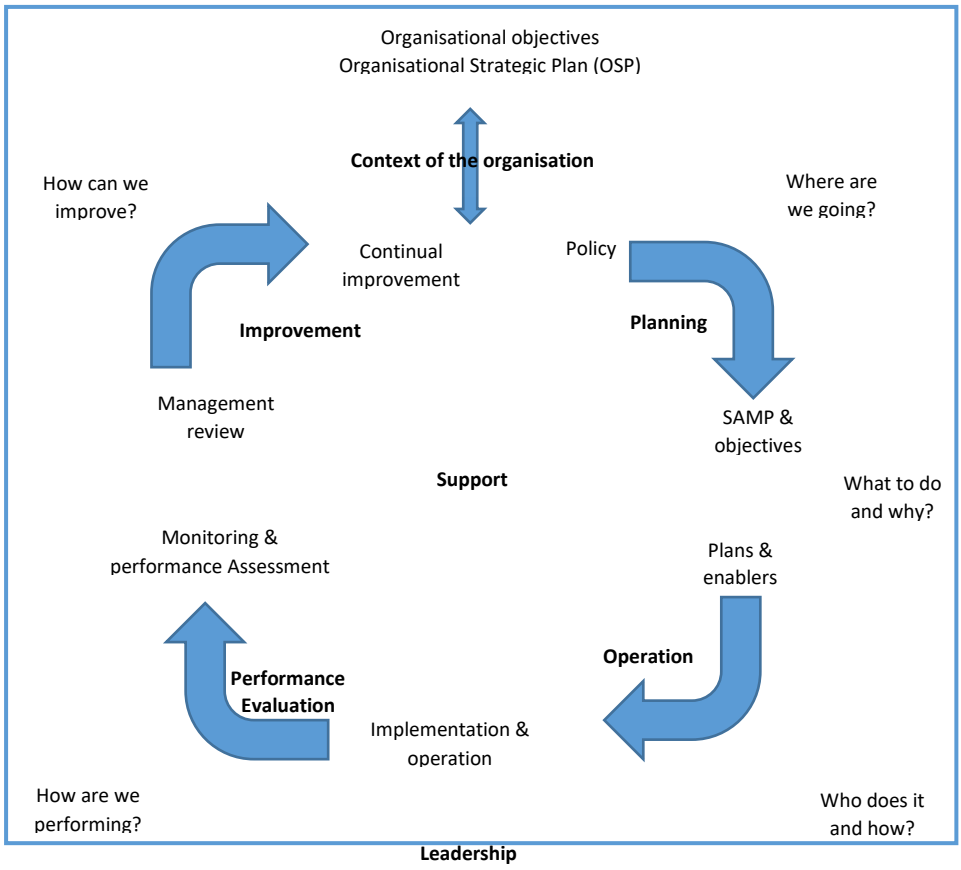


Figure 2.5: Asset management system (AMS)

These are the responsibility of top managements. Management review and continual improvement should be based on assessment and evaluation of performance; there should be plans on how operations are managed, monitored and evaluated. Improvements should be updated in context and OSP, how this process is driven depends on the influence of leadership and support. ISO 55000 prepare organizations to create a detailed life-cycle asset management system, management of risk, boosting performance and improving competitive advantage with the aim of improving organizations' image (Woodhouse 2013).

2.4.3 ISO5500 and Asset Management Policy

Asset management policies are outline and documented to support alignment with ISO 55000. The processes required for effective management of assets throughout their asset life cycle are as follows;

- Procurement
- Planning
- Design
- Construction
- Network operation
- Refurbishment
- Run to failure
- Asset replacement, retirement and disposal.

Asset management policy emphasizes on principles and strategy for managing asset consistently; it places guideline or direction that applies to implementation of asset management activities (Edwards 2010). The strategy considers organisational objectives increasing assurance and supporting investment. Key Elements of an Asset Management System in ISO 55000 are:

- **Context of the Organization:** organizations must define internal and external contexts, constraints, important objectives and capacity to achieve the outcomes from AMS: examples of context of the organization are organizational relationships, requirements and prospects of stakeholders in determining the scope and requirements of asset management system (ISO 55000 2014). The initial step in implementing ISO 55001 is to clearly identify and define organizational objectives and requirements of stakeholders, which can generally be referred to as business objectives. Step one is a key element of the standard, because the system is designed such that all actions should focus on maximizing the likelihood that these objectives will be met. Included in this element is also the clear definition of the scope of the asset management system, or in other words, what assets will help achieve the business objectives. In essence, these are the boundaries of the ISO 55001 system. Stakeholder influence is key to setting standards for decision-making and contributing to the goal setting of the organization. An asset management strategy must be developed to tie together the business objectives and asset scope into the fundamental approach the organization employs to achieve the

desired objectives (Al Marzooqi, et al., 2019).

- **Leadership:** ISO 55000 stipulates leadership must be clear, unambiguous and committed to asset management (establish, operate and improve) within the organization. This includes active sponsorship and ownership of the system, the establishment of an asset management policy, and the assignment of roles, responsibilities, and authorities for its ongoing management. It is essential for the organization to adapt their leadership, with the commitment of all levels of management, to successfully establish, operate and improve asset management within the organization (Woodhouse 2013). Top managers usually don't pay significant attention to company's assets till there is a breakdown but will rather give attention to other management issues. A well-structured and conceived asset management system will provide increased proactive leadership direction in major crisis; an appropriate reactive response is expected from such leadership. Responsibilities and corresponding authorities should be defined; employees must be trained and informed. Top management and the organization must share a common objective, which is crucial in this era.

- **Planning:** Planning is a fundamental element of AMS. Organization should develop a set of asset management objectives that align with their asset management strategy, these objectives should be measurable, monitored, communicated, and updated as necessary during the business lifecycle (Almeida, et al., 2021). An essential phase of planning is identifying and assessing risks to achieving objectives associated with each asset, and the appropriate risk mitigation actions that should be taken. Management determines the risks and opportunities to ensure the asset management system prevent or define unwanted effects and achieve continuous improvements of the organization. Objectives require plans to achieve them; these plans should include various activities, resources, and funding (ISO55000 2014). Organization must have an asset management plan, which includes risk management and goal measurements. Such integrated plan evaluates risk associated with a project; the specific requirement of risk assessment and management is a critical part of ISO 55001 (Alsyouf, et al., 2018). Planning involves documenting what needs to be done, who will be responsible, what resources are required, when it will be completed, etc.
- **Support:** Robust plan needs resource and support from management to be achieved.

This section has many subsections e.g. Resources, Competence, awareness, communication, information requirements, and documented information (Viveros, 2015). It is fundamental for Organization to have resources required to establish, implement, maintain, and improve the asset management system. Cooperation between different functional departments requires resources that will have to be shared. Competence ensures qualified staffs are running the activities of the asset management; Awareness of the asset management system, activities and objectives should be promoted. Information systems must be made available to support the process; documented information should be controlled, communicable and auditable. The information necessary to implement and manage the system should be defined as well as the required documentation to manage be verified with compliance, and this also demonstrates effectiveness of the system. Information is the key to good decision-making; it should be trusted and must be made available to support processes (Gaha, et al., 2021). An information system that can generate accurate project information will enhance decision making in this crisis. The system should specify the competency requirements for personnel involved in asset management; documented information should be controlled, communicated and auditable, to ensure staffs are operating base on organization policies, processes, asset registry, etc. Information systems must be made available to support the process; documented information should be controlled, communicable and auditable.

- **Operation:** Operation enables execution, guidance and control of asset management activities, which includes documenting evidence that plans are carried out and continuing to evaluate and control ongoing risks. Organization's operational planning and control capacity can quickly and precisely change its course with implementation of change management and management of change systems. Assessment or re-assessment of risks associated with changes is an essential role of asset management in the organization (Tsagkaraki, 2014). Operation covers outsourcing, which places same thoroughness on subcontracted service and suppliers to meet the objectives of the organization. It is essential management monitor operational risks that impact on staff's resilience; Operators must know the optimal conditions of their asset as they cause most system failures.
- **Performance evaluations:** asset management system must be monitored, measured, analyzed, evaluated and audited. Top management should review the asset management

system for the convenience, adequacy and effectiveness of the system. The performance results of the management activities should be kept as documented information (Jorge, et al., 2021). The performance assessments, combined with the estimation of the consequences of failures, give an understanding of the risks. ISO 55000 requires specifically for the efficient management of data and the transformation of data into information to measure the performance of assets. This element defines requirements for the ongoing monitoring, auditing, and evaluation of asset performance, and the asset management system itself (Parida, 2016). Specific descriptions are required when defining performance evaluation, including what, how, and when performance is evaluated, as well as the auditable retention of the evaluation documentation. Overall system compliance is assessed via internal audits and periodic management reviews.

- **Improvements:** improvement should be applicable to asset management activities: assets, system, processes, etc. Monitoring the performance of an asset boosts improvement as failure usually show area or systems that requires improvements; there is always room for continual improvements (Jorge, et al., 2021). Organizations need to identify nonconformity or potential nonconformities and implement tasks to correct them. Nonconformity includes appropriate documentation, implementation and management of a system; they can be identified through management reviews or audits. Nonconformities require corrective and potential preventive actions; Breakdown must be accompanied by an emergency response plan and business continuity plan. Organizations need to frequently assess and improve the effectiveness of itself asset management system.

Implementing ISO 55000 helps organization manage its assets effectively, ensures procedures are followed such as having regular cross-functional meetings plus evaluating and escalating risks and opportunities as normal practice (Alsyouf, et al., 2018). Change management help prepare for unexpected events and put contingency plan in place.

2.4.3.1 ISO5500 and Asset Management Policy: Decision making criteria

Decision criteria should be deliberated and decided by all internal and significant external shareholders with focused on areas and assets that provide utmost value; it could be economic investment, management and resource (Woodhouse J, 2010). Every organization is faced with the need to make decisions in a range of areas including asset management; effective decision-making is an essential part of any management system. This often leads to frustration with

those seeking to have decisions made, as they are constantly requested to bring forward new options, provide inordinate amounts of detail or generate slight variances on the existing options despite the seemingly disproportionate amount of effort required to generate the additional analysis (Burnett & Vlok, 2014).

Decision-making needs to be integrated with the 'process' and 'organizational roles' elements of the management system. From an organizational roles perspective, the management system needs to ensure decisions are being made by appropriately authorized and competent people with due consideration to an objective and rational decision making. A critical step in the process is to identify who can make the decision (Woodhouse 2013). The person needs to have the necessary authority (actual or delegated) to make the decision. The identification of the decision maker can be tactically important if it is likely that the decision will be subject to any legal challenge as, if this occurs, the decision maker is likely to be an important witness. Decision need to provide value to the asset management and organizational objectives and consequences of the decision need to be assessed against these criteria. Transparency in decision-making, solution to contradictory stakeholder prospects, and allocation of resources evenly to activities should be part of decision criteria (Gaha, et al., 2021).

2.4.3.2 ISO5500 and Asset Management Policy: Risk Management

The required steps for risk management are reduced within ISO 55001; specific requirements for risk management (such as the management of risks that change with time) are retained within ISO 55001. ISO 55000 manages the risks and costs associated with possessing asset, in an organized, efficient method that supports frequent improvement and continuing value creation. Technique for managing risks should be documented in organizations asset management effective base on ISO 55002 (ISO55000 2014). Assessment and management of risks is an essential skill in asset management, knowledge of business operation (asset that could significantly impact on business if they experience unexpected breakdown) contribute in risk management (Edwards 2010). Organization's attitude to risk, will impact on decisions made to eliminate or mitigate risks during the specification, design, construction/acquisition, operation, maintenance and eventual disposal of asset.

Organization should develop an appropriate balance between the cost to do something (treat the risk), the resultant risk from the expenditure of those resources and the expected asset (and organizational) performance output/outcome. The applications of the techniques of risk

management are all encompassing both within the asset management system and financial decision-making processes (Waldron, 2011). Risk management within asset management can be described as the tool that enables the desired future to come true. It is from this perspective that the role of the risk management process can be appreciated, both as a tool with which to identify and treat risks at an operational level, and also in a strategic sense as a tool that enables organizations to achieve their goals.

The risk management process is applied both to tailor the management system requirements to the needs of the organization and to define the processes, activities and tasks, which need to take place (Gaha, et al., 2021). The management of risk as part of asset management occurs at all organizational levels. The risk attitude adopted by the organization's Board and Executives should be reflective of stakeholder needs, and the level of assurance the stakeholders require that their needs will be met. This risk attitude should then be reflected in the organization's risk management plan, and then evidenced in the processes and procedures used by the various technical processes used as part of the asset management system (Waldron, 2011).

An organization's risk profile will be the aggregation of many individual risks, each with their own individual levels of severity. The organization's risk management plans should also provide a view as to how risks are collectively managed and communicated. There are many techniques to do this, but organizational risk register is a common tool used to record these risks (Gaha, et al., 2021). Each risk register has a set of mitigating actions/controls identified from the risk analysis processes, and each risk is allocated an organizational 'owner', who has accountability that the identified risk remains managed to a level which is acceptable within the organization's attitude to risk. All staff should understand the risk management framework and its application within the asset management system processes, particularly as it involves the reporting of risks and the requirement to follow risk treatment plans as applicable.

2.4.4 Alignment of ISO 55000 with other standards: its differences and similarities

ISO 55000 can be used with other asset-specific standards and technical specifications. Other standard it can align with are;

- ISO 31000 for risk management
- ISO 14001 for environmental management
- ISO 9001 for quality management

Compatibility with other management systems, operating on mutual structures and sustaining coordinate control are the basis for Asset management system that aligns with other standards and this allows consistency with other management systems. Furthermore, the power for organizations to establish the minimum requirement threshold that must be met in order for the firms to meet their objectives is the key benefit PAS 55 and ISO 55000 standard share (Minnaar et al., 2013). Asset management policy retains an important role in setting the asset management commitments; however, the flows from organisational strategic objectives, via asset management policy, into asset management strategy and objectives have being refined. In ISO 55001, these are split out into discrete requirements and the 'strategy' term is dropped in favour of Strategic Asset Management Plan (SAMP). SAMP is important component of a successful asset management system, often referred to as the asset management strategy. ISO 55000 defines asset management strategy as "documented information that specifies how organizational objectives are to be converted into asset management objectives, the approach for developing asset management plans, and the role of the asset management system in supporting the achievement of the asset management objectives". It bridges the asset management objectives with the overall organizational objectives. The explicit identification of different life cycle activities (such as create/ acquire, operate, maintain, renew/dispose) has also being dropped to accommodate more diverse life cycle stages of different asset types (Woodhouse 2013).

The Minnaar et al., (2013) study also proposes that the development of efficient decision-making process on asset-dependent activities such as cost and risks and performance profiles can be achieved if asset management system sticks to its requirements. For this benefit to be attained, it is critical that education and training of selected managers are provided in areas where short and long-term decisions can have an impact on the benefits accrued from implementations of these standards (Minnaar et al., 2013).

Despite the shared key benefit of PAS 55 and ISO 55000 aforementioned, the key difference between these two standards is the substantial modification in scope of their function (Ma, et al., 2014). While PAS 55 explicitly focuses on physical asset and acknowledges the dependent relationship its applicability have on the other asset types, ISO 55000 is designed to be applied to asset management irrespective of the asset type; this includes physical asset management (Woodhouse 2013). Another key difference between these two standards is that core definitions in the ISO 55000 standard are simplified and yet robust. Cross-disciplinary collaboration, risk-

based decision-making and life cycle planning are principal elements from PAS 55 that was improved in ISO55000 (Woodhouse 2013). It is realistic to anticipate potential development of elements, requirements, techniques and guidance found in ISO 55001 (ISO55000 2014); organisations should use these elements as they provide added value (IAM 2015).

Expectations need to be realistic; the requirements set out in ISO 55000 provide the framework for an asset management system, meeting these requirements does not guarantee that business performance will improve. When an organization does not embrace changes, the success of an asset management program will never be fully realized. In an open economy, SMEs have to sustain themselves by continuously increasing productivity and competitive strength by successfully facing competition from large-scale enterprises. Business survival and competitive strength of an organization mainly depends on the productivity level they can attain. It is in this context that, the study of role of ISO 55001 in ensuring an efficient asset management system in small and medium enterprises (SMEs) assumes significance.

2.4.5. Implementation of ISO 55000: Benefits and Hindrance

Despite the huge importance of ISO55000, debates still exist on both its benefits and hindrance to its implementation. The following section presents these arguments as a means for

2.4.5.1 Benefits of ISO55000 to Organisations

ISO55000 permits a company to identify assets that are critical to fulfilling its investor requirements, business goals and demonstrates the management of its assets. It manages the risks and costs related with possessing assets, in an organized, efficient method that supports frequent improvement and continuing value creation. ISO55001 require an organisation to set up a life cycle management plan that include the risk associated with the specific asset and the consequences of this risk (Anon, 2014). With ISO55000 Organisation are able to;

- ISO55000 standards require assets fulfilling its purpose.
- Understand the downstream impact if their equipment shuts down.
- Track the why of any breakdowns using error codes etc. so that they can have an effective predictive maintenance program.
- Make Extensive improvement of asset reliability and reduce costs of servicing assets.
- Better uptime and availability of asset.
- Reduce downtimes and outages.

- Higher return on assets as well as in invested capital.
- More Efficient and Effective Trainings of Staffs: better-defined procedures and documentation facilitates employee training and knowledge transfer.

Implementation of ISO55000 will allow organizations to adhere to the following;

- Pre-emptive in dynamic market and move away from the break-fix approach.
- Manage risks, services and outputs successfully thereby making informed asset investment decisions, improve financial performance and demonstrate its social responsibility as well as compliance.
- The process of creating a holistic asset management system will bring new perspectives to the organization and new ideas on value creation from the use of assets. These perspectives will stimulate improvement in other organizational functions (e.g. purchasing, finance, information technology and human resource) (ISO 55001, section 2.5.2, p. 5).
- Top management will be able to recognize the need to improve communication and interaction across functions, which will ensure that assets are managed in an integrated manner.
- Management will be able to communicate with employees, suppliers and contracted service providers, which will increase the improvements on quality of asset information and create asset awareness amongst individuals (ISO55001, section 2.5.2, p. 6).
- Conscious of robust financial information, which is based on integrated processes between the asset management and finance functions. Therefore, this will allow the organization to improve assessment of financial position and funding requirements in relation to assets (ISO55001, section 2.5.2, p. 6). Identifying critical factors to be addressed for its success in SMEs.

2.4.5.2. Benefits of the implementation of ISO 55000

The main benefit of ISO 55000 is that it offers a set of requirements for an effective asset management system but allows the organisation to decide how best it should be implemented to suit their needs (Woodhouse 2013). An advanced AM system that sticks to these requirements permits reliable decision-making on actions that influence cost, risk associated with asset and performance. This indicates that management should be prepared to make reliable decisions that include compromises between short and long-term consequence. Studies

have shown that fundamental achievement of asset management is decent communication, supported by excellent information system and well-informed executive.

Thus, the main objectives and problems of Asset Management nowadays are to guarantee cooperative procedures among internal and external shareholders- this requires good communication channels, skilled managers and efficient systems (Woodhouse, 2010). Company assets have a potential of using Asset Management as its competitive advantage; for this to occur, there is a need to develop a culture for maintenance, which is a subset within efficient Asset management. As it's shown in table 2.2 below, one of the key benefits of ISO 55000 is that it tells the user what to do, and not how to do it. The implication therefore is that Organisations are left to determine appropriate tools and methodologies for decision-making themselves.

Key ISO 55000 Benefits	Outcomes
Improved financial performance	Enhance return on investment and reduced costs without forgoing organizational performance. It maintains the asset value.
Informed asset investment decisions	Encourage management and leaders to make knowledgeable investment decision that balance cost, risk, opportunity, and performance.
Managed risk	Leads to reduced financial losses, improved safety, good will and reputation, minimized environmental and social impact, resulting in reduced liabilities such as insurance premiums, fines and penalties
Improved services and outputs	Achieved by consistently meeting or exceeding the expectations of performance of the organization and its assets in delivering services or products to the needs and expectations of customers and stakeholders
Demonstrated social responsibility	Improved ability to demonstrate socially responsible and ethical business practices and stewardship within the organization's community including reduced emissions, resource conservation, and adaptation to climate change
Demonstrated compliance	Achieved through transparent conformity with legal, statutory, and regulatory requirements, and adherence to asset management standards, policies, and processes
Enhanced reputation	Achieved through improved customer satisfaction, stakeholder awareness and confidence
Improved organizational sustainability	Effective management of short- and long-term effects, expenditures, and performance improves sustainability of operations and the organization
Improved organizational efficiency and effectiveness	Accomplished through review of processes, procedures, and asset performance

Table 2.1: Benefits of ISO 55000 implementation

2.4.5.3 Factors that will affect Implementation of ISO 55000

There are important factors which should be resolved that influence the implementation procedure of ISO55000. Organisations must have clear strategic intent, flexible organisational structure for efficient quality assurance. Difficulties companies experience while implementing ISO:

- Lack of support and commitment from top management
- Staffs resisting change
- Lack of understanding of ISO requirements and ISO 55000 system;
- Limitation of resources (manpower, time and finance)
- Lack of employees training
- Unknown benefit of procuring ISO certification.

An appraisal of existing standard in the organization ought to be check alongside necessities in ISO 55001 to decide the level to which AM are executed and if improvements are necessary (ISO55000 2014). Terminology in ISO 55000 must be clarified within organization's to avoid disparities (Woodhouse 2013); the appraisal provides evidence organization use to formulate strategies for implementing and prioritizing asset management system.

2.5. Impact of interruptions on Asset

Given that small and medium-sized enterprises (SMEs) versus large organizations vary in their operations and strategies (Karuppiah et al. 2020), the impact of breakdown varies across industries (Paul & Chowdhury 2020b). Breakdown can force businesses on altering the way they operate, risk they are willing to accept and their approach to risk management. Most businesses faced financial challenge, logistics issues; these can force plants to operate at reduced capacity, emergency mode or even shutdown completely, which makes maintenance more expensive. While most asset are allowed to operate nonstop due to demand in supply, this can be unfamiliar to these assets and against manufacturer recommendation for business to delay maintenance. Increase in production as per high demand leads to challenges in maintenance as most asset are running to failure; reduction or adjustment in production still needs routine maintenance. The hurdles to maintenance are also suppliers stopping or reducing delivery of spare parts to the plant; non-availability of raw materials, fewer maintenance technicians on each shift. Consequences of delayed proactive maintenance can affect asset condition; increase corrective maintenance, service interruptions and failures, significant financial costs. The consequences of late maintenance are mostly underrated, or not considered in asset management for lack of framework and strategy to accurately measure these consequences. Routine maintenance of critical assets is very important, even when plants are not in operation or operating below capacity. Without routine maintenance, unplanned downtime upsurges with cost, thereby business performance and profit decreases as effect increases cost. Unplanned downtime breed customer dissatisfaction, which affect image of

businesses at a critical time as economy, recovers. Asset management encourages business investing in maintenance to avoid negative impacts on performance. The cost of doing maintenance has increased, with increasing cost of PPE, cost of disinfecting working surfaces, as well as staffing cost. The reduction of maintenance cost will help in times of tight budgets; however, the least possible risk should be considered as the impact might be felt as the economy picks up. Cost reduction must be done very cautiously and systematically to avoid triggering long-term competitive disadvantages. Top management need to do more and better long-term thinking as right choices should be made; while the need to be flexible as for some asset, the right maintenance has to be done at the right time.

During the pandemic some companies transitioned their operations to a 'new normal', providing new services together with previous ones, or striking a different balance; thou seem outstanding but the short and long-term impact on assets needs to be considered (Moktadir et al. 2019). Modification and upgrades of plants or equipment can provide significant advantages over new plant or equipment investment that might normally be considered. The maintenance strategy of a repurpose plant and equipment must be put into consideration, as organisations need to go beyond maintaining their current maintenance strategy. Expertise and knowledge of senior management enhance effective decision on upgrades and modifications of plant and equipment, a clear and unambiguous leadership is required.

Suitable crisis management depends on robust Asset management, which improves plant reliability and performance: Others see crisis as an opportunity, thou uncertain in how to achieve them but the only certainty is cost control and efficiency improvement. Companies must check their asset management strategy, as some will need to go beyond maintaining their current strategy. A factual strategy plays a critical role in decision-making and a robust asset management entails the identification, assessment, management and mitigation of these risks and their consequences. ISO 55000 when implemented changes the way organizations look at business and how the management of assets can help reduce risk and achieve its management goals.

2.6. Hypotheses development from key research gaps in prior studies - linking ISO55000 adoption to improved SMEs Asset management

This section presents the key research questions, developed hypothesis, purpose of this study and key contributions. So far, we have reviewed the importance of maintenance strategy and

asset maintenance tools like *ISO55000*, the factors that affect its implementation generally, its links with other maintenance tools like PAS55 and EAM, and its importance to the survival of SMEs and the role organizational culture plays in maintenance. From the above literature review, we can see that little or no critical research has being carried out with regards to the aspects of ISO55000 that need adjustments for it to be successfully implemented in SMES. This lack of research, in light of the issues presented above, this study seeks to answer the following research questions:

- What are the current practices employed by SMEs to maintain and sustain the management of their assets?
- How can a new approach to ISO55000 be developed to suit SMEs?
- Which ISO 55000 elements are the most important for SMEs?
- How will the adoption and implementation of ISO5500 elements improve SMEs asset management?

Furthermore, in light of the critical issues raised from the review of prior studies, this research proposes hypotheses to be tested. One of the key benefits of ISO55000 successful adoption in huge corporations is the improvement of their asset efficiency. The studies of the ISO55000 show a strong link between adoption of ISO550000 and improved asset performance. For example, a study by Mutuku & Mathooko (2014) concludes that there is a positive correlation between 'ISO55000 adoption' and 'asset performance'. This study therefore makes the following hypotheses in light of SMEs:

Hypothesis $H_{0.1}$: The efficiency of assets will improve with the adoption of ISO55000.

Hypothesis $H_{0.2}$: The implementation of ISO 55000 contributes to effective management of SMEs.

2.7. Summary of Chapter

This chapter critically reviewed both existing literature and prior studies on how SMEs will benefit from ISO55000 concepts and practices for asset management, the benefits of ISO55000 standard, certification, management system, and asset management in terms of performance, concepts, practices and philosophies of Small and Medium-Sized Enterprise (SMEs). Breakdown creates an opportunity for organizations to review their asset management strategy, and its associated risks, when changes in organization context occur (e.g., customer demand changes, new market opportunities, etc.). Activities should also be identified and regularly

reviewed, especially those activities that are required beyond the planning timeframe; processes to objectively establish decision-making criteria should be properly documented.

The research identify that in the current globalized world, the issue of the continuous survival of SMEs and their corporate profitability has become a topical area of concern for business owners, policy makers and local and international government agencies alike. Secondly, existing studies suggest that there is a positive correlation existing between 'asset management', 'asset productivity' and 'asset life'.

Third, the important contributions ISO55000 made is enhancing positive correlations in huge corporations through its holistic approach to asset management. And finally, the need for these positive relationships to be extended to SMEs through the development of a version of the ISO55000 model that better reflect and addresses the challenges peculiar to SMEs.

These key findings lead to the following overarching question emanating from the literature: How can ISO 55000 maintain an edge in Industries? The answer to this question lies in the answers to the four key research questions, restated as follows: RQ1 - What are the current practices employed by SMEs to maintain and sustain the management of their assets? RQ2 - Can a new approach to ISO55000 be developed to suit SMEs? RQ3 - Which ISO 55000 elements are the most important for SMEs? RQ4 - What impact will the adoption and implementation of ISO5500 elements give to SMEs?

In order to answer these questions, the following specific research objectives have to be achieved: (1) To determine the factors that limit the success and growth of small businesses; (2) To contribute towards providing functionally sustainable asset management system in SMEs, which will not only be able to meet present needs but also the future needs as projected by the rapid development (3) To develop a new approach to implement an effective and efficient method through which SMEs could adopt and implement ISO 55001 in Asset Management; (4) To develop a conceptual framework that can be used to identify capabilities needed in the management of assets. This question led to the development of 2 stable hypotheses from the review of existing literature SMEs:

Hypothesis $H_{0.1}$: The efficiency of assets will improve with the adoption of ISO55000.

Hypothesis $H_{0.2}$: The implementation of ISO 55000 contributes to effective management of SMEs. The next chapter addresses in detail the research methodology for testing the above hypotheses and answering the research questions for this study.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the philosophical stance of the research and methods employed in collecting data required for this study. Research philosophy depicts development of knowledge, which includes key assumptions of researcher's opinion towards the world (Saunders *et al.*, 2016). In pursuit to creating knowledge, basic stance of knowledge building like ontology and epistemology philosophies are considered, they support the philosophical position of any research. This chapter also presents the ontological and epistemological stance of this research. The previous chapter critically reviewed the relevant strategic theories behind the thesis' research questions and objectives. The overarching question emanating from the literature is: *How can ISO55000 help SMEs maintain an edge in Industries*? The answer to this question lies in the answers to the four key research questions, restated as follows:

RQ1 - What are the current practices employed by SMEs to maintain and sustain the management of their assets?

RQ2 - Can a new approach to ISO55000 be developed to suit SMEs?

RQ3 - Which ISO55000 elements are the most important for SMEs?

RQ4 -What impact will the adoption and implementation of ISO5500 elements give to SMEs?

In order to answer these questions, the following specific research objectives have to be achieved: *(1) To determine the factors that limit the success and growth of small businesses;(2) To contribute towards providing functionally sustainable asset management system in SMEs, which will not only be able to meet present needs but also the future needs as projected by the rapid development (3) To develop a new approach to implement an effective and efficient method through which SMEs could adopt and implement ISO 55001 in Asset Management; (4) To develop a conceptual framework that can be used to identify capabilities needed in the management of assets.* In order to achieve these objectives this chapter critically evaluates the alternative methodologies used in engineering management research, and provides justification for the choice of the most appropriate research design and methods that would ensure the key research questions are answered. This chapter is divided into four sections.

Section 3.2 provides justification for choice of research design and methods for study, by discussing the different research methods in terms of techniques for collecting data and

procedures for analysis. This is achieved by plotting research design, methods, questions and objectives. Also, the process of identifying, engaging and sampling participants is discussed.
Section 3.3 addresses ethical and other methodological issues;
Section 3.5 showing the piloting of the questionnaires to inform main study.
Section 3.6 provides a summary of the chapter and link to the next chapter of data analysis. The chapter defines the scope of the research design, and positions the research among current research traditions.

This chapter discusses the methodology used in this study, the related issues with the chosen research methodology when investigating the factors affecting the adoption of ISO55000 by SMEs. It also presents the different tools and levels of implementation of ISO55000 by these firms and the relationship between ISO55000 implementation and Asset management performance of these SMEs. This chapter also presents the steps that were taken to address the research design, data collection and analysis methods used to conduct the research in order to realize the research objectives and answer the relevant research questions for this study. It presents first a number of research designs and methodologies available to conduct doctorial research and provides a review of existing literature on research methodologies, research strategies and research methods implemented in the field of Asset management. Subsequently, this study chosen research methodology is justified in terms of appropriateness and usefulness in the quest to achieve the study's research objectives. After this, the research population/ sample, data collection methods employed, stages of collecting the data from the field, the procedures and problems encountered during each stage of the fieldwork as well as the actual data collected and methods of analysis are also explained.

3.2 Research Methodology: Philosophical justification for choice of research design and methods for the study.

Research methodology is "The theoretical, political and philosophical backgrounds to social research and their implications for research practice and for the use of a particular research methods" (Sekaran & Bougie, 2016). Research methodology can be divided into quantitative and qualitative research methodologies that are centred on assumptions, on what represents a valid research and what methods are most suitable for a specific study. Quantitative methodology creates knowledge by examining things that could be gauged while qualitative methodology improves understanding social world we live and why things are the way they

are. The research methodologies used by a researcher depends on the philosophical and theoretical view in their social science research as this research focuses on quantitative methodology. The choice of research methodology most times depends on philosophical issues that are linked to basic principles of ontology and epistemology (Tuli, 2010). Ontology and epistemology are the ground on which researchers build their research, as it forms the strategy to theory and methods. Ontology is concern with nature of existence; understanding what exists and how they exists, how the researcher relates to what is real and factual. Realism is an Ontological position which claims that truth and reality exist independent of human interpretation. Realists believe one truth and reality exist, regardless of our beliefs. Relativism claims that reality is a concept of the human mind as it is relative to the observer and it argues that there are no objective truth or reality but subjective interpretation of reality or truth. Relativism is not entirely an ontological position rather an epistemological stance; realism theorizes an objective reality while relativism challenges the existence of the objective reality and emphases on the subjective nature of knowledge and truth (Moon & Blackman 2014).

Epistemology is concerned with how knowledge is created, ways of knowing and learning about social reality (Bryman & Bell, 2013), it is the correlation between the researcher and reality or how this reality is known. Epistemology describes what knowledge is valid in research, what forms acceptable sources of evidence and end results of knowledge (findings) (Douglas et al. 2010). While ontology supports the existence of reality epistemology supports the measure to which that reality is knowable. Epistemology influence how research is construed and understood, terms established to explain the position of epistemologies in this research are; (post) positivism/ objectivism, subjectivism and constructivism, these categories provide context to quantitative methods used in this research (Moon & Blackman 2014). Positivism beliefs that social reality is objective and independent of individual interest, it takes a slight view on knowledge creation, concentrating on what can be measured and observed. Post-positivism beliefs are portrayed by an assumption that reality can be known with some conviction. Post-positivism was established as a reaction to positivism (Reed, 2010), post-positivism acknowledge individual perception and error, then commits to objective measurement and observation. Objectivism presumes truth and reality exist independently from individual experiences though it is reliant on the object, therefore truth and reality could be determined by thorough investigation. Objectivism was linked to positivism and post positivism, labelling it an objective meaning that exists separately from the operation of any

consciousness. Subjectivism presumes truth and reality is form by independent human thoughts from the object and it is pluralistic. While constructionism discards the theories of both objectivism and subjectivism arguing that truth and reality is a concept originating from the alliance between subject and object, amid mind and world.

Recognition of the ontology and epistemology at the start of research process is very important as it defines the choice of the research design to be adopted which influences the research approach as well as the research strategy, methods of data collection and data analysis. The theoretical perspectives and epistemological stance adopted by the researcher is influenced by the methodology adopted, once a researcher accepts a particular epistemology, he/she normally will adopt methods that are characteristic of that position.

Philosophical Position of this Research

This research adopts positivism and post-positivism philosophy as a suitable approach; as it is linked with scientific research that is often based on formulating hypothesis. Knowledge in this case was demonstrated by hypothesis testing with high structured and sizeable samples, requiring theories to be verified (positivism) or falsified (post positivism). The principle of positivist philosophy was appropriate to the research objectives in terms of independence, exploration of the correlation between variables, objective standards, deductive approach, quantitative and generalization. Ontologically it assumes existence of a single reality, which is external, objective and independent of social actors. Epistemologically it assumes reality can be measured and only observable experiences can provide reliable data. The researcher is independent of the data, the inquiry was value-free and upholds an objective stance.

In order to develop a framework that supports and improves the management of assets at a strategic level, the organizational environment was examined to ascertain the present state of Asset management, context and to pinpoint issues that may arise. The review of past study, modern theories, models and methods was conducted. Several articles, textbooks and websites have being consulted to gather information on different Asset Management related topics, which include Asset Management practices and models, Asset Maintenance Management. Extensive gathering of data on the specific and related fields were undertaken and the acquired data analysed. Through practical application and testing the hypotheses will be validated. The most prevalent methodologies are quantitative research (White & Millar, 2014).

Adopting the appropriate Research methodology ensures contemporary issues such as research validity, data reliability and research ethics are covered using globally and academically agreed procedures (Creswell 2014), (Saunders et al., 2015). In order to understand these issues, a clear understanding of the term 'research', and its association with validity, reliability and ethics in a doctoral research project. Research is referred to as quest for knowledge or academic activity that examines a specific topic from different points of view. The term "research" has being defined in a variety of ways. For example, The Oxford Learners Dictionary (2017) defines research as the 'careful study of a subject, especially in order to discover new facts or information about it. Research is usual refer to as search for knowledge and can also be define as a scientific and methodical search for relevant information on a specific topic. Research aids in investigating or disapproving, modify and re-assert the existing theories and to establish new one.

Designing a research is significant as it guides the researcher to spot the appropriate method of data collection, analysis and circumstances in which the activity of research will be done, considers estimate of funds to be used while preserving the link to the purpose of the research. Flexibility, effectiveness and suitability are the characteristics of a properly developed research design that results in least or no inaccuracy. Formation of a research framework becomes the next step; the framework presents the study objectives in a pictorial pattern containing steps taken to achieve the objective. Determining the theoretical context of the research is a key factor in the research framework. From the above explanations, research in several fields has greatly improved in modern times. The first step in conducting an academic research therefore is the selection of the appropriate research methodology that symbolizes the researcher's philosophy on what is considered acceptable knowledge. This desire to establish universally accepted standards on research designs and systems for research approach has necessitated the development of various research standard criteria.

3.3 Research strategy: Techniques for collecting primary data

Research strategy refers to a clearly laid out plan of how to answer the research question(s) that includes achieving research objectives, detailing the source of data collection, and consider research constraints for this research (Saunders et al., 2015). There are several research strategies available to researchers with each having its advantages and disadvantages. The main strategies used however by most researchers are: surveys, case studies and experiments. What informs a researcher's research strategy should not be convenience; rather it should depend

largely on the research questions and the type of data required to answer the research question(s), objective(s), research philosophy, and the extent of existing knowledge (Easterby-Smith et al., 2014).

- **Questionnaire use in Research:** In order to produce findings that are statistically relevant and findings that can be generalized, the use of survey strategy through questionnaire is best. However, questionnaires have their drawbacks as surveys are generally difficult in terms of time and cost, and it has limited structure since follow-up questions cannot be asked (Easterby-Smith et al., 2014). Despite these difficulties, questionnaires are commonly used in studies relating to Asset Management and SMEs, therefore it is appropriate for this study as it is easy to obtain the minimum sample and this is appropriate in explicitly answering all the research questions.
- **Case study use in Research**: Conversely, case strategy using interviews are ideal for getting deep understanding of the underlining reasons behind the relationships between variables. Another advantage is that it easy to manage since it requires small sample size and unlike questionnaire its design allows follow-up questions which gives researcher opportunity to explore attitudes and perceptions of the subject area deeper. However, case studies/interviews have some documented drawbacks, which include the inability to generalize the study findings across the population since they are not viewed as statistically reliable. Despite these drawbacks, since the aim of this study is to determine how ISO55000 implementation can be used to improve SMEs Asset management, case studies/interview can be an appropriate instrument in understanding the factors that hinder the implementation of ISO55000 in SMEs.
- **Use of archival studies in Research:** Another instrument available to researchers is Archival studies, which employs the use of secondary data and thus not new data collection. Despite the fact that this method is generally cheap to implement, its drawbacks include the fact that archival studies does not allow researchers to explore underlying relationship, it is rare getting enough data that covers all variables required for the new research from historical archives and since the researcher has little control over how the data was collected, it raises the question of data reliability and credibility. As a contemporary tool, obtaining secondary/archival data on ISO55000 in SMEs asset management will not be an appropriate data collection method for this study. However, secondary/archival data on ISO55000, SMEs and asset management are used in the

literature review chapter. Furthermore, a comparison between the finding and archival data of this study will be used to assess the contribution to knowledge.

- **Action Research use:** Action research is another data collection instrument available to researchers, which accords a researcher opportunity to fully control the situation as the researcher is embedded in the data itself. It requires the researcher to be part of the company on which the research is based in order for it to be solution-driven and used in work or real-life situations. However, it is a very difficult, time-consuming and complex data collection method and it is extremely difficult to write up findings. Furthermore, there are issues of bias and findings credibility since the research is actively involved in the process being investigated. Therefore, for this study, action research is an inappropriate tool as the researcher is not an employee or an active participant in any SME.
- **Experimentation use in Research:** Similar to Action research, Experimentation is most appropriate for controlled environment and research situations and gives researcher greater control over the variables, good results and clearer cause and effect relationship. It however exposes research to issues of ethics and practicality due to artificial situations-controlled environments presents. Since it accords a researcher greater control, it is subject to human error, unreliability of data collected, efficiency of results, generalizability of findings, it is very expensive and may not reflect real life situations since it is a contrived scenario. It is therefore not relevant for this study since replication of the variables for assessing ISO55000 in SMEs in a controlled setting is not practical or feasible.

This study uses questionnaires in the collection of data, as they are most appropriate; it has being successfully used in researches regarding Asset management and SMEs. Primary data for this study is thus obtained from questionnaire survey of SMEs (engineering, maintenance and oil industries). Data was gathered through the distribution of a survey questionnaire to company staff in charge or operate their assets, the objective of the questionnaire survey is to identify the issues relating to Asset Management in SMEs. The development of the survey questionnaires was determined based on identified factors revealed from the literature review such as SMEs scope, ISO55000 framework, requirements and scope, and asset management in terms of policy, practice and expected outcomes. The response scales for the questions in the questionnaire were designed for easy understanding for the targeted SME respondents, which

include equipment operators and technicians, asset managers and maintenance managers. For this study, the underlying philosophy on which the questionnaire is developed is based on the following:

- Information required from questions in the questionnaire is what respondent can provide easily with no ethical issues, breach of confidentiality nor compromise of company secrets.
- The numbers of questions in the questionnaire were limited so that respondents are likely to fully complete the questionnaire and successfully interpret these questions through the use of simple and clear language were possible.
- Broad long-winded questions were avoided; rather specific questions were used in the questionnaire using closed-ended question structure
- Respondents of the study were provided the opinion to select a 'no-opinion' or 'I don't know' thereby ensuring that the questions are not construed as leading questions.
- Wider Likert scales were employed rather than the narrow 'agree / disagree' response options
- The questionnaire sequences were ordered from general to specific with no ambiguity.
- Questions with more than one item were avoided to increase the integrity of response.

3.3.1 Quantitative research Questionnaire Design - Quantitative Data in this study

One of the most popular designs to conducting social research is the Quantitative approach which is rooted in a strong academic philosophy that places huge trust in numbers that represent diverse concepts and opinions (Mertens et al., 2017). Quantitative methodologies focus on objectivity, relationship, and reliability; research questions are addressed using variables. As a result, quantification in the collection and analysis of data is how quantitative research is conducted. Variable (correlations, regressions and factor analysis) are suitable for addressing studies concerned with "how variables, observed, relate to each other" (Wang et al., 2013) and generate results based on an averaged set of parameters. It relies mainly on a theoretically deductive hypothesis with an objective to test the theory by way of observation and data collection, the findings of which, following analysis, would either confirm or reject the theory.

The designed and applied questionnaire gathered data that measure relations between or among variables; it used a Likert scale technique that presented a set of statements. Respondent were asked to indicate agreement (by way of support) or disagreement on a five-point scale with

positive and in one case a negative statement, this will ease comparison within the various questions. Numerical value was given to each degree of agreement from one to five, which enable ease analysis of responses. For respondent with neutral reaction, an odd number of steps to permit the use of a middle step meaning 'neither agree nor disagree was selected. Fundamental considerations were taken into account in the questionnaire development and application. The first fundamental consideration is clarity of what each questionnaire scales should measure. The Second fundamental consideration is ensuring that the measuring instrument is designed from a critical theoretical review and developed into question theme. The researcher helped design the Likert scale for this questionnaire and a validated questionnaire comprising of open and close-ended question used to gather data from primary users in the field. The questionnaire was distributed within SMEs and addressed to persons that are directly involved in the field of Asset Management. The questionnaires from the equipment operators, Asset engineers and maintenance engineers (Appendix I) were used to ask about SMEs, Asset management, maintenance tasks, their skill levels and opinions about ISO55000 and the Implementation. The questionnaires also asked for the respondents to explain what they believe are the necessary requirements or constraint in Implementing ISO55000. This is critical because some of the respondents are sufficiently knowledgeable on ISO55000 to be able to answer this effectively while for others, the aim is to capture their perceptions to triangulate against the actual detail of what is required for ISO55000 as stated in the framework

The questionnaire used in the data collection was verified and confirmed accurate by experts in Asset Management and Asset Maintenance Management, endorsement of the content appropriateness was made. The questionnaire queried participant's opinions on asset maintenance and awareness on the implementation of ISO55000. Respondents were asked elements in ISO55000 they would want implemented in their various companies. Underpinning the questionnaire design are the following testable hypotheses developed in the literature review chapter:

$H_{0.1}$: The efficiency of assets will improve with the adoption of ISO55000.

$H_{0.2}$: The implementation of ISO55000 contributes to effective management of SMEs.

Appendix I, shows the final full version of the questionnaire used in the main study, after an initial pilot study led to rephrasing of some of the questions.

For ethical reasons, the questionnaire does not capture the demographic characteristics of respondent e.g. age, gender, marital status, employment status and educational level. It uses a 3-point Likert scale where '1' indicates 'Yes', '2' indicates 'No' and '3' indicates 'I do not know'. Also in the questionnaire are 5-point Likert-scale, where, '1' indicates 'strongly disagree', '2' for 'disagree', '3' for 'neither disagree nor agree', '4' for 'agree' and '5' for 'strongly' agree. There are 6 pre-selected themes based on the literature review on Asset management, SMEs and ISO55000. These themes are linked to helping answer the research questions in the study, the questionnaire design and in solving the proposed hypotheses for this study. These pre-selected themes are shown in the table below:

Table 3.1
Pre-selected themes used in Questionnaire design
Source: See Appendix I

Broad Themes	Related Research question	Specific Questionnaire questions
Theme #1 – Asset Management-planning	RQ1	29,8, 10,16,21,28,30,31,32
Theme #2 – SME-firm structure	RQ1, RQ2	2,4,5,7,9,12,19,20,21,27,28,31
Theme #3 – Asset Management-implementation	RQ4	11, 13,15,18,20,30
Theme #4 – ISO55000 and management tools	RQ2, RQ4	22, 23,24,25,27
Theme#5- Asset Management-control	RQ4,	8,14,17,30,32
Theme #6- SME-needs	RQ3, RQ1	26, 31,3,6

RQ1 - What are the current practices employed by SMEs to maintain and sustain the management of their assets? RQ2 - Can a new approach to ISO55000 be developed to suit SMEs? RQ3 - Which ISO 55000 elements are the most important for SMEs? RQ4 - What impact will the adoption and implementation of ISO5500 elements give to SMEs?

3.3.2 Identification, recruitment and sampling of participants - questionnaires

Before the participating SMEs were selected for this study, a pool of 30 Small and Medium scaled enterprises (SMEs) were identified and then contacted informally by email and/or telephone, to find out if they were interested in participating in the study. 13 out of the 30 contacted responded positively through email and/or telephone. A mix of operations managers, assets and maintenance engineers in the 13 SMEs were written to formally, and presented with Participant Information Sheet (Appendix II). Out of the 13 SMEs presented with the Participant information sheet, 8 SMEs voluntarily agreed to take part in the study (Appendix II). More specifically, the process of conducting the questionnaire survey required the researcher to develop 8 contact persons in the 8 SMEs for the purpose of populating the online questionnaire within their email system. These contact persons were incentivized to administer the questionnaires randomly by email to willing workers within their firms between May and

August 2017. The workers had the choice of completing the questionnaires at their convenience. Therefore, they would have vital information on maintenance procedures of the firm, production outputs of the machines and deep insight on if the firm were currently achieving their asset maintenance objective. Similarly, both Asset managers and Maintenance engineers have information critical to this study on firm operations using the assets and equipment of the SMEs to produce their goods and services. Therefore, they would have vital information on maintenance procedures of the firm, production outputs of the machines and deep insight if the firm were currently achieving their asset maintenance objective in their respective organisations. The participants were identified through snowballing and convenience sampling techniques, involving managers in the participating SMEs, and were recruited formally, and presented with Participant information sheet and consent form (Appendix II).

3.4 Procedures for quantitative data analysis to achieve research objectives

The online questionnaires responses were collated from google survey and exported to Microsoft excel version 2016. Labels, codes and measuring criteria were then assigned to each row in preparation for SPSS analysis. The data was then exported and subjected to statistical analysis using Factor analysis, followed by multiple regression analysis procedures available on IBM Statistical Package for the Social Sciences (SPSS) version 22 for Windows.

A 5-Step Procedure for Quantitative data analysis
Source: (Williams & Sutton 2011; and Easterby-Smith et al., 2014)

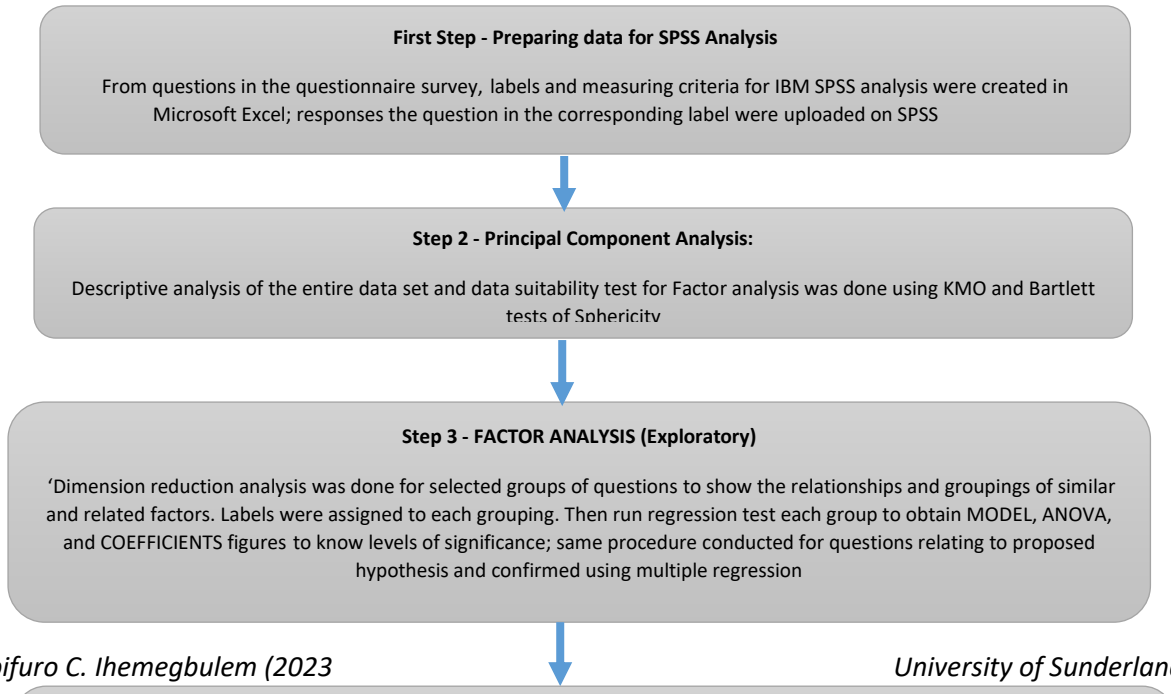


Figure 3.1: procedure employed in the study

In order to effectively answer the research questions in this study, effective analysis of the quantitative data is required. This will help explore the critical success factors in the implementation of ISO55000 in SMEs asset management and the underlining links between these factors. The exploration of these underlining links provides deeper understanding on the exact nature of the factors driving and hindering the implementation of ISO55000 as stated by the participants.

3.5 Addressing ethical and other methodological issues

Ethical issues refer to a researcher's code of conduct and attitudes with relation to participants' rights (Easterby-Smith et al., 2014). The need to address ethical issues has become topical especially in business and management research because individual participants and participating organisations may be affected directly or indirectly by the outcome(s) of the study (Saunders et al., 2015); (Bryman & Bell 2015)). This section therefore deals with the relevance of ethics in engineering research as they relate to the credibility of the study in terms of validity and reliability, and generalizability.

3.5.1. Addressing ethical issues in this study

In order to achieve research integrity and standard, codes of conduct were strictly adhered to at all stages of this study; this includes from the selection of appropriate research topic, to the fair but critical review of relevant literature, to methodology justifications and the types of data collection instruments used and analysed and finally in the non-plagiarized write-up of research findings. The research follows the strict guideline as laid out in the University of Sunderland's Ethical Policies, Procedures and Practice for Research (UoS, 2016) were followed at every

stage of the research process. Although this researcher acknowledges that all issues of ethics cannot be totally eliminated from any research, by adhering to the strict norms in research, this researcher ensured no harm came to neither the individual research participants, participating firm, University of Sunderland nor the researcher herself (Saunders et al., 2015).

Table 3.2 below highlights the applicability of key ethical issues in the study and how they were addressed during the 4 stages of this research. The rights of the research participants; obtaining participants' consent; voluntary research participation; avoiding any possible harm to participants or participating firms; Research participants' right to privacy, anonymity, confidentiality, and handling and storage of data securely are some key ethical considerations made in this research. For example, the research area of Asset Management, ISO55000 and SMEs are all acceptable areas of doctoral research in University of Sunderland and thus were approved by the University of Sunderland Research Ethics Committee. Therefore, no ethical issues or rights were infringed upon in this stage since here neither rights, consent, anonymity and privacy of participants, nor were confidentiality and data security of any significant concern.

Ethical issues	Stage 1 – appropriateness of the research topic	Stage 2 – critical review of literature	Stage 3 – appropriateness of research design and methods	Stage 4 – write up and dissemination of findings
Voluntary participation	N/A	N/A	Applicable	N/A
Participants' consent	N/A	N/A	Applicable	Applicable
Rights of participants	N/A	N/A	Applicable	Applicable
Preventing harm to participants or participating firms	N/A	N/A	Applicable	Applicable
Participants' right to privacy	N/A	N/A	Applicable	Applicable
Anonymity	N/A	N/A	Applicable	Applicable
Confidentiality	N/A	N/A	Applicable	Applicable
Data security in terms of handling and storage.	N/A	N/A	Applicable	Applicable

Table 3.2
How specific ethical issues were addressed in this study

Table 3.2 above also show that no ethical issues arose in the literature review stage as the researcher avoided plagiarism in writing, proper referencing of sources of different prior

studies. Therefore, no ethical issues or rights were infringed upon in this stage since here neither rights, consent, anonymity and privacy of participants, nor were confidentiality and data security of any significant. In the methodology stage, the research ensured rights, consent, anonymity and privacy of participants, confidentiality and data security were guaranteed at all times and that only the appropriate tools and questions relating to the topic at hand were asked. Finally, in the last stage of this study, the researcher ensured that consent from all participants before the publication of findings and that all stored data are destroyed appropriately. In terms of risk assessment before commencement of the study, in order to eliminate personal risks, In addition, during the data analysis and reporting stage, data protection policies outlined in the research ethics of the Sunderland University were adhered to with all personal identifying factors striped from the transcripts in order to maintain anonymity and confidentiality.

3.5.2 Major Limitations of the choice of Methodology for the study

A common methodological limitation of the chosen methodology for this study is the credibility of quantitative data since the honesty of respondents contributes to the validity of research findings. Therefore, to reduce this limitation, this researcher ensured participant were aware that this research was for purely academic purpose and thus honest answers would help in developing a framework on how ISO55000 can be successfully used in Asset management of SMEs. The limitation of the questionnaire survey is the lack of depth in providing insights on the reasons hindering the adoption of ISO55000.

3.5.3 Piloting of Questionnaires schedules to inform main study

Before the questionnaire survey schedule for the study was arrived at, a rigorous pilot study was done to determine the appropriateness and validity in asking the different questions. In the case of the questionnaire study, an earlier version of questionnaires was first piloted to a small group of people comprising of 16 respondents. This initial piloting resulted in some changes to the questions in the main study due to feedback received from the pilot group. For example, the piloted Likert-scale statement/question: How many people are involved in the asset management function? Was confusing to respondents as they all played a role in asset maintenance in some capacity? This led the question being removed in the final draft of the questionnaire for the main study. The results of the pilot study enabled the researcher to expand the scope of the respondents.

In total, 128 questionnaires were completed and included in the analysis, yielding a 12% response rate. This sample size is considered acceptable given the sample size of studies on

asset (Emmanouilidis & Komonen, 2013) and maintenance (Simões, et al., 2016) management. The questionnaire was responded to by organizations that were located in UK and Nigeria. Majority of responses to the survey were from the manufacturing industry (51.6%).

Industries (Standard Industrial Classification)	**Share (%)**
Manufacturing	51.6
Construction	9.3
Electricity and Gas Supply	13.6
Information and Communication	8.1
Automobile	17.4
Total	100

Table 3.3. Sample distribution by Industry

3.6 Summary of chapter

This chapter explores the concepts of research methodology, philosophical considerations; the ontological and epistemological assumption explained justifies the choice of methodology and methods of this research. It looked at the research approach and strategy adopted to address the research objectives and further provides a rationale for the choice of research approach and methods adopted for data analysis. Quantitative paradigms judge the quality of a research with the terms reliability, validity; this is based on the principle that reliability and validity assume that a single, total truth of social reality is possible. Data were collected from questionnaires with non-participant observations; thus enabling the research findings, this was deemed to be the most appropriate method in order to explore the Asset management process within SMEs. The responses from the questionnaires was subjected to statistical analysis using Factor analysis, followed by Multiple regression procedures available on IBM Statistical Package for the Social Sciences (SPSS) version 22 for Windows. Section 3.3.4 dealt with the issues of Identification and sampling of participants - questionnaires. Section 3.4 itemized the Procedures for quantitative data analysis to achieve research objectives while section 3.5 Addressed issues of ethics and methodological limitations and how Piloting of Questionnaires informed the main study. The ethical issues addressed include: the rights of participants; seeking participants' consent; asking for voluntary participation; avoiding any possible harm

to participants or participating firms; respecting participants' right to privacy, anonymity, confidentiality, and data security in terms of handling and storage. The next chapter present the results of the quantitative analysis of responses from the questionnaire, followed by discussion and interpretation of findings. The research was undertaken in an unbiased way, the researcher is independent of the data and maintains an objective stance.

CHAPTER FOUR
DATA ANALYSIS

4.1 Introduction

The purpose of this chapter is to present the primary data of this study comprising of questionnaires and followed by their individual analysis. First, using statistical techniques, the questionnaires responses are analysed with the help of the IBM SPSS software. The rationale for these analyses is to provide answers for the key research questions (RQ1-RQ4), achieve the research objectives (RO1-RO4), and verify the postulated research hypotheses ($H_{0.1}$-$H_{0.2}$). The second purpose of this chapter is to present the discussions and interpretations from the questionnaire and compare with contrast findings from prior studies; through this rigorous process the contributions to knowledge of this study is made clear.

To achieve the purpose of this chapter, it will subsequently be divided into 5 key sections: Section 4.2 presents the findings from the online questionnaire survey of 129 SME staff involved in asset management. The next Section 4.3, presents the interpretations of the findings and from these builds critical discussions which includes comparing and contrasting the findings with the findings from prior studies. This formed the basis for teasing out the study's contribution to knowledge and the theoretical and practical implications from this study. Subsequently, Section 4.4 provides the key results and discussions from the chi-square test of questionnaire. Finally, Section 4.5 provides a summary of the chapter and a link to the next chapter on the conclusions and recommendations of the study.

4.2. Presentation of the Results: statistical analysis of the questionnaire survey

The aim of this section is to present the primary data collected for this study; this begins by presenting the data collected through the questionnaire survey and its analysis subsequently.

4.2.1. Presentation of the results from the statistical analysis of the questionnaire survey

Link access were sent to the 8 contacts within the 8 SMEs who had agreed to take part in this study and each contact was informed that the target should be responses from 25 staff members per SME in order to achieve a target of 200 questionnaire responses. The questionnaire links was distributed via internal email by the contacts and out of the targeted 200 questionnaire responses, 128 online questionnaires we duly completed and collated using the google survey form. This study indicates a good response rate of 64% (*128/200 X 100)* (Saunders et al., 2015); 128 questionnaires were fully completed and used for analysing the quantitative data of this study. The next subsection presents the results from the analyses of the 128 questionnaire responses.

4.2.2. Development of questionnaire measures and scales: Exploratory Questionnaires Survey of Customers data preparation for analysis.

This section presents the development of dependent and independent variables for this study. The first step before the analysis is to first export the data from google drive to Microsoft Excel in order to prepare the data for rigorous analysis. Each column on the excel spread sheet was painstakingly labelled using the full questions asked in the questionnaire. The next step was to create a unitary system for measure. This involved developing measuring scales for each question type. For example, for questions with 5 Likert scale responses (e.g. have you adopted ISO 55000? Which of the following elements in ISO 5500 structure have you adopted? What are the major barrier faced towards development and implementation of Asset Management process), '1' indicates 'strongly disagree', '2' for 'disagree', '3' for 'neither disagree nor agree', '4' for 'agree' and '5' for 'strongly agree' as indications of their responses to the questions asked. Similarly, questions that required multiple selections where further re-categorised and spit up so that each option had an option of 'yes' (1), 'No' (2) and '3' (I do not know) depending on the option that was selected by respondents. The next step was to conduct a simple frequency of response and develop self-explanatory charts on Excel spread sheet. The data is then carefully transferred to IBM SPSS spreadsheet for rigorous analysis. Each column was coded giving it short names alluding to the theme of that question, while the full questions were typed in the labelling columns. The measuring scales of 1-6 or 1-3 were then inputted in the variable view making the data ready for SPSS analysis. The next section presents an overview of the descriptive statistics of the questionnaire followed by rigorous statistical analysis.

4.2.3 Factor Analysis: Exploratory Questionnaires

Factor analysis is a symbiosis method its main purpose is to describe the underlying construct within variables in the analysis (Hair Jr et al., 2014); it uses significant patterns inside large amount of data and exploratory data analysis to examine underlying factors from certain set of variables. Factor analysis backs data interpretations as a linear statistical model by decreasing variables that extracts highest common variance from all variables and puts them into a mutual score (Bartholomew et al., 2011). Exploratory Factor Analysis and Confirmatory Factor Analysis (CFA) are two types of factor analysis. Exploratory factor analysis (EFA) determines the kind concepts that influence certain responses; it reveals the underlying factor model that suits the data best. Exploratory Factor Analysis was done to see how the different Asset Management, ISO 55000 and SME items in the questionnaire interact with each other and

crystalize to proffer generic quantitative-based solutions for implementing ISO55000 in SME Asset management drive.

4.2.3.1 Factor Analysis Steps

Three main steps for factor analysis are; assessment of the suitability of the data, factor extraction, and factor rotation and interpretation.

Step 1: Data Suitability Assessment

To determine data suitability, sample size and strength of the relationship have to be considered through a series of tests such as sample size adequacy, effective size to determine the correlations within the variables using Data factorability. In addition, the determination of the extent of homogeneity of variance across samples through Bartlett's Test of sphericity, and determination of sampling adequacy through Kaiser-Meyer-Olkin (KMO) test (Hair et al. 2010; Pallant 2010); all available in the IBM software SPSS which was used. It is however important to note that it is not in every situation that size of research sample is critical, large sample is recommended for factor analysis however, a small sample size can also be adequate if solutions have high loading marker variables consequently the sample size of 128 for this study is deemed sufficient, as it is significantly higher than the minimum suggested in the aforementioned studies.

Step 2: Factor Extraction

Factor extraction involves establishing the smallest number of factors that can be best use to represent the correlation among set of variables. To obtain factor solutions, principal component analysis and common factor analysis is used, the selection of each of these procedures is dependent on research objectives. The categorization of driving factors of ISO55000 in Small and Medium-Sized Enterprise (SMEs) and factors for enhancement of performance of business and equipment by ensuring regularly and efficiently performance to prevent loss or breakdown are the main objectives of this study. Against this backdrop, PCA was selected as the appropriate analytical procedure for this study in order to achieve the minimum number of factors needed to represent the data set. Two methods used in deciding what factors to extract and retain; Kaiser's criterion (Eigenvalue Criterion) and the Scree test to determine the number of unrotated factors to be extracted.

Step 3: Factor Rotation and Interpretation

Factors gotten in the initial extraction stage are usually challenging to interpret because of significant cross loadings in which several factors are correlated with several variables. Orthogonal factor rotation is used in this study; the results are simpler to interpret. Varimax technique was used to reduce the number of variables that have high loadings on each factor. Table 4.1 below presents the results of Communalities for this study and the most of the loadings are 0.6 or greater indicating a strong correlation between the items of a variable and all other variables.

4.2.3.2 Factor

```
 /VARIABLES SME_prob_severity Maintenance_strat Maintenance_strat_appropraite
Existing_maintenance_plan Maintence_activity_triggers Maintenance_KPI
maintenance_plan_hinderance
Good_KPI_measures Asset_mgt_proceedure_availability centralized_asset_mgt
Asset_mgt_barriers
comp_asset_mgt_vision Asset_mgt_policy_implementation existing_ISO_cert
ISO55000_awareness
SME_greatest_needs ISO55000_compliant_structure_in_place SME_risk_plan
Asset_mgt_levels
Asset_mgt_implementation_support_level Asset_mgt_performance_evaluation_level
Asset_mgt_internal_audit_level Asset_mgt_improvement_level
 /MISSING LISTWISE
 /ANALYSIS SME_prob_severity Maintenance_strat Maintenance_strat_appropraite
Existing_maintenance_plan Maintence_activity_triggers Maintenance_KPI
maintenance_plan_hinderance
Good_KPI_measures Asset_mgt_proceedure_availability centralized_asset_mgt
Asset_mgt_barriers
comp_asset_mgt_vision Asset_mgt_policy_implementation existing_ISO_cert
ISO55000_awareness
SME_greatest_needs ISO55000_compliant_structure_in_place SME_risk_plan
Asset_mgt_levels
Asset_mgt_implementation_support_level Asset_mgt_performance_evaluation_level
Asset_mgt_internal_audit_level Asset_mgt_improvement_level
  /PRINT INITIAL CORRELATION SIG KMO EXTRACTION ROTATION
  /FORMAT BLANK (.30)
  /PLOT EIGEN
  /CRITERIA FACTORS (4) ITERATE (25)
  /EXTRACTION PC
  /CRITERIA ITERATE (25)
  /ROTATION VARIMAX
  /SAVE REG (ALL)
  /METHOD=CORRELATION.
```

The Tables below presents the outputs from the SPSS explorative factor analysis of the 33 variables from the questionnaire.

Communalities

	Initial	Extraction
3) Levels of problems faced by the SME	1.000	.652
5) Levels of company's maintenance strategy	1.000	.809
6). Do you believe that this strategy to maintenance is the most appropriate method for the company?	1.000	.568
7). Does your organization have an existing maintenance plan?	1.000	.366
8) Levels of maintenance activity triggers	1.000	.712
9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance?	1.000	.576
11) Levels of hindrance to maintenance plan implementation	1.000	.539
12) Levels of company's KPI measures	1.000	.627
14). Are there written processes for asset management and are they made accessible?	1.000	.738
15). Asset management is centralized within your company?	1.000	.652
18) Levels of barriers to development and implementation of Asset Management process	1.000	.173
19). Company has a training/education/development vision to ensure that the long-term asset management strategy can be delivered.	1.000	.566
20). Can your company translate Asset Management Policy & Strategy into clear business objectives and Lifecycle Plans for specific assets as well as asset types.	1.000	.475
22). Does your organization have an ISO certification?	1.000	.252
24). Are you aware of ISO 55000?	1.000	.686
26) Levels of your company's greatest need	1.000	.660
27). We do have the organizational structure to comply with ISO 55000	1.000	.607
28). Planning [The organization has planned actions to address risks and opportunities, taking into account how these risks and opportunities can change with time]	1.000	.344
29) Levels of Asset management	1.000	.502
30) Levels of support in Asset management implementation	1.000	.466
31) Levels of performance evaluation in Asset management	1.000	.462
32) Levels of internal audit in Asset management	1.000	.461
33) Levels of improvements in Asset management	1.000	.412

Extraction Method: Principal Component Analysis.

Table 4.1 Communalities

Rotated Component Matrix[a]

	Component			
	1	2	3	4
3) Levels of problems faced by the SME				.798
5) Levels of company's maintenance strategy	.658			
6). Do you believe that this strategy to maintenance is the most appropriate method for the company?			.568	
7). Does your organization have an existing maintenance plan?			.546	
8) Levels of maintenance activity triggers	.550			
9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance?			.693	
11) Levels of hindrance to maintenance plan implementation		.590		
12) Levels of company's KPI measures		.585		
14). Are there written processes for asset management and are they made accessible?			.774	
15). Asset management is centralized within your company?			.522	
18) Levels of barriers to development and implementation of Asset Management process	.385			
19). Company has a training/education/development vision to ensure that the long-term asset management strategy can be delivered.	-.529			
20). Can your company translate Asset Management Policy & Strategy into clear business objectives and Lifecycle Plans for specific assets as well as asset types.	-.651			
22). Does your organization have an ISO certification?				-.399
24). Are you aware of ISO 55000?		-.763		
26) Levels of your company's greatest need		.759		
27). We do have the organizational structure to comply with ISO 55000		.771		
28). Planning [The organization has planned actions to address risks and opportunities, taking into account how these risks and opportunities can change with time]			.558	
29) Levels of Asset management	.704			
30) Levels of support in Asset management implementation	.604			
31) Levels of performance evaluation in Asset management				.515

32) Levels of internal audit in Asset management	.676			
33) Levels of improvements in Asset management	.626			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Table 4.2 Factor loading for the rotated factors

The decision to use rotated component matrix instead of the unrotated component matrix is informed by the fact that rotated component matrix presents a considerably clearer factor structure and therefore a truer representation of item loadings per factor. Table 4.2 above presents the rotated Component Matrix of the factor analysis.

The rotated component matrix results show 4-factor solutions. A few things can be observed in the rotated component matrix; with factor 1 having 9 loaded items and a variance of approximately 25.2%. The loaded items for component 1 are *company maintenance strategy, maintenance triggers, and barriers to Asset management, Lack of training, Lack of Asset management objective, Asset management level, and Asset management support*, all of which were labelled as ***Develop comprehensive Asset Management Strategy*** due to the similarities between each loaded item. The labelling of components is done based on identifying the sub-themes as items loading on each component, establishing the similarities in each sub-theme and creating a new theme by combining the similar elements of the sub-themes as is shown in table 8 below. Factor 2 (labelled as ***organisational needs and ISO55000 compliant structure*** loaded items (hindrance to maintenance plan implementation, *Company success measure, Are you aware of ISO 55000,* company's *ISO 55000* need and *organizational structure to comply with ISO 55000*) and a variance of approximately 11.7%. Factor 3 (labelled as ***Risk management, monitoring and control strategy)*** has loaded items; believe the strategy to maintenance, *existing maintenance plan, use any KPIs in maintenance, Accessible Asset Management policies, Centralised Asset Management and Plan for Risk management;* and a variance of 9.0%. Factor 4 (labelled as ***Operational issues and evaluation****)* has loaded items; SME Problem, lack of ISO certification and performance evaluation; and a variance of 7.6%. These 4 factors account for cumulative percentage of 53.5.

Component Transformation Matrix

Component	1	2	3	4
1	.723	.453	.493	.170
2	-.650	.700	.260	.141
3	-.233	-.520	.822	-.009
4	-.034	-.185	-.116	.975

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 4.3 Component Transformation Matrix

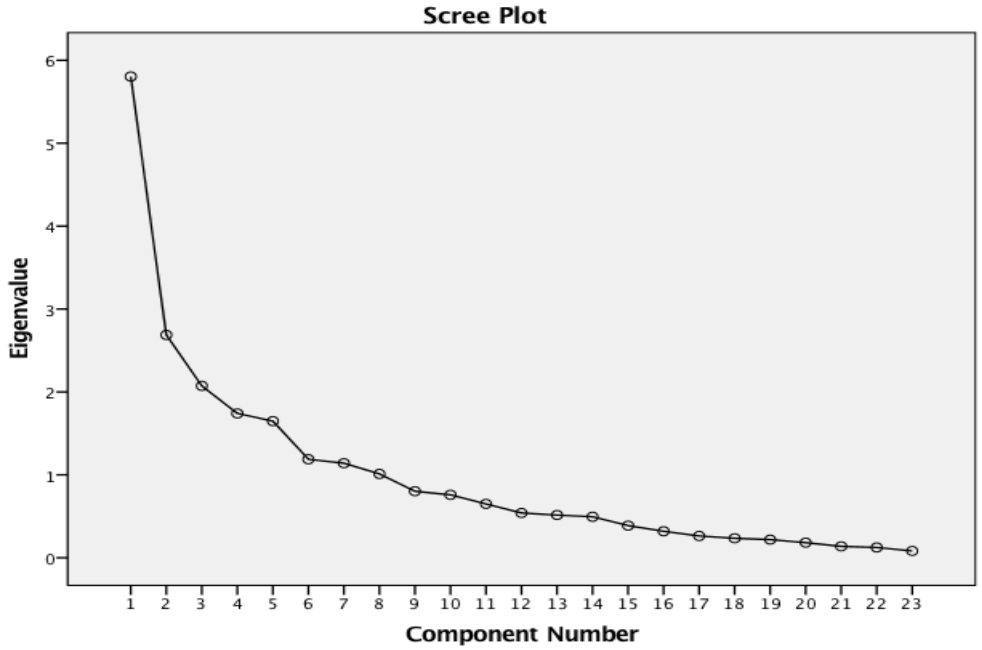


Figure 4.1: Scree plot for component extraction criterion

Figure 4.1 Scree plot, a graph with eigenvalues on the y-axis against the twenty-three component numbers in order of extraction on the x-axis. The scree plot is used to ascertain the number of factors that can be extracted and retain.

Table 4.4 Total Variance Explained by Extracted Factors

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.804	25.234	25.234	5.804	25.234	25.234	4.280	18.609	18.609
2	2.687	11.683	36.917	2.687	11.683	36.917	3.128	13.602	32.211
3	2.073	9.014	45.930	2.073	9.014	45.930	3.019	13.125	45.337
4	1.741	7.569	53.500	1.741	7.569	53.500	1.878	8.163	53.500
5	1.648	7.165	60.665						
6	1.188	5.166	65.831						
7	1.140	4.958	70.789						
8	1.011	4.396	75.185						
9	.802	3.487	78.672						
10	.759	3.298	81.970						
11	.649	2.823	84.793						
12	.540	2.348	87.141						
13	.515	2.239	89.381						
14	.494	2.149	91.530						
15	.388	1.687	93.217						
16	.319	1.389	94.605						
17	.263	1.142	95.747						
18	.235	1.020	96.767						
19	.218	.948	97.715						
20	.182	.793	98.508						
21	.137	.597	99.105						
22	.124	.538	99.643						
23	.082	.357	100.000						
Extraction Method: Principal Component Analysis.									

Table 4.4 explains the eigenvalues and total variance; principal component analysis was the extraction method used in this study. Twenty three (23) linear components are acknowledged within the data set before extraction, then after extraction and rotation four linear components within the data set for the eigenvalue > 1. The four factors extracted recorded a combined 53.5% of the total variance. As proposed the proportion of total variance described by the retained factors should be at least 50%. This result shows KMO value of 0.680, which signifies that factor analysis is suitable for the variables and the first solution implies that the final solution will extract not more than four factors. The first component has explained 18.6% of the total variance with eigenvalue 5.8. The second component has explained 13.6% variance with eigenvalue 2.68. The third component has explained 13.13% variance with eigenvalue 2.1. The fourth component has explained 8.16% variance with eigenvalue 1.74.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.680
Bartlett's Test of Sphericity	Approx. Chi-Square	1510.031
	df	253
	Sig.	.000

Table 4.5 KMO and Bartlett's tests of the suitability of the data for factor analysis

Table 4.5 illustrates the value of KMO statistics is equal to 0.680 > 0.6 which indicates that sampling is adequate and the factor analysis is appropriate for the data. KMO values between 0.6 and 0.7 are good while those above 0.8 are excellent; thus, give an indication that factor analysis is appropriate for the data collected and further supports the application of a principal Component Analysis (PCA) (Kaiser 1974). For this data set, the KMO is 0.680, which is adequate for sampling and indicates the correlation patterns are compact and thus will produce distinctive and reliable results. Bartlett's test of sphericity is highly significant at $p < 0.000$ shows strong the relationships between the variables in the data set. Chi-square test value is of 1510.031 with a correlated degree of significance that is less than 0.000. The significant value < 0.05 suggests that the use of dimension reduction of the factors is appropriate.

There is no general view on the optimal number of factors to be extracted and it is entire left to the researcher to decide what number is best that will better explain the underlying relationship among the variables (Pallant, 2010). This study through critical literature review identifies asset

management drivers and theories and this information was used as a guide in selecting the number of factors to be extracted. Besides the Kaiser Criterion and extracted cumulative percentage variance ends when the limits of the highest variance is reached. Thereby ensuring the goal of factor analysis, which is to group large variables to a manageable amount, is achieved (Pallant 2010). It is however important to note that the fewer manageable amount obtained after extraction is comprehensive enough to cover much of the components tested.

4.2.1.3 Hypothesis Testing

The following hypotheses were conducted: (1) 'adoption of ISO55000' against all items in the questionnaire and; (2) 'Having Complainant ISO 55000 organizational structure' against all items. Table below Hypotheses Testing - using ANOVA Regression Analysis.

Table below presents the results of the hypothesis tests. In summary, all hypotheses should be accepted. The above general hypothesis is split up into the following two hypotheses:

$H_{0.1}$: The efficiency of assets will improve with the adoption of ISO55000.

$H_{0.2}$: The implementation of ISO 55000 contributes to effective management of SMEs.

***Testing $H_{0.1}$:** The efficiency of assets will improve with the adoption of ISO55000.*

In Table 4.6, for Hypothesis 1 (H0.1) we can see that for the independent or predictor variables, the R-value and R-square value are respectively 0.530 and 0.281. The R-value of 0.530 suggests a strong positive (uphill) linear relationship between customer communication capabilities and service quality; thus, the hypothesis should be rejected. The R-square value of 0.281 suggests that the relationship can be explained statistically; thus, further suggesting that the results from PCA cannot be used conclusively and may require further qualitative testing.

Regression

```
 /DESCRIPTIVES MEAN STDDEV CORR SIG N
 /MISSING LISTWISE
 /STATISTICS COEFF OUTS R ANOVA COLLIN TOL CHANGE ZPP
 /CRITERIA=PIN (.05) POUT (.10)
 /NOORIGIN
 /DEPENDENT ISO55000_adoption
 /METHOD=ENTER Maintence_activity_triggers maintenance_plan_hinderance Maintenance_strat
comp_asset_mgt_vision
 /SCATTERPLOT= (*ZRESID, *ZPRED)
 /RESIDUALS DURBIN
 /SAVE PRED ZPRED ADJPRED SEPRED MAHAL COOK RESID ZRESID SRESID.
```

Model Summary[b]

Model	R	R	Adjuste	Std.	Change Statistics	Durbin-

		Square	d R Square	Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Watson
1	.530[a]	.281	.258	.71705	.281	12.038	4	123	.000	1.890

a. Predictors: (Constant), 19). Company has a training/education/development vision to ensure that the long-term asset management strategy can be delivered. 8) Levels of maintenance activity triggers, 11) levels of hindrance to maintenance plan implementation, 5) levels of company's maintenance strategy
b. Dependent Variable: 25). Have you adopted ISO 55000?

Table 4.6: Multiple regressions: Model Summary, ANOVA and Coefficients $H_{0.1}$ (The efficiency of assets will improve with the adoption of ISO55000.)

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	24.758	4	6.189	12.038	.000[b]
	Residual	63.242	123	.514		
	Total	88.000	127			
a. Dependent Variable: 25). Have you adopted ISO 55000?						
b. Predictors: (Constant), 19). Company has a training/education/development vision to ensure that the long-term asset management strategy can be delivered. 8) Levels of maintenance activity triggers, 11) levels of hindrance to maintenance plan implementation, 5) levels of company's maintenance strategy						

Table 4.7. Analysis of Variance (ANOVA)

The ANOVA section also shows that the variance between all the variables (cumulatively) is significant with the *F-ratio* of 12.038 and *Means Square* of 6.189, which is far from 1 thus implying that the probability of getting this result by chance is low, since this results gives indications the mean value of the equality of item. Furthermore, the *F* ratio figures suggests the equality of means Null hypothesis be rejected since the *F* ratio is significant at $p = .0000$ as is shown in Table 4.7 for this study. There are sufficient variations in item means, which gives justification to move to the coefficient results table to see which variables have significant relationships.

Coefficients[a]

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	Correlations	Collinearity Statistics

		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.014	.342		5.883	.000					
	8) Levels of maintenance activity triggers	-.113	.092	-.147	-1.229	.222	-.266	-.110	-.094	.406	2.466
	11) Levels of hindrance to maintenance plan implementation	-.297	.078	-.346	-3.802	.000	-.439	-.324	-.291	.706	1.416
	5) Levels of company's maintenance strategy	.142	.085	.208	1.668	.098	-.211	.149	.127	.376	2.657
	19). Company has a training/education/development vision to ensure that the long-term asset management strategy can be delivered.	.166	.046	.316	3.597	.000	.425	.308	.275	.757	1.322

a. Dependent Variable: 25). Have you adopted ISO 55000?

Table 4.8 Coefficient results

The coefficient results identify all two (2) independent variables have significant positive effect on the dependent variable adoption of ISO 55000 (Table 4.8). For example, the coefficient table shows 'Levels of hindrance to maintenance plan implementation' to have the largest impact on adoption of ISO 55000 (β = -0.346; Sig. 0.000). This is followed by 'Organization has a training/education/development concept to guarantee lasting asset management strategy can be attained' (β = 0.316; Sig. 0.000). All these variables had positive significant impact on adoption ISO 55000 at P<0.05 which further gives partial support for rejecting the hypothesis.

$$Y_{sq} = 0.01 + x_{ad} + e$$

$$Y_{ISO} = 2.014 - 0.346x_{hind.maint} + 00.316x_{training} + e$$

From the equation above, shows that maintenance and training capabilities factors contribute positively to the adoption of ISO 55000.

Testing $H_{0.2}$: *The implementation of ISO 55000 contributes to effective management of SMEs*

From table 4.9 below, we can see that for the independent or predictor variables, the R-value and R-square value are respectively .645[a] and .417. The R-value of .645[a] suggests a strong positive (uphill) linear relationship between effective management of SMEs and structure to comply with ISO 55000; thus, the hypothesis should be rejected. The R-square value of

.417suggests that the relationship can be explained statistically, the ANOVA section also shows that the variance between all the variables (cumulatively) is significant with the F-value of 17.422, which is far from 1 thus implying that the probability of getting this result by chance is low. This gives justification to move to the coefficient results table to see which variables have significant relationship.

REGRESSION

```
 /DESCRIPTIVES MEAN STDDEV CORR SIG N
 /MISSING LISTWISE
 /STATISTICS COEFF OUTS R ANOVA COLLIN TOL CHANGE ZPP
 /CRITERIA=PIN (.05) POUT (.10)
 /NOORIGIN
 /DEPENDENT ISO55000_compliant_structure_in_place
 /METHOD=ENTER Maintenance_KPI Existing_Asset_management_activity Good_KPI_measures
Asset_tracking_systems SME_greatest_needs ISO55000_adoption
 /SCATTERPLOT=(*ZRESID, *ZPRED)
 /RESIDUALS DURBIN
 /SAVE PRED ZPRED ADJPRED SEPRED MAHAL COOK RESID ZRESID SRESID.
```

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.645[a]	.417	.393	.87316	.417	17.422	5	122	.000	1.666

a. Predictors: (Constant), 25). Have you adopted ISO 55000? , 9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance? 12) Levels of company's KPI measures, 13). Do you perform any Asset Management activities? 26) Levels of your company's greatest need

b. Dependent Variable: 27). We do have the organisational structure to comply with ISO 55000

Table 4.9 Multiple regressions: Model Summary, ANOVA and Coefficients for $H_{0.2}$

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66.415	5	13.283	17.422	.000[b]
	Residual	93.015	122	.762		
	Total	159.430	127			

a. Dependent Variable: 27). We do have the organizational structure to comply with ISO 55000

b. Predictors: (Constant), 25). Have you adopted ISO 55000? , 9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance? 12) Levels of company's KPI measures, 13). Do you perform any Asset Management activities? 26) Levels of your company's greatest need

Table 4.10. Analysis of Variance (ANOVA)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.282	.549		4.158	.000					
	9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance?	-.338	.307	-.085	-1.099	.274	.075	-.099	-.076	.802	1.247
	13). Do you perform any Asset Management activities?	.542	.264	.156	2.055	.042	.198	.183	.142	.828	1.208
	12) Levels of company's KPI measures	.231	.077	.227	2.997	.003	.413	.262	.207	.836	1.197
	26) Levels of your company's greatest need	.375	.086	.331	4.352	.000	.501	.367	.301	.827	1.209
	25). Have you adopted ISO 55000?	-.383	.101	-.284	-3.797	.000	-.466	-.325	-.263	.853	1.172

a. Dependent Variable: 27). We do have the organisational structure to comply with ISO 55000

Table 4.11 Coefficient results

The coefficient results identify three (3) independent variables have significant positive effect on the dependent variable do have the organisational structure to comply with ISO 55000; thus, the hypothesis should be rejected (Table 4.11). For example, the coefficient table shows 'company's greatest need' to have the largest impact on structure to comply with ISO 55000 (β = 0.331; Sig. 0.000). This is followed by 'company that have adopted ISO 55000' (β = -0.284; Sig. 0.000) and finally 'company's success measures' has the smallest positive impact (β = 0.227; Sig. 0.000). All these variables had positive significant impact on SMEs at P<0.05.

$$Y_{ISO} = 2.282 + x_{ad} + e$$

$$Y_{ISO} = 2.282 + 0.331_{need} - 0.284x_{adopt} + 0.227x_{kpi} + e$$

It is essential the opinion of those involve in asset management practices contribute in effective

asset management performance plan development because their knowledge would provide key insight into how respondents comprehend current asset management in their workplace, performance of Asset and ISO 55000 standard.

4.2.1.4 Presentation of Chi-square test of quantitative data

Besides the PCA and hypothesis testing, additional Chi-square test of the following items presents some of the key items with significant relations after the crosstab analysis

Item 1	Significant Relationships
Adoption of ISO55000'	The company size in terms of employee size[1]
	The industry the company operates [2]
	Levels of company maintenance strategy[5]
	Belief the maintenance strategy is the most appropriate[6]
	Having an existing maintenance plan[7]
	Levels of maintenance triggers[8]
	Levels of hindrance to maintenance plan implementation[11]
	Levels of company's KPI measures[12]
	Performance of any Asset management activities[13]
	Having accessible written process for asset management[14]
	Having Centralized asset management in the company[15]
	Having asset inventory system in place[16]
	Levels of barriers to asset management process implementation[18]
	Having training, education and vision for long term Asset management strategy[19]
	Company's ability to translate AM policy to business objectives[20]
	Having ISO certification[22]
	Awareness of ISO55000[24]
	Levels of company's greatest needs[26]
	Levels of Asset Management[29]
	Levels of support in Asset management implementation[30]
	Levels of Performance evaluation in Asset Management[31]
Having Complainant ISO	Levels of maintenance activity triggers[8]

55000 organizational structure	Levels of company's KPI measures[12]
	Having Centralized asset management in the company[15]
	Having asset inventory system in place[16]
	Levels of barriers to asset management process implementation[18]
	Having training, education and vision for long term Asset management strategy[19]
	Top management attitude to Asset management[21]
	Awareness of ISO55000[24]
	Levels of company's greatest needs[26]

Table 4.12 Chi-square test

4.3. A critical assessment of the extents to which the key research questions have been answered - major limitations and areas for future research.

This section critically assesses the extent to which the key research questions have been answered. This is followed by a discussion of the limitations of the study, and identification of areas for further research at the post-doctoral level.

4.3.1. A critical assessment of the extents to which the key research questions have been answered.

The overarching research aim (Promoting the adoption of ISO55000, which better reflect the challenges faced by SMEs) has been achieved to a great extent, in terms of the four related key research questions. First, is in response to the key research question #1 (RQ1 - What are the current practices employed by SMEs to maintain and sustain the management of their assets?) and its related research objective #1 (RO1- To determine the factors that limit the success and growth of small businesses). Chapter 2, of the thesis provides a critical review of existing literature and contemporary developments in Asset management, maintenance and Small and Medium-scaled Enterprises (SMEs), which led to identification of the 15 variables relating to current practices in the areas of Asset maintenance and management and 4 factors limiting the success and growth of small businesses in relation to their Asset management. This is critical given the strong correlation between assets management and business performance and competitive advantages. These critical factors that are impacting on Asset management in general: ISO 55000, Operation, Maintenance strategy, Risk management, Planning, Decision-making process, Performance evaluation, Monitoring, KPI (Key Performance Indicator), organizational effectiveness, Top management, Organization's culture, Physical assets, Employees, Continual improvement, ISO certifications, Internal Audit, Routine inspection,

Policy and Training. These factors were the basis on which the questionnaire survey was built upon. Question 11 in the questionnaire addresses these driving factors, which are related or associated with the potential and successful adoption of ISO55000 in SMEs; which prior has being shown in its current form to be most suitable for larger firms. The 4 factors limiting the success of SMEs are: keeping up to speed with technological change, breadth of equipment requiring maintenance, finding trained engineers and Budget constraints. Addressing these will help in contributing to the success of SMEs in terms of Risk management, planning, monitoring and control, resource allocation, and senior management support as revealed in question 12 in the Questionnaire. This will help address the most severe problems faced by SMEs revealed in questionnaire question 3 as: said High cost of Production and less access to finance.

Second, is in response to the key research question #2 (RQ2 - Can a new approach to ISO55000 be developed to suit SMEs?) and its related research objective #3 (RO3- To develop a new approach to implement an effective and efficient method through which SMEs could adopt and implement ISO 55001 in Asset Management). Chapter 4 and 5 provides evidence that a new approach to ISO55000 can be developed. This new approach is presented in the form of the holistic framework developed for this study. The keys to this new approach rely on 'the Development of comprehensive Asset Management Strategy', 'addressing organisational needs and ISO55000 compliant structure', 'implementing risk management, monitoring and control strategy', and by 'tackling Operational issues and evaluation'.

Third, is in response to the key research question #3 (RQ3 - Which ISO 55000 elements are the most important for SMEs?) and its related research objective#2 (RO2- To contribute towards providing functionally sustainable asset management system in SMEs, which will not only be able to meet present needs but also the future needs as projected by the rapid development). The results from the analysis in Chapter 4, reveals 5 key elements most important for SMEs in relation to asset management. Furthermore, question 26 in the questionnaire identifies the following ISO55000 elements as SME greatest needs in order of importance: Organizational Improvement, Organizational Support, Organizational Performance Evaluation, Organizational planning, Organisational operation, and Organizational leadership. This will increase the ease at which SMEs will adopt ISO55000 in their Asset management process and by extension, would see them achieved better performance and improved competitive advantages.

Finally, in response to the key research question #4 (RQ4 - What impact will the adoption and

implementation of ISO5500 elements give to SMEs?) and its related research objective#4 (RO4- To develop a conceptual framework that can be used to identify capabilities needed in the management of assets) and the hypotheses (H01 and H02). Chapter 4 and 5 presents the holistic framework for the adoption of ISO55000 in SMEs. The results of the two hypotheses reveal that the efficiency of assets will improve with the adoption of ISO55000 (H0.1) and that the implementation of ISO 55000 contributes to effective management of SMEs (H0.2). This will be achieved by improving belief the strategy to maintenance, existing maintenance plan, use any KPIs in maintenance, Accessible Asset Management policies, centralized Asset Management and Plan for Risk management.

The above evidence, clearly, shows that the four key research questions (RQ1-RQ4) have been answered, primarily because the related research objectives have been achieved. This next section discusses the major limitations of the study in light of the gaps in existing literature and prior studies, and identifies areas for further research.

4.3.2 Research limitations

Lack of literature (ISO55000) on this subject stems from the fact that data on SMEs is difficult to find reason being that majority of SMEs are privately owned and are not mandated to publish their full information; lack of knowledge or understanding of their data and lack of information on how to use their data or what to do with the data. Desired data was difficult to obtain due to lack of transparency and bureaucracy met at the organizations; it requires time and cost, due to lack of proper and formal internal control, that permits free and accurate flow of information; which makes it difficult to collect suitable and accurate information for research purposes. SMEs sometimes being owned or controlled by the owner resulted in the staffs feeling reluctant to share data makes obtaining information a difficult task; they are unwilling to give away information that can be revealed to and used by their competitors.

During the study it became a challenge to find adequate variety of textbooks and articles to accomplish an overview on the subject. In the early stages, a lot of time was spent on reading and gaining basic knowledge. It was also a challenge to decompose and extract principles and requirements from the ISO 55000 suite. The process of creating the questionnaire form and decides whom to participate, and how many; the researcher had to create well formulated questions able to provide adequate feedback. The accessibility and quality of the collected data limited the analysis; when attempting to make overviews based on analytical research findings; there were unexplored views and practices.

Finally, by testing the 2 hypotheses, it reveals a positive correlation between the adoption and

implementation of ISO55000, which enhance superior business performance.

Summary of Chapter

This chapter took the appropriate methods and technique to achieve the aim of the research by formulating direction for the research and establishing the intended paradigms. The techniques used in processing and analysing the collected data for this study was questionnaire survey and presented in statistical analysis. Processing and analysing of this data involved some careful procedures; summarising the collected data and arranging them in a way it answers the research questions (objectives). The collected raw data were examined to detect errors, omissions and correct them if possible; review and adjustment of collected survey data with an aim to control the quality of the collected data. Data editing is significant in ensuring that the errors surfacing during collection, recording, assimilation are discarded or reduced, this guarantees reliability as it has practical impact on the final analysis and outcomes. Analysis began with the labelling of data as to its source, how it was collected, and the information it contains and converts collected information into numerical data. This is done through exploratory Factor Analysis of the Questionnaires, Hypotheses Testing - using ANOVA Regression Analysis and the Presentation of Chi-square test of quantitative data. The next section discusses all the results from the questionnaire analysis and compares and contrasts these results with the finding from other studies.

CHAPTER FIVE
DISCUSSION OF FINDINGS

5.1 Introduction

This section discusses the results from the PCA, Hypotheses testing and Chi-Square analyses with a view of teasing out the findings from this study and this study's contribution to knowledge. This is critical since the result from the Hypotheses testing show that *the efficiency of assets will improve with the adoption of ISO55000 ($H_{0.1}$) and that the implementation of ISO 55000 contributes to effective management of SMEs ($H_{0.2}$).*

This emphasizes the criticality of the implementation of ISO55000 Asset management strategy to the survival and profitability of SMEs. This is because studies have shown that implementation of ISO55000 contributes positively to effective management in firms. Study by Woodhouse show that organisation needs to establish and implement an asset management system because the implications of not adopting the AM approach, or of not being ISO 55001-compliant, can be severe (Woodhouse 2010) this was further confirmed by another study by Rugsveen indicate that not being ISO 55001 compliant, organisations could lose opportunities in new licences, lose partnerships, and lose competitiveness against competitive organizations (Rugsveen 2014).

5.2 Discussion of Results from the Questionnaire Analysis: PCA, Hypothesis testing and Chi-Square: studies have confirmed the results of the hypothesis finding that *the implementation of ISO 55000 contributes to effective management of SMEs ($H_{0.2}$).* Study by Edwards suggest effective asset management require all key areas to be aligned with the organizational strategy and objectives, also referred to as providing a clear "line of sight" from the strategy to the daily operations (Edward 2010). Effective asset management practices can result in improved service delivery.

Therefore, the critical importance of benefits of implementing ISO55000 in SMEs cannot be over emphasized. The question therefore is how ISO55000 can be implemented in SMEs (RQ) so that these benefits enjoyed by larger firms can be enjoyed by SMEs as well. The factor analysis testing reveals that implementation of ISO55000 in SMEs depend on *the* ***Development of comprehensive Asset Management Strategy, addressing organisational needs and ISO55000 compliant structure, implementing risk management, monitoring and control strategy and by tackling Operational issues and evaluation.***

5.2.1 Factor solution 1: Implementation of ISO55000 in SMEs through the Development of comprehensive Asset Management Strategy.

The first factor solution from the factor analysis is the importance of developing asset management strategy for the implementation of ISO55000 and to achieve the overall objectives of the company. This finding is in line with similar study carried by the Government of South Australia's department of planning, transport and infrastructure (2017). In their proposed strategic asset management framework (SAMF) (Strategic Asset Management Framework 2017), which is aligned to ISO 55000 approaches; one of the key conclusion is the development of the asset management strategy before the implementation of ISO 55000 or any maintenance strategy. While the SAMF suggests that asset management strategy depends on 20 different items, the findings provide an in-depth clarity for the development of a comprehensive maintenance strategy by proposing 3 key terms that encompasses the 20 items from the SAMF. The 3 holistic asset management strategy from the factor analysis are: (**1) Stages in organisation maintenance strategy[i5] and triggers[i8], (2*) Organisational constraints* in terms of long-term training and vision[i19], Policy & Strategy and business objectives actualization[i20] and (3) *Asset management configuration* in terms of its Levels[i29], its support for implementation[i30], internal audit[i32], barriers to its process[i18], and improvements[i33].** The importance of these 3 crucial factors for successful development of a comprehensive Asset Management Strategy to meet the challenges facing SMEs in today's world is discussed below.

- **Developing comprehensive Asset Management Strategy through robust Stages in organisation maintenance strategy[i5]:** As stated in previous chapter, Maintenance strategy is a combination of techniques that depend on factors such as the nature of the plant, the maintenance goals or the equipment that will be maintained, the work environment and the work flow patterns by product focus, and/or process focus (Alsyouf 2007). The critical importance of a good maintenance strategy led to Pinjala et al. (2006) defining the relationship between business and maintenance strategies as " *coherent, unifying and integrating pattern of decisions in different maintenance strategy elements in congruence with manufacturing, corporate and business level strategies; determines and reveals the organisational purpose; defines the nature of economic and non-economic contributions it intends to make to the organisation as a whole"* (Pinjala et al., 2006). The result of the factor solution is in line with the findings of (Pinjala et al., 2006) as this study reveals the criticality of a good maintenance

strategy with clearly defined maintenance stages. This is because as (Crespo Marquez & Jatinder N. D. Gupta 2006)) state, maintenance strategies are a means of transforming business priorities into maintenance priorities. Organisations should therefore have strategies to guide maintenance work, to facilitate strategic management of maintenance; a process for the formulation of maintenance strategies should be developed and tested. Therefore, it was difficult to determine how effective the planned and preventive maintenance system was.

Figure 5.1 below shows respondents answer to the basic types of internal maintenance strategies used; planned (105), predictive (105), preventive (105) corrective (101) while those rarely used were reactive maintenance (7). The data collected and analysed from the questionnaires showed that 90% of respondents indicate they use a mixture of planned, predictive, preventive and corrective maintenance with a small amount of reactive maintenance. This finding is a contradiction to the limited amount of available research, which states that the majority of maintenance practices, within SMEs are reactive and based upon a "repair-when failed" approach.

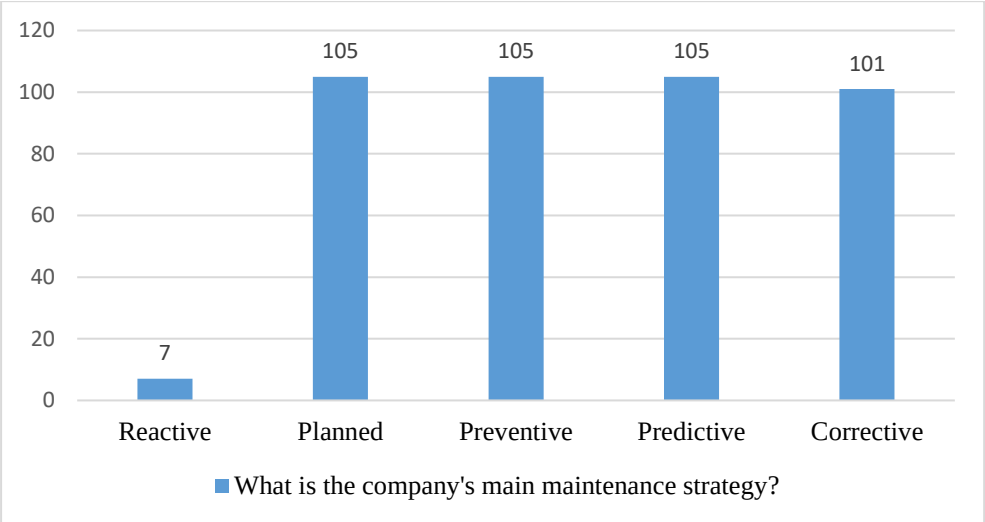


Figure 5.1 Mix Maintenance Strategies

This finding shows a shift from the Reactive "repair-when failed" maintenance approach that other researchers associate to SMEs to a more comprehensive maintenance strategy. The few respondents stated that reactive maintenance is suitable for certain equipment because they could not take equipment out of service for preventive maintenance since, at best the probability of failure would remain unchanged or equipment would deteriorate. Based on the definition of Maintenance strategy this shows the organisation uses mix method, which depend on their maintenance objectives, equipment kind to be maintained, work environment and flow

designs. The absence of a strategy eliminates the need to plan ahead for maintenance but this chart signifies the organisation have a strategy in place. For an organisation to establish an effective maintenance strategy on any equipment they need to understand how the equipment fails and determine which failures they desire to control based on the consequences of the failure. This finding therefore corroborates several findings on the importance of developing a comprehensive maintenance strategy in order for business continuity.

The proficiency of maintenance management needs a predictive strategy. Preventive maintenance (PM) is similarly an operative strategy for guaranteeing the durability of machines before the machine is used or in some instance while it is still in operation Wang et al. (2010); PM guarantee a higher level of safety because it reduces disruptions. Corrective Maintenance wasn't regularly used in this analysis; CM is irregular maintenance determined by sudden machine failure. This strategy is unplanned as it occurs despite PM being carried out and the machine is not operational until it is serviced (Pintelon & Parodi-Herz 2008; Ratnayake & Markeset 2010a). These strategies should be in place for asset managers or machine operators for complete overhauling and rapid servicing.

Related to the need for a comprehensive strategy is the question on what **Triggers**[i8] maintenance procedures. As stated earlier, Equipment failure is a common problem faced by many organizations; this failure can have devastating and have far-reaching effects. Maintenance triggers indicate that maintenance must be performed at an operational level; it is used to alert a technician that maintenance is required. When triggers are received, operational necessities for maintenance can be planned, acted upon, and recorded. Respondent were asked how maintenance activities are triggered in their organisations.

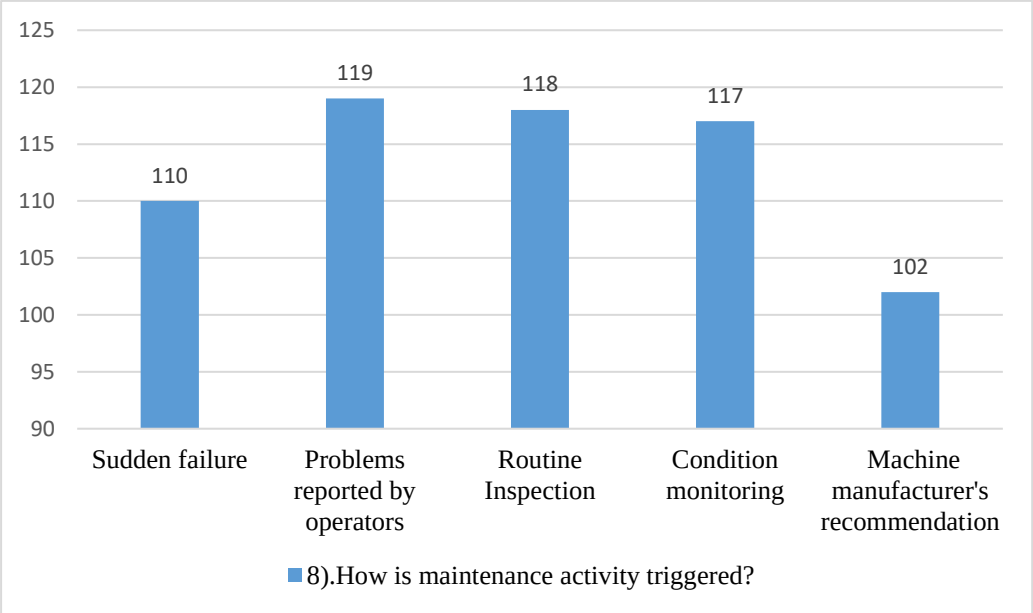


Figure 5.2 How Maintenance are triggered

An analysis of the questionnaires from this study shows maintenance activities are triggered in the following order: problems reported by operators, followed by routine inspection, condition monitoring, sudden failure and lastly machine manufacturer's recommendation. The response shows most of these organisation use mix method to carry out its maintenance activities. Respondent also indicated that maintenance is also carried out when there is sudden failure and at machine manufacturer's recommendation; however, studies have shown that waiting for sudden failure raises capital expenditures because, while waiting for the equipment to break, the life of the equipment is shortened (Too 2010). Labour costs associated with unplanned repairs may be higher than normal because the failure may require more extensive repairs than would have being required if the equipment had not being run until it failed. Depending solely on manufacturer recommendations for maintenance tasks are possible but organizations need to verify that they are suitable for their operational use; manufacturers are usually unable to anticipate factors such as business-related consequences of failure, safety, regulatory requirements, availability of resources and environmental conditions. Most equipment is operated beyond their design limits; therefore, organisations need to look beyond the recommended maintenance. Manufacturer's recommendation can be a starting point in deciding the maintenance program but should be reviewed. The use of condition monitoring techniques, sufficient operational knowledge and maintenance historical records, can be possibly relied on for maintenance practices. Thus, this finding confirms other research findings that suggest equipment does not have to finally breakdown before maintenance is carried out and implementing a good maintenance policy prevents equipment failures and leads

to high productivity (Vineyard et al., 2000). Frequent breakdown of equipment is usually caused by either poor maintenance or mistakes in implementation of strategies (Chompu-inwai, et al. 2008); lack of maintenance activities instigates unexpected breakdowns mainly associated to high maintenance costs.

5.2.2. Factor 2 Developing comprehensive Asset Management Strategy to address Organisational constraints in terms of long-term training and vision[i19]

From the chart below, 82 respondents strongly disagree that the company has training/education/ development vision to ensure the long-term asset management strategy; this shows that staffs are not adequately trained and not made to be aware of the vision of the company. Prior researches have shown Engineers, technicians and every other employee involve in physical contact with equipment or asset management activities must be aware of the mission and vision of their company. In European Federation of National Maintenance Societies (EFNMS) conference, Christer Pandell described the vision and mission statements of his company as **"*We want to be a world-class bottling facility with wine and spirits and in that way the natural choice of bottling site for V&S Wine and V&S Distillers*"** (V & S. Group 2006). Pandell further commented that when working with the 'vision' of your company as well as from your plants with your employees, you create a common understanding of a whole lot more than just the text in your own version. There is a greater understanding in each individual of the meaning in the bigger context. "My employees and I know that we are not working to world-class standards yet, and they know that the only stable condition in our department will be the changes needed to work towards our vision – and they accept it, because they have been involved creating our common vision". The vision for the maintenance department is – **"*TSA (Technical Service Department, including Maintenance) want to be the most effective service department using optimal world-class methods and techniques*".**

In order to carry out effective asset management activities, the team players must be dedicated, committed, unflagging, and focused on achieving good practices. Top management and organization must share a common objective.

Maintenance departments are often under staffed and usually not trained effectively; Employers must "ensure that all persons who use work equipment must receive adequate training for the purposes of health and safety, this should include training in methods that may be adopted when using work equipment, risks the use of such equipment may entail and the precautions to be taken" (**PUWER regulation 9**). Company are to organize training according to:

- The job or activity
- Current competence of workers
- Conditions of the work
- Work Equipment etc.

The findings from the questionnaire analysis corroborate these research findings and indicate an urgent need for trainings in SMEs before the long-term asset management strategy can be delivered. The recommended training standard required should be adequate in ensuring the health and safety of workers and anyone who will be affected by the work. Everyone using equipment at work must be adequately trained using the manufacturer's instructions and the background knowledge or skills of more experienced workers and managers. Employees should be competent for the work they undertake; competence can (in most cases) necessarily include medical fitness, physical and mental capacity for the activity. Depending on firm's current capability, the required skills, education and training may differ. Therefore, Asset Managers must ensure that their staff are appropriately skilled and trained especially if asset management activities are outsourced. Sustaining the required asset management standard will necessitate a need for ongoing training and education and regular motivation of staff to attend on-the-job training and coaching, relevant training or workshops, and avenues to engage with industry experts.

Policy & Strategy and business objectives actualization[i20]; From the chart most of the respondent said "YES" that the company could translate Asset Management policy and strategy into clear business objectives and lifecycle plans. Asset Management policy and strategy that is appropriate to the organization, provides a framework for setting objectives, continuous improvement and sustaining must be established. In line with Torbay council research findings which show asset management policy must be consistent with the organization's plan and policies, be appropriate to the organization's assets and operations, be available, communicated and periodically reviewed, updated if needed (Torbay Council, 2018). This is critical because Asset management policy and strategy create an efficient work setting that departments should relate inter-dependently in a successful approach whilst it intends to enhance organizational productivity by meeting and exceeding client prospects. Organization planning framework should comprise of strategy and policy with effective quality delivery service; this will enable an asset manager to make effective decisions regarding the asset lifecycle phases, lifecycle costs of the assets.

Implementing this policy and strategy organization therefore is expected to proactively respond

to strict regulation, dynamic market and shareholders need while sustaining client's needs. Strategy at a suitable level and corresponding with the companies' aim of function and size are to be implemented. Asset management policy and strategy ought to consider different options to achieve the company's expected outcomes in terms of service delivery, costs, lifecycle, benefits and risks associated with each chosen option.

Asset management objectives in terms of its levels[i29], its support for implementation[i30], internal audit[i32], barriers to its process[i18], and improvements[i33]. From the chart below respondent where asked if their company's asset management objectives are

- Measurable, monitored and communicated to relevant stakeholders;
- Asset management related risks considered by management.
- Objectives are reviewed and updated as appropriate
- Do they have contingency plan

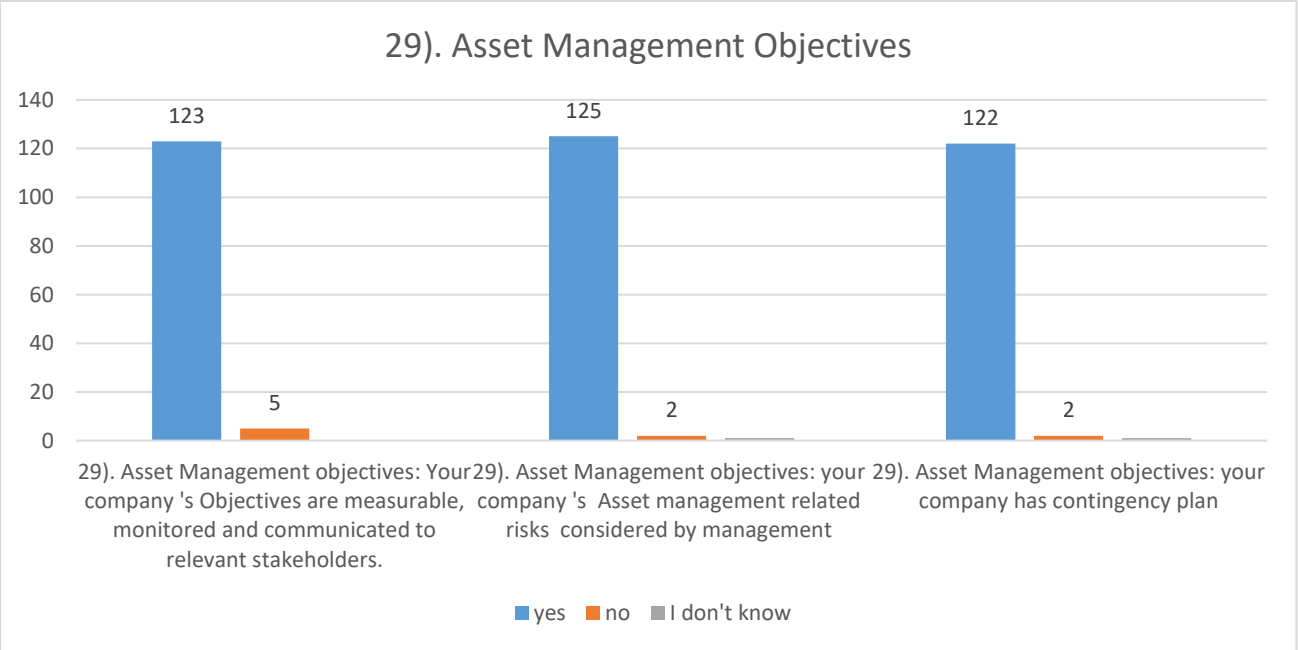


Figure 5.3 objectives of Asset management

According to survey results from this study, the majority of participants have attested to incorporating asset management objectives into their organisational strategic objectives; thus, confirming the findings from the Torbay Council (2018) research. As stated in chapter 2, objectives are used to articulate a clear, measurable, outcome of an asset management process. Objectives support the delivery of services that align with overall organisational Strategic

Guidelines. Asset management objectives capture the performance essential from an asset in order to support the target of the organisational objectives.

Support for Implementation[i30]: Respondent was asked how asset management objectives were supported in their organisation in respect of the following;

a. Resources provided for maintenance, continual improvement and implementation of asset management system.
b. There is collaboration (Awareness and Information requirement) in all departments.

From the responses in the questionnaire, the overwhelming majority of the respondent states that resource and collaborations are in place in all departments of their organisations that support of asset management objectives. This finding is in line with Crespo et al., 2006 results, which underlined the absolute criticality of a support framework before any maintenance plan can be successfully and comprehensively carried out. This is because the greatest risk to any asset management initiative lies in not having appropriate support from organisation, senior leadership, and staff.

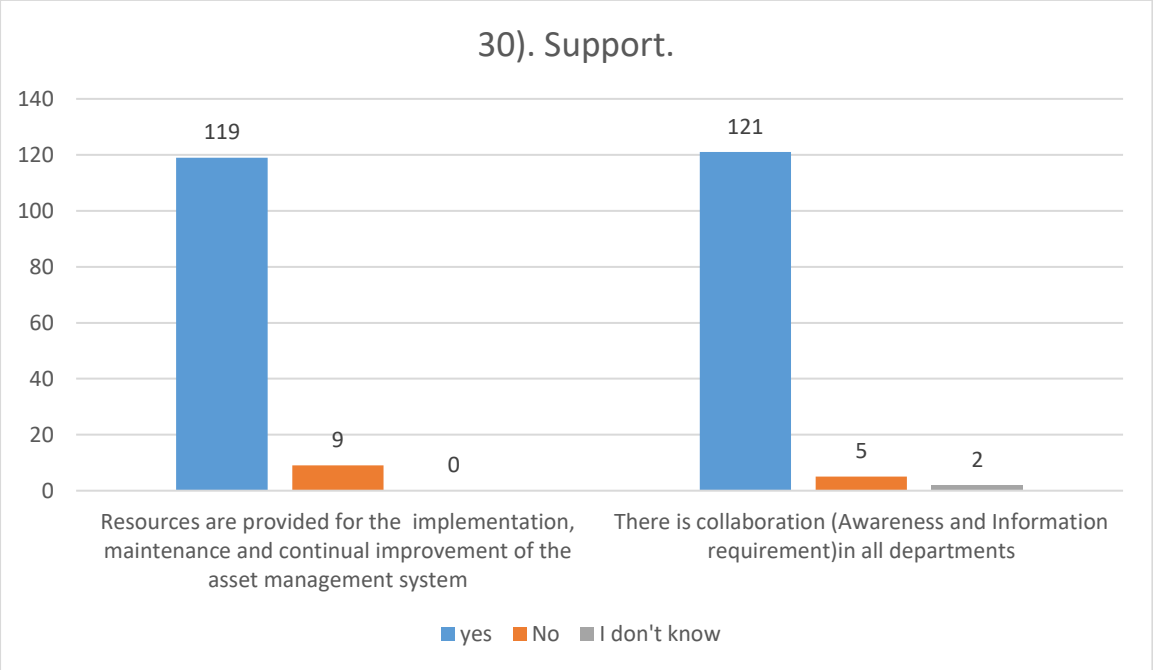


Figure 5.4 Support for Asset management objectives

Similarly, in a study titled '*use of geospatial information for supporting maintenance management in a technical network system*', (Kazmierczak et al., 2012) conclude organisational and technical support is essential for successful maintenance implementation. Without support, an asset management initiative can rapidly lose focus, get diverted or abandoned, and fail to produce the desired business outcome. To initiate a lasting change and

truly unlock improvements in sustaining infrastructure, internal support is required. The initiatives should cover a wide range of areas, from sharing people, knowledge and data to specific departments. Collaboration requires trust, discipline, and incentive alignment. Information must be readily available to plant personnel, engineers and vendors; effective collaboration is critical to working efficiently. Documents must be revised to reflect all maintenance procedures, technological updates and equipment changes. The benefits of collaboration are that it would provide a learning opportunity for relevant staff and a focal point for considering potential opportunities to leverage assets with commercial potential. Downtime or unexpected delays can create a number of on-going problems, such as unfulfilled contracts, profit loss and environmental incidents.

Organisation Improvements[i33]: Question was asked if there is improvement of asset management objectives in their organisation in terms of;

- Reaction to nonconformity and corrects incident
- Have established preventive action to proactively fix failure
- Evaluate its preventive action

Most of the respondent's state that improvement of asset management objectives are in place in their organisations. Improvement includes potential to reduce the standard of service, dispose or divest of an asset or assets; these signifies a potential change to the standard of service and should be managed, completed with some form of appraisal, comparing diverse options and choosing an ideal option based on whatever process is appropriate. Standard of service can be improved by acquisition, enhancement; Asset management Improvement monitors organisation capital programme, reporting on project delivery against programme timescale and financial out-turn against approved budget in consultation with service departments. Companies should have both preventive and corrective maintenance measures. Risk associated with Improvements should be evaluated before executed; issues identified and evaluated based on criticality should be addressed by operators and the recipe described in "corrective action".

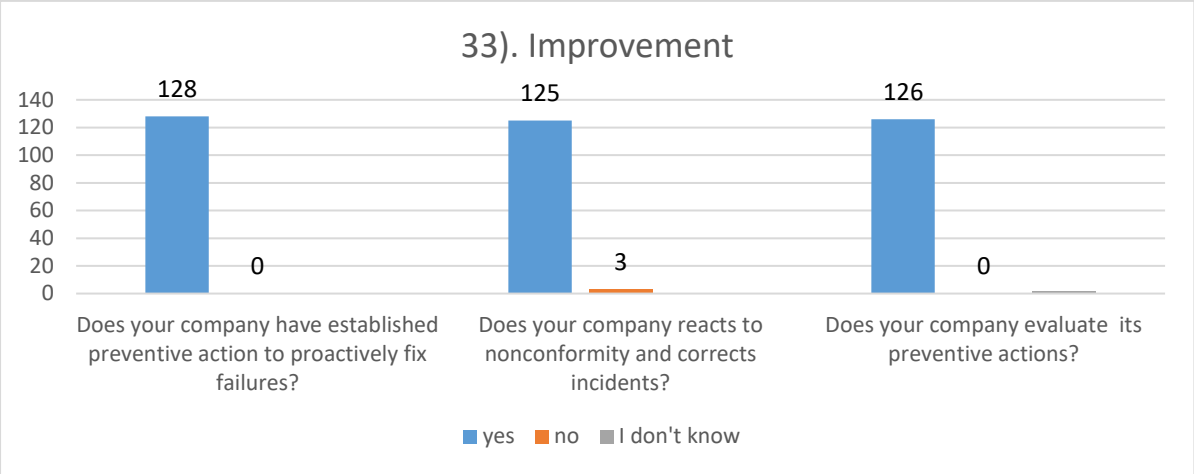


Figure 5.5 Support for Asset management objectives

Improvement, productivity and maintenance of equipment should be instilled into asset management culture and processes of an organisations (Dieffaga et al., 2013). Data and Information on operations should be accessible as this can influence future decision-making and risk-based techniques for prioritisation and decision-support should be applied. Organisations should also be able to share the asset data with relevant stakeholders.

Barriers to its process[i18]: 114 of the respondent state that lack of resources are one of the major barriers faced in development and implementation of Asset Management process. Resources can be financial, human and equipment use in managing organizational assets. Lack of resources and appropriate organizational strategy can limit the implementation and operation of effective asset management activities. Lack of financial resources limits or restricts the size of organization, quality, and employment; access to capital allows innovation. This findings support other research that conclude lack of human resources (skills, time, and resources, and strategies) (Agarwal et al. 2004) (Rao & Drazin 2002) and poor resource allocation as a major challenges in organisations.

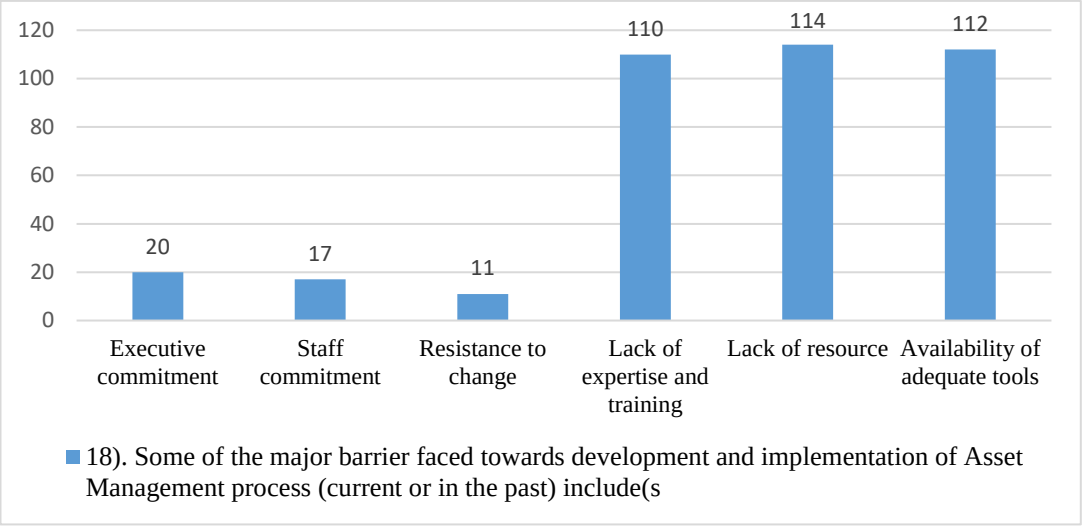


Figure 5.6 Barriers for implementing Asset management

These studies further suggest that to overcome these constraints, organisations;

- Require resources with high competencies
- Should establish resource and funding allocation mechanism.
- Reallocating resources within programmes.
- Enhanced efficiency of resource allocation

To achieve organisations objective, it is essential to design a plan that allocate and brings together the resources available with the required work. It is against this competitive backdrop that the performance and availability of key resources and assets have started to be identified as an important factor contributing to improved productivity.

Availability of adequate tools: Adequate logistic support should be given to Asset Management process to ensure maintenance is carried out properly and efficiently. About 112 of the respondents said that there are inadequate tools for Asset Management process. The lack of adequate or reliable tool reduces the business capacity, leading to failure to meet contract or jobs within time schedules. In line with several other findings, this study shows that tools and equipment assist the maintenance personnel in determining the condition of asset and allow them to predict mechanical breakdown (Edward, Holt & Harris 1998).

Lack of expertise and training: Furthermore, 110 of respondents said lack of expertise and training is a major barrier. From the response, most staffs are unskilled and unprofessional, which seriously ruins the efficiency of organizational assets management. Asset management requires expertise that suit the task involved, comprising applicable knowledge, skills, experience, behavior, attitudes and attributes. This finding is in line with contemporary studies that state there is currently a shortage of properly trained and qualified staffs to undertake

maintenance (Feilden 2003), Lack of operational knowledge of the system, commitment, sharing information and knowledge between manufacturers, service providers and operators create organizational issues. Lack of communication between maintenance personnel and other experts is an issue; deployment of expert is very important.

Getting the right people into positions in asset management involves identifying the competencies that are needed and recruiting; organization should consider experience when hiring staffs and coordinate competent training; existing staffs need to develop expertise to meet service needs. Staff training provides employees with the knowledge, skills, and experience (through practice) to accomplish their jobs effectively; organisation should provide professional trainings for assets management staff, improving their awareness and professional competence This can lead to efficient assets management, achieving the optimal distribution of organization assets, and maximizing the utility of organizational assets.

Internal Audit[i32]; from the charts question were asked on how internal audits were conducted in respondent's organizations; from the response it was agreed that audits conducted with organization requirements. ISO 55002 (2014) states that internal routine audits should be conducted to guarantee the effectiveness and appropriateness of AMS base on the objectives of the organization. Active participation of competent staff, top management and objective personnel within or outside the organization is required and everything should be documented; outcomes of the audit are used to avert or correct nonconformities by offering guidance to organization.

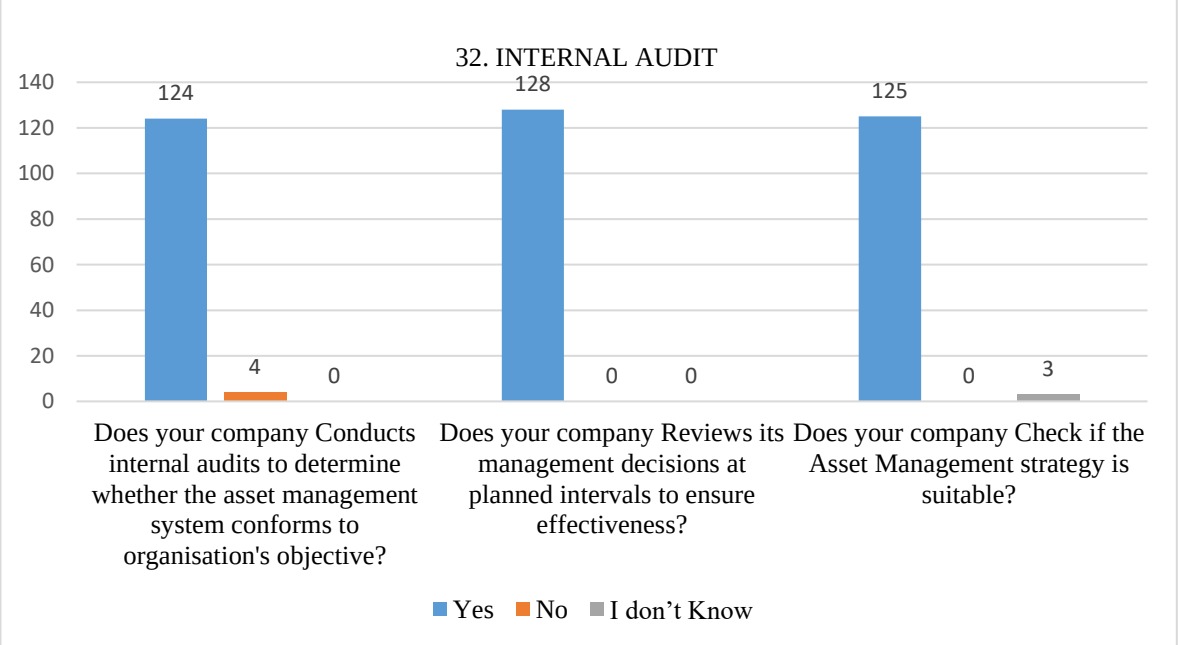


Figure 5.7 organisational internal audits

Respondents agreed decisions were reviewed at planned intervals in accordance with best value principles to guarantee their asset policies, strategies and plans are up to date, covers all major asset types and adequately informed future decisions. Internal audit should be supported by strategic plans, or asset management plans and base on frequency, methods, responsibilities and reporting, consideration of the processes and results of previous audits. Internal audit provides analysis of financial and performance reporting, financial results and key internal controls; auditors should be objective and impartial, results are reported to management and documentation is retained. Audit reviews should provide organisations with recommendations that lead to continual improvement.

Therefore, the development of a comprehensive Asset Management strategy for SMEs Factor solution 1 can be expressed diagrammatically as follows:

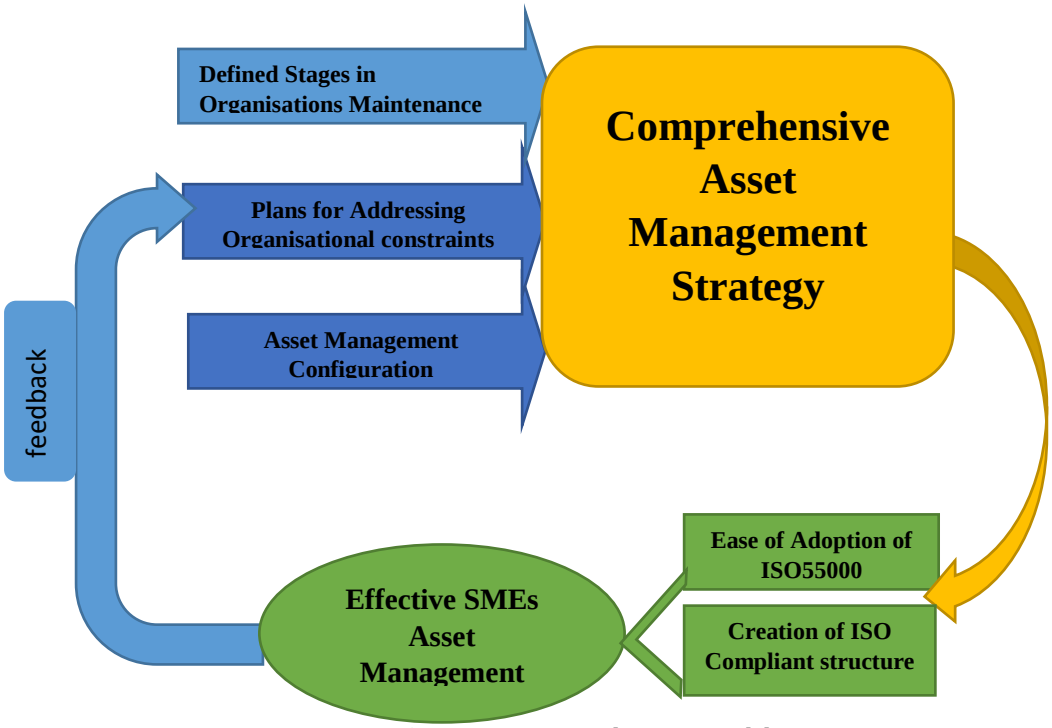


Figure 5.8 Factor solution 1 Model

5.2.1 Factor solution 2: Implementation of ISO55000 in SMEs by addressing organisational needs and ISO55000 compliant structure has five (5) loaded items

- **Limitation to maintenance plan[i11]**

From the chart above respondent were asked the biggest challenge face when implementing maintenance programme, 84 respondent attest that **keeping up to speed with technological change** is their biggest challenge. Technology is a key factor in asset management, which impact on the effectiveness of organisational asset management, fundamental to many phases

of the investment process including trading, risk management, operations and client service. Technology has the ability to manage and use information; which supports asset managers in decision-making process, organizing up-to-date asset management system. Organisation should invest and keep up to date with technologies essential in their business and staffs should be train on how to use technologies. Technology ensures information flows smoothly throughout the system and helps asset experts measure their risks comparative to returns objectives specified by clients.

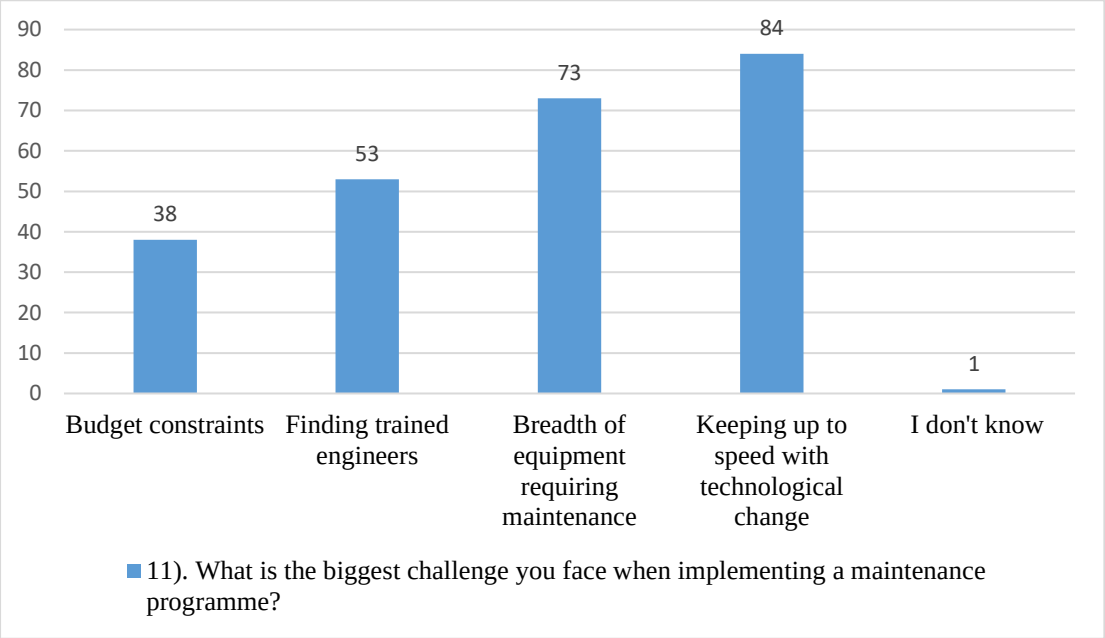


Figure 5.9 challenges faced in maintenance

The **breadth of equipment requiring maintenance** was another biggest challenge face by organisation. Most organization cannot produce result that predict equipment failures, and unexpected asset failures still occur. Equipment maintenance takes place when downtime occurs due to planned or unplanned stops; unplanned stops caused by failures and disruptions are the most common unanticipated factors that have the non-trivial impact on overall productivity. It is necessary for organisation to develop technical strategies to improve their equipment productivity and availability by displaying scope of maintenance to be carried out.
53 respondents said **finding trained engineers** are the biggest challenge faced by organisation. Finding engineers or operators that are multi-skilled (mechanical, electrical, experience and qualification) is a challenge according to the survey. Operator's skills and knowledge of his/her plant boost operating effectiveness: the operator can detect early signs of wear, maladjustments, leaks or loose parts. Makin & Keane located six areas of skills needed to

achieve 99% maintenances; installation (25%), plumbing (19%), mechanical (18%), electrical (18%), power supply (14%) and motors (5%); Relatively this services assist in returning service to 66% of out-of- service equipment involved in their report (Malkin & Keane 2010). Maintenance Engineers or operators need to be skilled in lots of different areas so as to make improvement suggestions to eliminate losses due to the breakdown or sub-optimal performance of the plant. The root cause of skills gaps are staffs not being trained, partly completed training or because staff are new to the role.

38 respondents stated that **Budget constraints** were their biggest challenge**.** Budget constraints mean that full funding for a project is not available; with constant pressure to reduce maintenance costs as well as short-term budget constraints to evaluate risks and opportunities for deferred maintenance interventions, asset managers are compelled to continue operating aging assets while deferring maintenance and investment. Budget cut can make even a well-planned maintenance program obsolete, as finance for different categories of maintenance expenditures may drop below the minimum operative level. Such interference often becomes one of management's biggest challenges. The reality of budget cuts, workforce gaps, aging equipment, expensive technology, and shrinking profit has forced maintenance managers to seek new technologies that allow organizations to scale and prevent costly failures in the future. Establishing a maintenance budget, the review committee consisting of the chief maintenance engineer can significantly enhance budget preparation process.

- ***Company success measure[i12]***

Respondent were asked what will contribute to the success of their organization; 124 respondent state that **Risk management** contributes to the success of their organization. The ISO 55000 (2014) states that a proper evaluation of risks and opportunities are essential to the effective control and the governance of assets to achieve the desired balance of cost, risk and performance. Organizations should prepare a risk management plan that describes the potential and outcomes of risks, and plans that need to be implemented for assets under their control. Risks and efficiency of the risk management plan need to be monitored as assets are utilised to ensure that changing circumstances do not alter the risk priorities; monitoring and review is an essential and integral step in the process for managing risk.

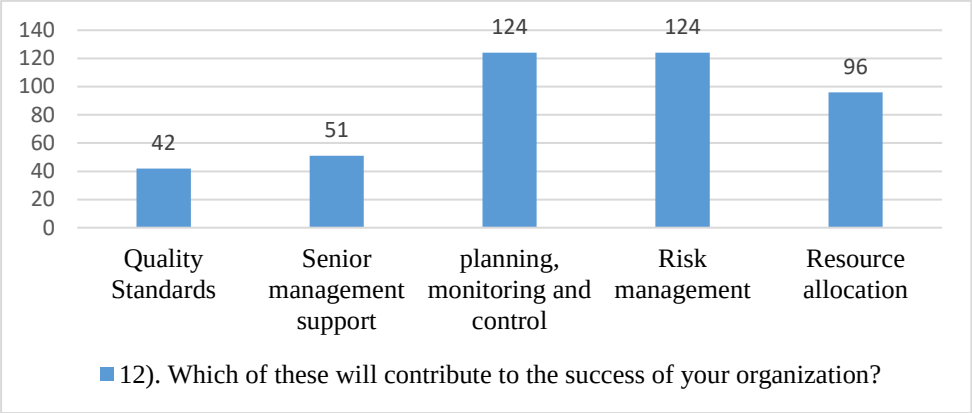


Figure 5.10 factor contributing to organisational success

124 Respondents said **planning, monitoring and control** contributes to the success of their organizations. Planning, Monitoring and Controlling procedure manages all the tasks and method essential to ensure that the approved and authorized project is within scope, on time, and on budget so that the project advances with minimal risk; this involves comparing actual performance with planned performance and taking corrective action to produce the anticipated outcome when significant differences exist. Planning and control of maintenance minimise downtime, overhaul unreliable components prior to failure; monitoring the condition of unreliable components and replace when failure is imminent. Monitoring and Controlling process is continuously performed throughout the life of the project.

96 respondents stated that **resource allocation** contributes to the success of their organisation. Organization should harness their resources to meet its objectives by using the most effective method (BSI 2008); Resource allocations should be firmly rooted in principles of equity and focusing on business and engineering practices.

Organisation should have a dynamic resource allocation framework that makes sure that resources are available for operations through various mechanisms; staff should be provided with the necessary resources to deliver in accordance with their responsibilities. Organisation must identify resources needed to achieve the maintenance objectives; ISO 55001 require the organization to determine and provide the resources needed to establish and maintain an asset management system. Organisation documentation must be clear about the resource allocation base on the requirements in ISO 55001 sub-clauses. Resource allocation is fundamental to asset management; Human resources are key area of management system including employee involvement, teams, solving problems and should relate with quality initiatives.

51 respondent said **senior management support** is an important factor for the success of projects. Senior management are to ensure the viability of the asset management strategy,

objectives, targets and plans, organizational structure, working procedures, and the importance of meeting asset management requirements should be clearly communicated to all relevant employees. Senior management should assign clear responsibilities to its staff and ensure that those who are given responsibilities are competent, have adequate skills and training to perform their duties and deliver the required outcomes, in line with the asset management policy, strategy and objectives for the management of assets.

Senior management should ensure that adequate resources are available for establishing and maintaining asset management system, which includes equipment, human resources, expertise and training.

- ***Organizational ISO 55000 awareness[i24],***

To find the level of '**awareness**' of ISO 55000 surveys was used with targeted question base on their understanding of asset management policy, how to effectively contribute to asset management success, how they view their contribution to achievement of the organization's asset management goals, and what more they can do to make a positive difference; 72 said they are aware and 49 said they are not aware of ISO 55000. Still in its infancy, management seem not to be aware of the ISO 55000 standard, especially with 49 respondents not being aware from the survey.

The 'awareness' stated in the ISO 55001 standard is about the extent or role a stakeholder knows of their organization's asset management system, its impact and opportunities in delivering asset management plans. Awareness is far greater than a personal level of awareness; it is more about taking a business owner's perspective of risks, opportunities and service delivery quality. Asset managers or anyone with responsibility for asset reliability needs a sound understanding of ISO 55000 and its goals; necessary skill and knowledge are mandatory to enable system tailored to the organisation's needs.

- ***Organization ISO 55000 needs[i26];***

Organizational Improvement: respondent was asked their greatest need within the element of ISO 55000; most of the respondents choose more than one element. 127 said their greatest need was **Improvement.** Improvement includes appropriate documentation, implementation, and management of a system to identify, evaluate, and act on preventive and proactive opportunities, such that non-conformance can be avoided. Organizations are required to regularly review and make changes by improving the effectiveness of the asset management system by updating the system. Improvement shows an organisations ability to address the following;

- Informed asset investment decisions,
- Managed risk,
- Improved services and outputs,
- Demonstrated social responsibility,
- Demonstrated compliance,
- Enhanced reputation,
- Improved efficiency and effectiveness:
- Improved financial performance:
- Improving the return on investments.

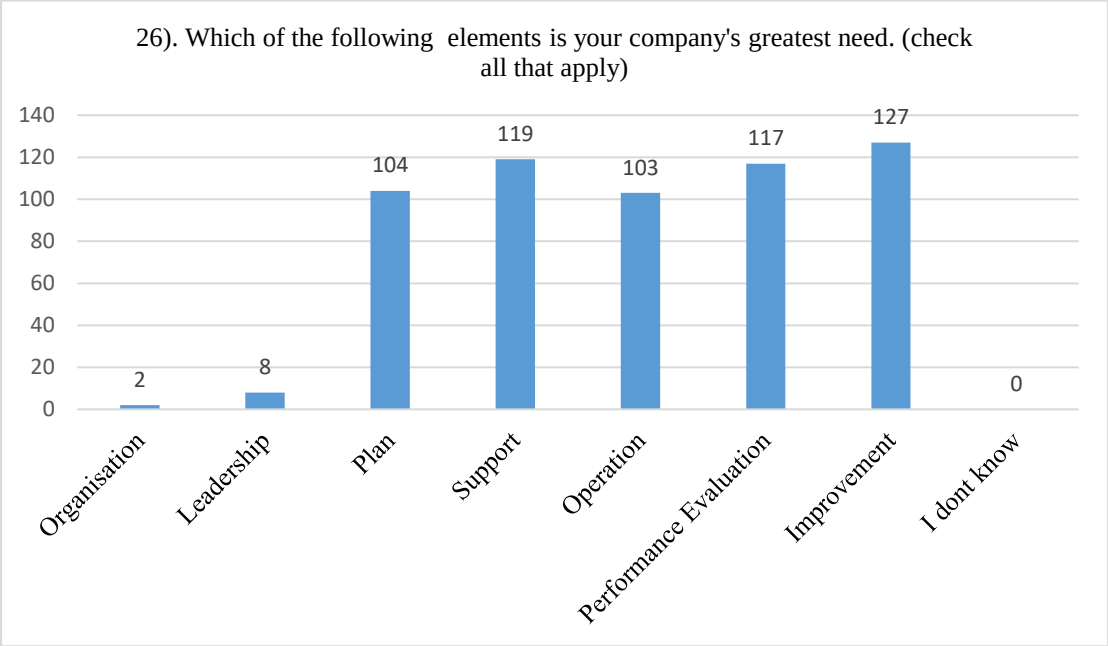


Figure 5.11 ISO 55000 elements needs

Organisations should implement processes for monitoring and identifying potential risks, be proactive in eliminating these risk and/or putting in place contingencies to mitigate or minimize the effects. Improvement demonstrates suitability, adequacy, and effectiveness of asset management and asset management system.

119 respondents stated that **Organizational Support** is their greatest need. This element describes the need for organization-wide support, which includes developing organizational awareness of the asset management system, requirements for communication the provision of appropriate resources, and the assurance of competency of those resources, required documentation to manage, verify compliance, and demonstrate effectiveness of the system.

There need to be a culture of collaboration and continual improvement supported by senior management as well as ensuring that the right resources are made available. For an asset management system to function correctly you need to provide processes, infrastructure, finance, knowledge, skills, information management, service delivery and cultural environment that produces the intended asset performance for the organization. Management need to ensure that the staffs that work within the area of asset management are competent; Departmental cooperation in terms of information sharing with the right people inside and outside the organization at the right time. Documents relating to asset management should be controlled, developed, approved, and maintained.

117 respondents stated that **Organizational Performance Evaluation** was one of their greatest need; this optimize the efficiency of asset management system by detecting the most appropriate methods of monitoring, measurement, and analysis Asset performance. Organisation should develop performance indicators to measure the effectiveness of their system; evaluate, audit and report on the effectiveness of managing risks and opportunities. Audits of the system need to be regularly carried out; management reviews be considered and the suitability, adequacy and effectiveness of the AMS. During this audit improvements and ways of managing assets more effectively will be identified.

104 respondents stated that **Organizational planning** is their greatest need. Organization should develop; specify appropriate plans in-line with their organisational needs, taking account of the life of its assets and organization's responsibility within a length of time. For organisation to achieve its planned objectives it is essential that necessary resources identified in the asset management plans be committed. Asset management plan(s) is a process that involves resolving conflicts between what is planned and what can be afforded considering financial constraints; this might require working with other departments in the organization to show how these objectives will be achieve, by addressing stakeholders need, address risks and opportunities. Organizational plan should contain a rationale for asset management activities, documented, operational and maintenance plans, capital investment (overhaul, renewal, replacement and enhancement) plans and financial and resource plans, often based on a review of earlier achievements. Organizational plans should be reviewed periodically to ensure continual alignment with the asset management objectives. Risks and opportunities should be identified, and plans put in place to address them to support the achievement of organizational objectives.

103 respondents said their greatest need is **Organisational operation**. Organisational Operation requires the implementation of every action-undertaken in-line with Asset management plans; it measures the effectiveness of the system to achieve the intended outcomes of the AMS. Operational plans should be consistent and aligned to the Asset management plans and decision-making criteria. Operations involve maintenance of facilities with the objectives of ensuring assets are safe, reliable, and performing to appropriate standards. Operations include compliance to standard and safety, shutdown and outage management, incident management, project management, and consistent recordkeeping are some of the key functions.

Only 8 respondents state that their greatest need is **Organizational leadership**. Leadership element of ISO 55000 involves setting the vision and direction for the organization, and establishing commitment towards achieving the vision. Leadership must be put in place by top management and given the authority, responsibility and resources to accomplish their objectives. Policies to guide organization's decision-making processes should be develop, defined and reviewed by asset management leadership.

- ***Organization compliant structure***[i27]

Respondent were asked if they have structure to comply with ISO 55000, 81 strongly agree that they have structure to comply and 25 were neutral about their organisation ability to comply to ISO 55000. Achieving real, long-term benefits, organisation need to ensure on-going compliance to regulation, market need or standard so that it becomes an embedded habit. Compliance requires organisational changes such as Policy writing; Procurement Specifications; Documentation of operational procedures. Organization will consider requirements of stakeholders and financial, technical and regulatory requirements when establishing objectives.

Therefore, the addressing organizational needs and ISO55000 compliant structure for SMEs Factor solution 2 can be expressed diagrammatically as follows:

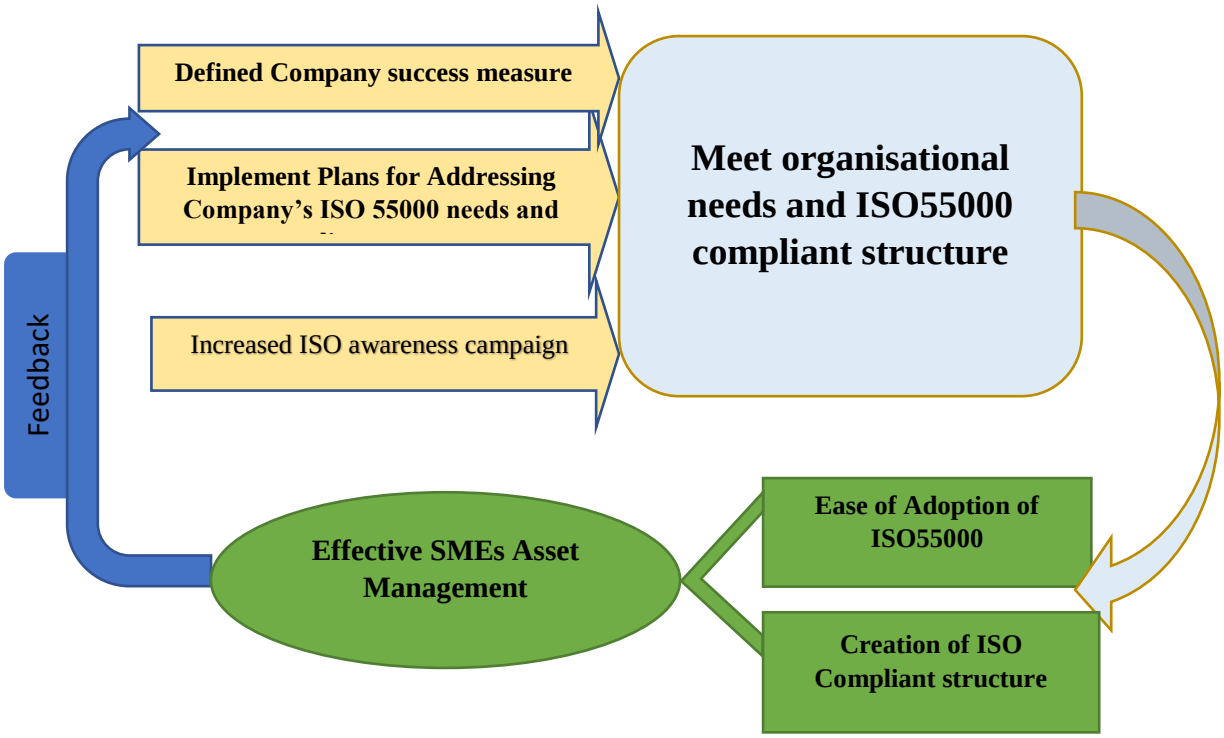


Figure 5.12 factor solution 2 model

5.2.3 Factor 3: Implementation of ISO55000 in SMEs through risk management, monitoring and control strategy has loaded items; Maintenance philosophy[i6], plan[i7] and use of KPI[i9] etc

1. ***Maintenance philosophy[i6]***

In factor one (1) respondent were asked maintenance strategy employed by their organisation (Levels of company maintenance strategy[i5]), different strategies were mentioned. In factor three (3) respondent were asked if they believe this strategy is appropriate for their company, 108 respondents said "YES" they believed in the strategy used. 20 respondents said "NO" they do not believe in the maintenance strategy employed by their organisation. The risk of equipment unavailability ought to prompt some level of thought about having reliable maintenance strategy.

2. ***Maintenance plan[i7]***

106 respondents said "YES" their organisation has maintenance plan. Maintenance plan is a document that set out what maintenance need to be done, when to do it, and who will do it; it tells how much it will cost and how the task will be monitored. Organisations are to implement their maintenance plan, integrating it into existing policies and providing financial resources to

implement the plan. All maintenance must be executed so that assets and systems operate efficiently and effectively.

3. ***Use of KPI[i9]***

117 Respondents said they use KPI; Maintenance KPI allows organisation detects issues. for the performance of an organization's assets to be ascertain, Key performance indicators (KPIs) should be established and be driven by the organization's policy objectives, established service standards, and available resources. It is important that organisation selects KPI that improve both equipment reliability and maintenance performance and not just saying what the problems are. Key performance indicators (KPIs) help to understand maintenance, its achievement for the business and what more it can do to improve operational performance. KPI help in selecting right strategy to either support or correct actions and provide evidence that objectives are being met or not.

4. ***Accessible Asset Management policies[i14]***

122 respondents said they have written processes for asset management and the processes are accessible. Policies and procedures that govern asset management and each asset are to be written and recorded in the asset registry.

- ***Asset management centralization[i15]***

117 Respondents said Asset management is centralized in their organization; which means asset management principles need to be collective and coordinated, and it is important that all elements in an organization be managed as a whole; physical, financial, and contractual attributes that enable the delivery of cost-efficient, timely business services is part of Asset management. ***Centralization*** involves the management of asset's identifiers, components, support and warranty dates, costs, contract associations, and all events associated with the asset. Asset planning and management should be integrated into relevant policy and planning structures, budgetary and evaluation processes and are aligned with organizational objectives. Every department should have the same overreaching target that brings them in the same direction.

- ***Plan for Risk management[i28]***

Efficient asset management involves identifying and assessing risks to facilitate well-informed decisions about risk management and treatment plans; Majority of the respondents said YES, they have planned actions to address risk and opportunities. According to ISO 55002 (2014) risks and opportunities related with change should be measured against their impact on the asset management system. Risk management must be an integral part of an organization's

culture, whether positive (opportunities) or negative (threats) and should examine the whole asset lifecycle, when establishing asset risk management plans. **Therefore, the Improved Risk management, monitoring and control strategy for SMEs Factor solution 3 can be expressed diagrammatically as follows:**

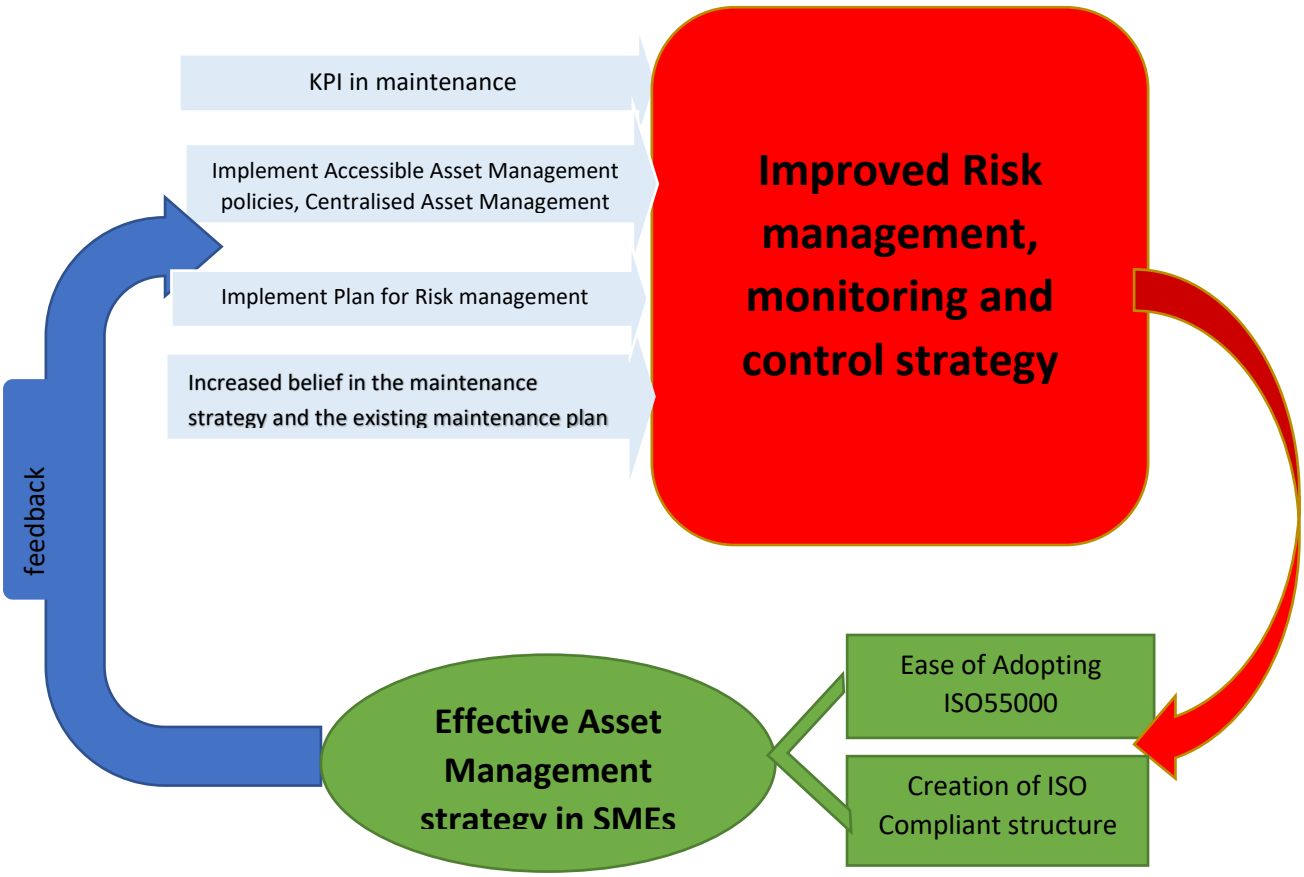


Figure 5.13 factor solution 3 model

5.2.4 Factor 4: Implementation of ISO55000 in SMEs by addressing Operational issues and evaluation has loaded items;

- **SME Problem[i3]**

Respondents were asked problems faced by their business, from chart below 118 respondents said **High cost of Production** are part of the problem faced by their organisation. Production costs include wages, benefits and other costs of plant staff, costs of raw materials and variable costs changing in proportion to production. High production cost mostly depends on the material costs. Production cost is related to productivity, material utilization and production efficiency; so organisation is to have a cost control strategy that reduces production costs.

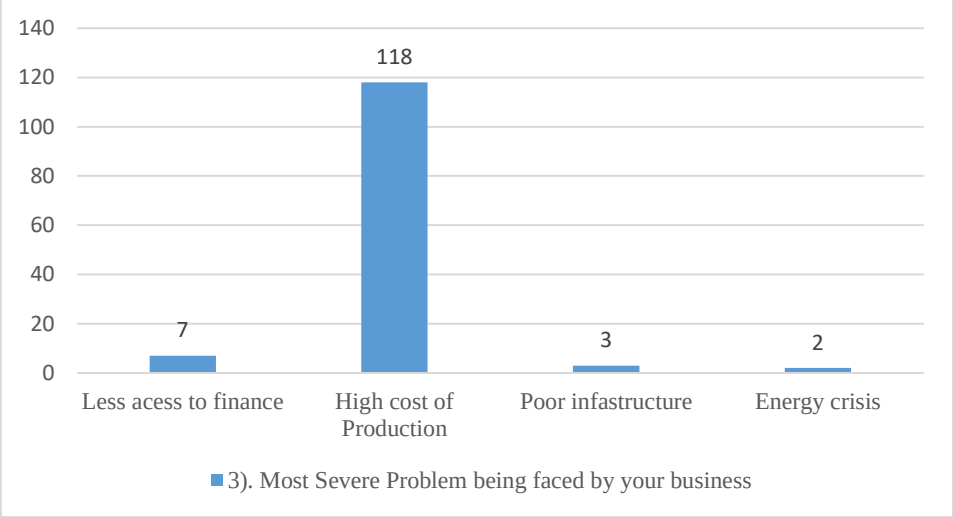


Figure 5.14 Problems faced by SMEs

7 respondents describe **less access to finance** as problem faced; cost of transaction contributes to the inability of the SMEs to access finance has being an issue repeatedly raised by numerous studies as a major constraint to industrial growth. The ability to access finance is a major factor affecting the growth and success of SMEs; Many businesses face a lot of challenges acquiring loans from banks and SMEs are the most affected (Moro et al., 2014). Finance constraints prevent organizations from financing in innovative projects, seizing growth opportunities, or undertaking restructuring in case of distress negatively affect productivity, employment, innovation and income gaps.

- **Lack of ISO certification**[i22]

Majority of the respondents said their organisation is ISO certified; from the items loaded, lack of ISO certification could affect the efficiency of an asset. ISO certification functions as an external platform to assess and determine whether an organization meets the standards set in place by an authorized institution; ISO standards focus on customer satisfaction. Quazi & Padibjo (1998) stated that certified companies experience an improvement over their quality and increase in their sales and market share while (Haversjo 2000) indicated an increase in sales correlates with an increase in the rate of return for certified companies, as opposed to non-certified companies.

ISO certified organizations have comparative advantage; they report high level of customer satisfaction, company profitability and productivity greater awareness of quality delivery (Kaminski 2012) and improvements in evaluation systems and operational effectiveness. ISO certification is a powerful tool, an essential component applied to strengthen quality improvement and drive patient safety initiatives. Therefore, organizations that participate in

the accreditation process, confirm their commitment to safety, improved efficiency, quality improvement and this is a demonstration of transparency in terms of accountability. Institutions that set or accredit standards ensure challenges and successes are taken into account. Key clients or stakeholders demand ISO certification most times; managers adopt certification, not being convinced of its usefulness, not operating the methods for efficient management tool. Corbett et al. (2002) also indicated that certification does not lead to significant internal financial improvements.

- **Asset Management evaluation**[i31]

From the survey findings below 127 respondents said their organization determines what asset they monitor and measure; Organizations are to determine what asset to be monitored and measured, the techniques to monitor, measure, analyze, evaluate and validate results, when it shall be done and what results should be analyzed and evaluated.

121 respondents said their organization evaluate and report on asset performance, asset management performance. Report on asset performance, asset management performance is integral to business success and are used to provide objective information that management can use, to influence the business outcomes and behaviour of their shareholders, customers, and employees. An Asset manager must regularly review the performance of its organization's assets; a suitable performance measures are the connection between organisations' business performance and asset performance, allowing organisations to understand the causes for poor asset performance and business performance.

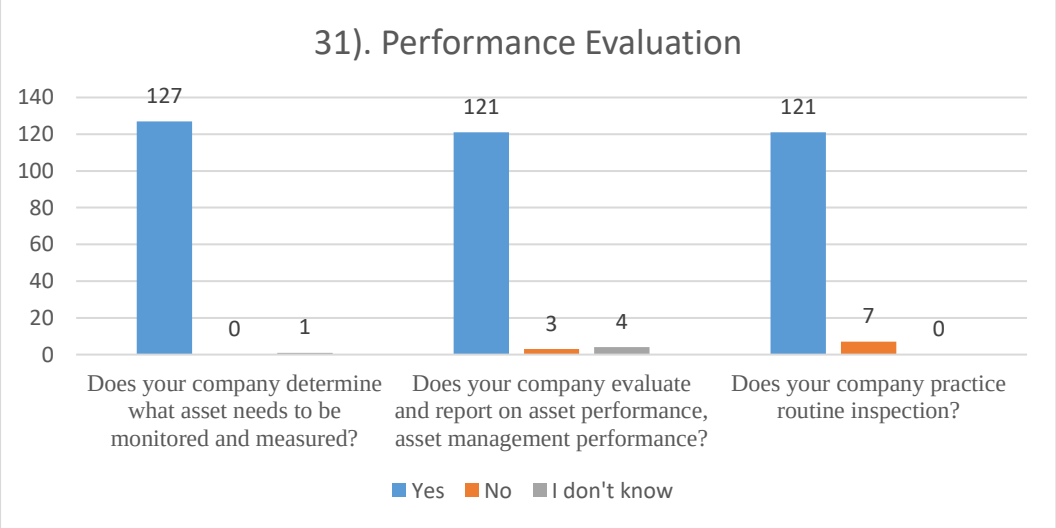


Figure 5.15 Asset management evaluation

Asset managers should monitor performance against their own established performance or

asset standards, targets or benchmarks to establish whether assets are being managed effectively, underperforming or costly to own and operate considering available resources.

121 respondents said their organization practice routine inspection. Routine inspections include both daytime and night-time asset inspections and occur at a frequency. Routine inspection of the assets and surroundings help to ensure trouble free operation; this should include visual checks for dust, dirt, and contaminations; checks for leaks and periodic measurements of performance.

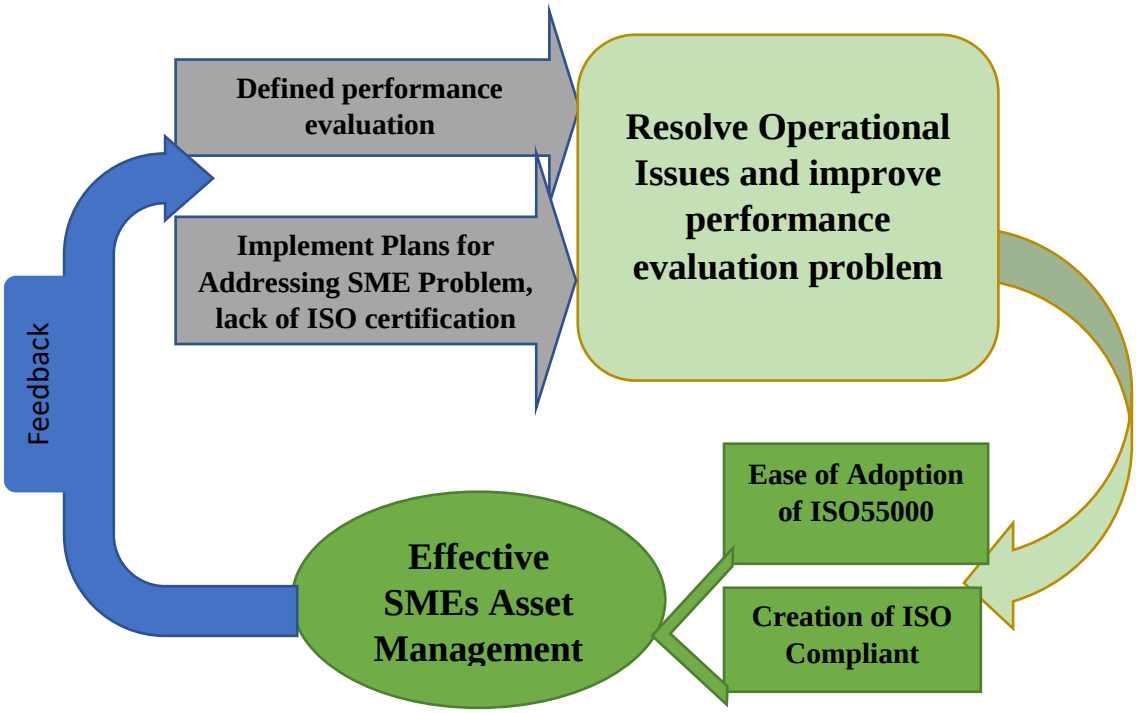


Figure 5.16 factor solution 4 model

Therefore, the addressing Operational Issues and improving performance evaluation for SMEs Factor solution 4 can be expressed diagrammatically above:

5.3 Additional insights from subsequent Chi-square analysis of Questionnaire

Table 5.1 below shows the relationship between organization that has adopted ISO 55000 and the size of organization in terms of employees in influencing asset management (ISO 5500) implementation by illustrating the distribution of frequency scores given by the participants. Participants' responses show that the highest responses fall in the **>250 staff,** that have adopted ISO55000; this shows the large organization are at advantage of implementing it.

Crosstab

Count

		1). What is the company size in terms of employee size			
		<50 staff	Between 51 and 250 staff	>250 staff	Total
25). Have you adopted ISO 55000?	Yes	1	1	62	64
	No	12	4	16	32
	I don't no	2	1	29	32
Total		15	6	107	128

Table 5.1 Chi-square Crosstabs analysis of frequencies of participants for company size in terms of employee size that adopted ISO 55000

b. Significance

This section investigates whether responses given by the participants are given at random. To assist this enquiry, values of Chi-square are determined. Table 5.2 depicts the values of Chi-square and the associated values of significance under H0 (H0: Probability of scores given at random).

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	36.126[a]	4	.000
Likelihood Ratio	32.732	4	.000
Linear-by-Linear Association	3.125	1	.077
N of Valid Cases	128		

- 5 cells (55.6%) have expected count less than 5. The minimum expected count is 1.50.

Table 5.2 Summary of the level of significance from the Chi-square test

The results of this test show that, for a level of significance of <0.05, the null hypothesis is rejected for both the parameters, indicating that these scores were not given at random.

Crosstab

Count

		2). Which industry does the company belong?						
		Eng. and automotive	Manufacturing	Aerospace	Marine	Pharmaceutical	Oil and Gas	Total
25). Have you adopted ISO 55000?	Yes	1	0	0	0	0	63	64
	No	7	6	1	2	5	11	32
	I don't no	0	2	0	0	1	29	32
Total		8	8	1	2	6	103	128

Table 5.3 Chi-square Crosstabs analysis of frequencies of participants for companies that adopted ISO 55000

Table 5.3 shows that most of the organization that had adopted ISO 55000 is the oil and gas industry. The result shows oil and gas industry embracing the benefit of ISO 55000 that helps in effectively manage their assets to optimize its lifetime value.

b. Significance

The responses were analyzed for significance to investigate whether participants' responses were given at random. Values of Chi-square were determined to aid the investigation. Table 5.4 shows the values of Chi-square and the associated values of significance.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	60.511[a]	10	.000
Likelihood Ratio	61.074	10	.000
Linear-by-Linear Association	3.124	1	.077
N of Valid Cases	128		

a. 15 cells (83.3%) have expected count less than 5. The minimum expected count is .25.

Table 5.4 Summary of the level of significance from the Chi-square test

The results of this test show that, for a level of significance of $p<0.05$, the null hypothesis is rejected for all the parameters. This indicates that these scores were not given at random.

Table 5.5 shows the importance of maintenance strategy for effective asset management implementation. The results show that there is a relationship between those that have adopted ISO 55000 and companies with maintenance strategy. Those that have adopted ISO 55000 and companies with maintenance strategy are above average.

Crosstab

Count

		5) Levels of company's maintenance strategy			
		Very low	Average	Above average	Total
25). Have you adopted ISO 55000?	Yes	2	0	62	64
	No	22	6	4	32
	I don't no	3	2	27	32
Total		27	8	93	128

Table 5.5 Chi-square Crosstabs analysis of frequencies of participants for the importance of maintenance strategy and adoption of ISO 55000 Formulation for Asset Management Implementation

b. Significance

This section investigates whether responses given by participants are given at random. Values of Chi-square were determined to aid the investigation. Table 5.6 shows the values of Chi-square and the associated values of significance under H0 (H0: Probability of scores given at random).

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	80.043[a]	4	.000
Likelihood Ratio	82.333	4	.000
Linear-by-Linear Association	5.667	1	.017
N of Valid Cases	128		

- 3 cells (33.3%) have expected count less than 5. The minimum expected count is 2.00.

Table 5.6 Summary of the level of significance from the Chi-square test

The results of this test show that, for a level of significance of $p<0.05$, the null hypothesis is Rejected for all the parameters. This indicates that these scores were not given at random. Table 5.7 result shows organization's that perform Asset Management activities were able to adopted ISO 55000 this result enhances the implementation of effective asset management.

Crosstab

Count

		13). Do you perform any Asset Management activities?		
		No	Yes	Total
25). Have you adopted ISO 55000?	Yes	3	61	64
	No	10	22	32
	I don't no	2	30	32
Total		15	113	128

Table 5.7 Chi-square Crosstabs analysis of frequencies of participants for the importance of Performing Asset Management activities / adopting ISO 55000 for Asset Management Implementation

b. Significance

This section investigates whether responses given by participants are given at random. Values of Chi-square were determined to aid the investigation. Table 5.8 shows the values of Chi-

square and the associated values of significance under H0 (H0: Probability of scores given at random).

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.783[a]	2	.000
Likelihood Ratio	13.558	2	.001
Linear-by-Linear Association	.824	1	.364
N of Valid Cases	128		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 3.75.

Table 5.8 Summary of the level of significance from the Chi-square test

The results of this test show that, for a level of significance of <0.05, the null hypothesis is rejected for both the parameters, indicating that these scores were not given at random.

5.4 Summary of Chapter

This chapter revealed key findings in line with the objective of the research and exposes the critical factors that influence ISO55000 in Small and Medium-Sized Enterprise (SMEs) and enhance the performance of business and equipment by ensuring regularly and efficiently performance to prevent loss or breakdown. Survey was carried out targeting asset management practitioners in SMEs; the aim of the survey was to gather information on four areas. Firstly, was to gather information on the scope and basic profile of the organizations; assess if there is any asset management operation in the organization. Secondly, gather the opinions of asset management practitioners on the role of asset management in accomplishing organizations objectives and their perception on the factors that enables effective asset management implementation. Finally, the survey identified the most critical basic factors, which SMEs should consider in implementing asset management (ISO 55000) practice.

The respondents' views reflected factors essential in supporting effective asset management (ISO 55000) implementation and compliance. The factors regarded to be important includes:

1 Senior management support
2 Integrated asset strategy implementation;
3 Policy & Strategy and business objectives actualization.
4 Setting clear vision, goals and training;

5 Resource allocation and adequacy;
6 Expertise and training
7 Availability of adequate tools
8 Organization maintenance strategy
9 Asset performance assessment;
10 Continuous asset review programmed for monitoring and controlling performance;
11 High costs of production;
12 Asset management capabilities evaluation
13 Benchmarking of KPIs
14 Improved facilities and increased co-location and partnership working as concepts for assessing improved service delivery.

The above factors identified by respondents were evaluated in terms of the most critical underlying factors, which SMEs should consider in implementing asset management (ISO 55000) practice. Data was tested and was found to be suitable for factor analysis, 33 items were subjected to principal components analysis (PCA). Adopting the criterion cumulative percentage of variance rule, four components were identified. The extracted factors are labelled ***Develop comprehensive Asset Management Strategy*; *organizational needs and ISO55000 compliant structure; Risk management, monitoring and control strategy*; *Operational issues and evaluation*.**

The next chapter concludes the thesis by presenting its contribution to knowledge, evaluating the extent to which the research aims, and objectives of this study has being achieved, suggesting areas of future studies, presenting the proposed model from the results of the quantitative analysis that reflects the peculiarities of SMEs and making recommendation on how to facilitate the adoption of ISO55000 in the asset management of SMES.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The main purpose of this chapter is firstly to provide conclusions from findings of the quantitative analysis and the discussion thereof in the preceding chapter. Secondly, this chapter also offers practical recommendations in relation to the adoption of ISO55000 by SMEs in the quest to improve their asset management in line with the Global best practices, and at same time, incorporate the peculiar challenges and needs relating to SMEs (RQ1-RQ4). The remaining part of the chapter is divided into four sub-sections. Section 6.2, presents the interactions between the four critical factors identified in the study from the factor analysis, namely, ***'the Development of comprehensive Asset Management Strategy', 'addressing organisational needs and ISO55000 compliant structure', 'implementing risk management, monitoring and control strategy', and by 'tackling Operational issues and evaluation'.*** The underlining relationship between these factors underpins the holistic framework developed in this study for the ease of adoption of ISO55000 in SMEs Asset Management (RO4). Section 6.3, discusses the theoretical and practical implications of the holistic framework, by evaluating the significance of the key findings in the context of the thesis' general and specific contributions to knowledge. Section 6.4, critically assesses the extent to which the research objectives have being achieved, and key research questions answered, in order to tease out the major limitations of the study and areas for future research at the post-doctoral level. Finally, Section 6.5 provides a personal reflection of the researcher's journey over the duration of the study, with a plan for future personal development.

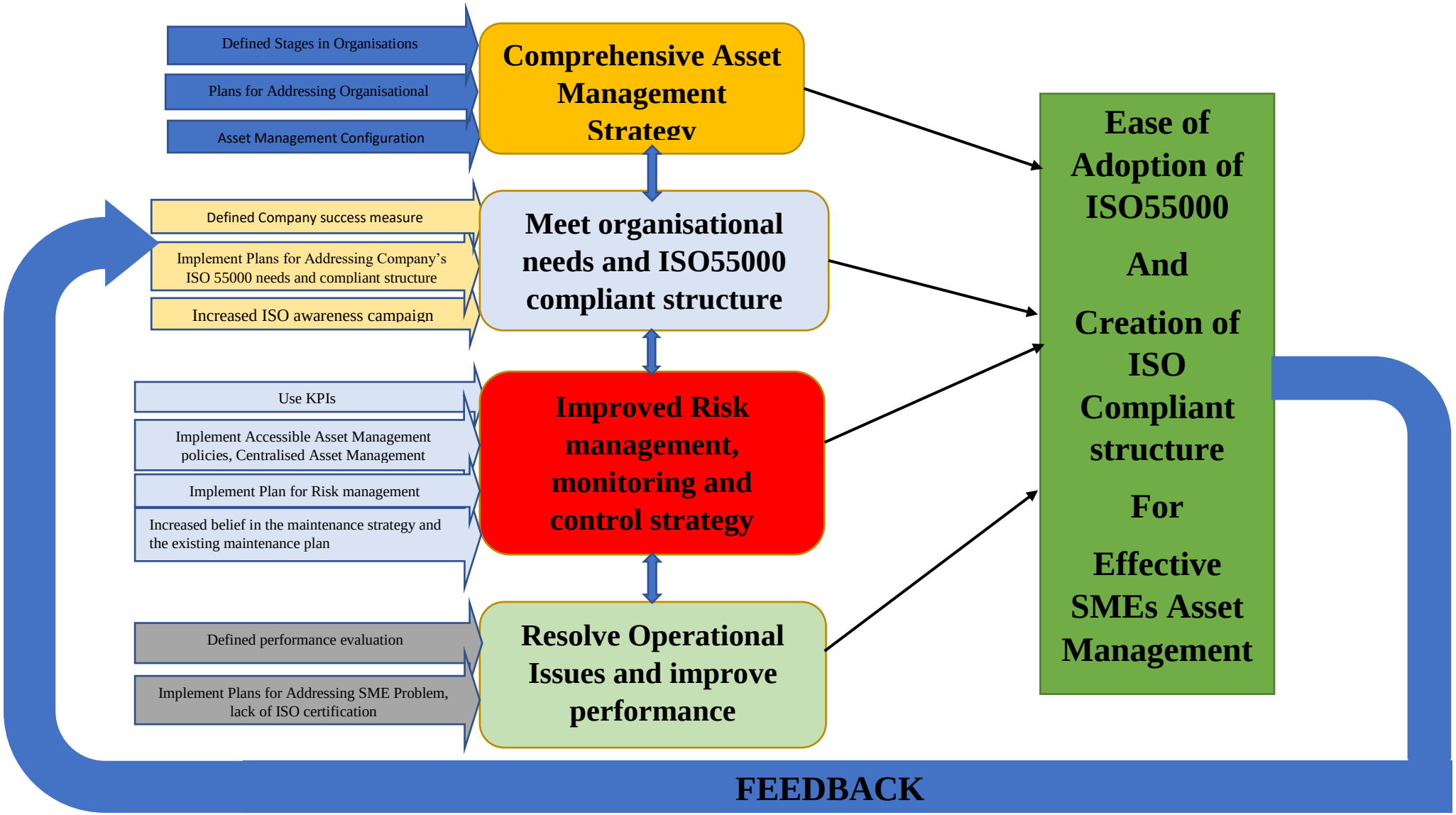
6.2. A holistic framework: *Comprehensive Asset Management Strategy, organisational needs and ISO55000 compliant structure, risk management, monitoring and control strategy and Operational issues and evaluation.*

The quantitative analysis of the 128 questionnaires reveals four factor solutions: the Development of 'comprehensive Asset Management Strategy', addressing 'organisational needs and ISO55000 compliant structure', implementing 'risk management, monitoring and control strategy' and by tackling 'Operational issues and evaluation', for the ease of adoption of ISO55000 in SMEs Asset Management (RO1-RO4). The relationship between these factors was tested through two hypotheses, which reveal that *the efficiency of assets will improve with the adoption of ISO55000 ($H_{0.1}$) and that the implementation of ISO 55000 contributes to effective management of SMEs ($H_{0.2}$).* The findings from the study reveal two key Asset

management principles underpinning the proposed framework for the adoption of ISO55000 in SMEs. The first principle relates to strategic reasoning or thinking about how to improve Asset Management as a source of competitive advantage this involves key activities which asset managers are engaged in e.g. identifying, diagnosing, conceiving and realising asset management issues. The second, principle relates to the RADAR (Results-Approaches-Deployment-Assessment-Review) philosophy, which underpins existing Asset Management models and frameworks. The above management principles (strategic reasoning; RADAR) and related planning- implementation-control management process form the basis for developing the holistic framework presented in Figure 6.1.

First, *Defined stages in organisational maintenance strategy, plans for addressing organisational constraints and Asset management configurations* all flow into the Asset maintenance process as inputs and transformed into a ***Comprehensive Asset management strategy*** which will result in ***Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management*** as outputs. Should this fail, the results are feedback and clearer Defined stages in organisational maintenance strategy, plans for addressing organisational constraints and Asset management configurations which flows into maintenance process as inputs to be transformed. This first part is premised on the assumption that the development of ***Comprehensive Asset management strategy*** is dependent on three deliberate interactive and iterative steps. Step 1 – identifying and assessing the gaps in asset management strategy and organisational needs; Step 2 – Processing the inputs collected in Step 1 and deciding Approaches and resource Deployment to achieve Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management; and Step 3 - efficient use of firms' feedback process, Assessment and Review to inform areas of improvement in its ***Comprehensive Asset management strategy***.

***Figure 6.1**: Holistic framework for ISO 55000 adoption in SMEs*



This also impacts on the ability to **meet organisational needs and ISO55000 compliant structure**, which is the second stage of the framework. Defined *company's success measures, Implement Plans for Addressing Company's ISO 55000 needs and compliant structure, and Increased ISO awareness campaign* all flow into the Asset maintenance process as inputs and transformed into the ability to **meet organisational needs and ISO55000 compliant structure** which will result in ***Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management*** as outputs. Should this fail, the results are feedback and clearer ***inputs*** all flow again into the maintenance process to be transformed. This second stage is premised on the assumption that the ability to **meet organisational needs and ISO55000 compliant structure** is dependent on three deliberate interactive and iterative steps. Step 1 - the ability to meet organisational needs and ISO55000 compliant structure; Step 2 – Processing the inputs collected in Step 1 and deciding Approaches and resource Deployment to achieve Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management; and Step 3 - efficient use of firms' feedback process, Assessment and Review to inform areas of improvement in its **ability to meet organisational needs and ISO55000 compliant structure.**

This also impacts on the firms' ability to **Improved Risk management, monitoring and control strategy**, which is the fourth stage of the framework. In this stage, *the Use of KPIs in maintenance, Implementing Accessible Asset Management policies, Centralised Asset Management, Implement Plan for Risk management* and *increased belief in the maintenance strategy and the existing maintenance plan* all flow into the Asset maintenance process as inputs and transformed into an **Improved Risk management, monitoring and control strategy** which will result in ***Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management*** as outputs. Should this fail, the results are feedback and clearer ***inputs*** all flow again into the maintenance process to be transformed. This third stage is premised on the assumption that **Improved Risk management, monitoring and control strategy** is dependent on three deliberate interactive and iterative steps. Step 1 – identifying the gaps in firms' Risk management, monitoring and control strategy; Step 2 – Processing the inputs collected in Step 1 and deciding Approaches and resource Deployment to achieve Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management; and Step 3 - efficient use of firms' feedback process, Assessment and Review to inform areas of improvement in its **ability to meet organisational needs and ISO55000 compliant structure.**

This also impacts on the firms' **Resolve Operational Issues and improve performance evaluation problem**, which is the fourth stage of the framework. In this stage, *Defined performance evaluation and Plans for Addressing SME Problem, lack of ISO certification* are flow into the Asset maintenance process as inputs and transformed into an ability to **Resolve Operational Issues and improve performance evaluation problem** which will result in ***Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management*** as outputs. Should this fail, the results are feedback and clearer ***inputs*** all flow again into the maintenance process to be transformed. This Fourth stage is premised on the assumption that ability to **Resolve Operational Issues and improve performance evaluation problem** is dependent on three deliberate interactive and iterative steps. Step 1 – identifying the gaps in firms' Operational Issues and performance evaluation problem; Step 2 – Processing the inputs collected in Step 1 and deciding Approaches and resource Deployment to achieve Ease of Adoption of ISO55000 and Creation of ISO Compliant structure for Effective SMEs Asset Management; and Step 3 - efficient use of firms' feedback process, Assessment and Review to inform areas of improvement in its ability to Resolve Operational Issues and improve performance evaluation problem.

6.3 Implications of the developed holistic framework - the significance of findings in the context of the contributions to knowledge.

The holistic framework developed in this study has key implications for improving the ease of ISO55000 adoption by SMEs in their asset management process as a means of superior organisational performance. The framework is in line with the RADAR philosophy, which underlines key management models for asset management, the developed framework, is also in line with systems thinking, and 'enabler-result criteria' which underpins the ISO55000 framework for delivering quality Asset management. The developed framework for ISO 55000 adoption in SMEs has implications in the practical sense as studies such as ***The Reasons and Symptoms of Failure in SMEs*** by (Ropega 20011) have shown that SMEs failures can be related to their lack of proven asset management structures and comprehensive asset management models as the ISO55000 enjoyed by bigger firms. The framework highlights the criticality of developing a comprehensive Asset management strategy by defining stages in organisational maintenance strategy, plans for addressing organisational constraints and Asset management configurations which is in line with the proposed SAMF model explained in the chapter 4 of this thesis. Furthermore, the Framework incorporates the peculiar challenges faced my SMEs and proffers solutions in ensuring that their business purposes are achieved through

robust Asset Management. The quantitative analysis on which this framework is built exposes the criticality of comprehensive Asset Management Strategy[F1], organisational needs and ISO55000 compliant structure [F2], risk management, monitoring and control strategy [F3] and Operational issues and evaluation [F4] in ensuring that ***the efficiency of assets improves with the adoption of ISO55000 ($H_{0.1}$)*** and that ***the implementation of ISO 55000 contributes to effective management of SMEs ($H_{0.2}$)***. This thus provides greater insights into understanding Asset Management, ISO55000 and ways of leveraging on the strengths and weaknesses faced by SMEs in this highly competitive business environment. The implication of this framework therefore is that the way SMEs can adopt and enjoy the benefits available through the adoption of ISO55000 is not only by having any type of asset management strategy but by developing ***Comprehensive Asset Management Strategy^{F1}***, ***organisational needs*** *and* ***ISO55000 compliant structure^{F2}, risk management, monitoring and control strategy^{F3}*** and ***Operational issues and evaluation^{F4}.***

6.4. Extent of validation of the holistic framework: Inability to see the proposed model implemented and results monitored throughout the limited study time.

The review of literature shows most of the existing asset management models focus on asset management as simply a managerial phenomenon and not a link to maintenance. The few models that have taken on-board asset management as a maintenance issue view its management as either on corrective, planned and predictive maintenance with very few models being holistic as the framework in this study to encompass element planned, predictive, reactive, and corrective; thus demonstrating a core shift in asset management philosophy which encourages organisations to have a maintenance strategy and use KPI. This research framework is in line` with the systems thinking, and the RADAR logic based on 'enabler-result criteria', and philosophical underpinnings of comprehensive asset management as a driver for SME's performance results through the transformation of required inputs to positive outcomes. There is however a need to test the developed framework to validate the research finding or a wider stakeholder ranges.

The research achieved its overarching aim and research objectives thereby providing answers to its research and sub-research questions, however the major limitations for this study is not validating the developed framework through field testing to expose the extent of its robustness. However, the recommended area for future studies is to test the holistic framework presented

in this study within the industries practicing Asset management in view of implementing ISO 55000.

6.5. Contributions to knowledge

This study links principle of Asset management in SMEs with the philosophy of ISO55000 and from this, it teases out key contributions in relation to theoretical development. This study assessed the key barriers and challenges faced by SMEs in their quest for improved asset management and thus competitive advantage thereby contributing to the theoretical understanding of the peculiar issues faced by SMEs. The finding postulates 4 factors limiting the success of SMEs: keeping up to speed with technological change, breadth of equipment requiring maintenance, finding trained engineers and budget constraints.

The study extends the knowledge on how ISO55000 framework could be adjusted to reflect the needs and challenges of SMEs; thereby increasing the ease of its adoption. There are hardly any academic researches aimed at exploring ways through which ISO55000 can be adopted by SMEs. Therefore finding from this study reveals four **(4)** areas to improve the ease of ISO55000 adoption by SMEs; **'Development of comprehensive Asset Management Strategy', 'addressing organisational needs and ISO55000 compliant structure', 'implementing risk management, monitoring** and **control strategy',** and **by 'tackling Operational issues and evaluation'.** This study provides deep insights on how SMEs are to implement ISO55000 in order to achieve high business performance.

6.5.1 Specific contributions to knowledge

This research demonstrates the influencing applicability of ISO 55000 in SMEs; findings discussed contribute to the literatures in asset management. The research also revealed that with the level of limited available data and information within SMEs, it is not feasible to apply ISO 55000 comprehensively the way it is practiced currently in big companies, however a practical, cost effective approach to asset management is possible, even with the limited data available. Based on the limited data and identifying the current context of recurrent necessities in SMEs, a unique ISO 55000 (asset management) model was develop with an aim to achieve 'customer satisfaction' and a 'change' in working culture. The proposed model was based on organisational strategic objectives and asset management practice to achieve functional sustainability. The research validate that application of asset management (ISO 55000) contribute to 'cost reductions' and provide procedures for maintenance strategies. The administration of a questionnaire brought to light the asset management practices of SMEs, it

helped discover the detailed mechanisms employed by SMEs in the management of their Asset. These internal practices are usually not made available as part of published information, which makes it very difficult to accumulate adequate and accurate information for research purposes.

6.6. Conclusion

Literature review was used to create theoretical framework about the topic and the purpose of the research was to discover the benefits that ISO 55000 could provide for SME, how asset management system create an excellent opportunity to monitor the activities that play an important role in a company's own development and partly in the development of a competitive advantage. The research discloses strategies that can be implemented to reduce these impacts.

The paper explains the concept of ontology and epistemology philosophy, which shows the nature of reality and the relationship that exist between the researcher and this reality. Data was collected on eight SMEs that participated in the study; their objective was to establish relationships and increase understanding of their business environment. The validity and reliability of results that the study finds are good when taking account that the research was conducted with questionnaire and the explanatory study give potential benefits ISO 55000 could offer. Further studies are needed to verify the results, as findings have considerable significance for theory and practice, they provide asset operators and managers a clear understanding of asset performance management. It is essential that organization be in a state of readiness to adopt the ISO 55000. To encourage the survival of SMEs and their value adding prospective, top management should embrace recommendations outlined in this paper.

6.6. Recommendation for future research at the post-doctoral level

This research is subject to limitations, which offer directions for future research. Quantitative method was adopted and results may not be generalized to all SMEs. Future studies should be mixed-method and conducted at a large-scale survey to test correlation, results of study should be verified as only in certain conditions could they be implemented; they are more like guidelines due to its explanatory study. This research can be extended to developing economies and industries to boost the external validity of findings. Though this study achieved its objective there were some identifiable issues, as majority of the data used and data collection techniques were staff based; future research might broaden the survey to customers while maintaining the same research focus aim and objectives. Broadening of the research scope

would be useful to gain wider experience from different approaches to asset management practice.

Another area for future studies will be the review of organization's current processes against the requirements of ISO 55001 has been achieved in a comprehensive matter base on the recommendation of ISO 55002 (ISO 55000 2014). This is because currently, there are challenges to determine how organization would improve and support the functioning of a compliant asset management system (ISO 55000). Further research could find techniques; tools, processes and structures that will support SMEs utilize or implement the model for better value-creation.

Furthermore, organization operating under asset management principles need to thoroughly review these processes in order to help organizations promote high level of improvement in all department of the asset management system using the developed framework. It is therefore recommended that a pilot study be performed using the develop framework developed in this study as a case study on the critical equipment in one department of the organizations. Besides these, this recommended further research could provide valuable perceptions on challenges of the certification process; certification of ISO 55000 should be considered in order to see if they have any monetary impact on the firms. This is because literature on the impact of certifications is unclear due to deficiency of similar work limiting the scope and comparison of framework outputs.

Recommendations for further research relates to the possible benefits organizations obtain from ISO55000 implementation. The inclusion of these benefits in the proposed framework in this study result in a comprehensive framework, which is of much value to SMEs. It is important for implementation issues to be considered when outlining recommendation. SMEs need to be able to obtain information with regards to the benefits and problems it is likely to encounter by initiating the certification process and implementation of ISO 55000. Based on these findings it should be able to make a more informed decision if to initiate the process to become ISO 55000 certified.

PUBLICATIONS

The process of reviewing the literature concluded in the write-up of a total of the following six papers, which were presented at a number of conferences.

PAPER TITLE	CONFERENCE NAME
IDENTIFYING ORGANIZATIONAL REQUIREMENTS FOR THE IMPLEMENTATION OF AN ADVANCED MAINTENANCE STRATEGY IN SMALL TO MEDIUM SIZED ENTERPRISES (SMES).	EURO MAINTENANCE 2016
ASSESSING THE EFFECTIVENESS OF ISO 55000 STANDARD IN SMALL TO MEDIUM SIZED ENTERPRISES (SMES).	AFRICA MAINTENANCE & RELIABILITY CONFERENCE (AMRC 2016)
ISO55000 STANDARD AS A DRIVER FOR EFFECTIVE MAINTENANCE BUDGETING.	INTERNATIONAL CONFERENCE ON MAINTENANCE ENGINEERING (INCOME II-2017)
ACHIEVING EFFICIENT ASSET MAINTENANCE THROUGH ISO 55000.	OPERATIONS AND MAINTENANCE CONFERENCE (OMAINTEC 2017)
THE ROLE OF ISO55000 STANDARD IN ASSET INTEGRITY.	CONDITION MONITORING AND DIAGNOSTIC ENGINEERING MANAGEMENT (COMADEM 2017)
THE IMPLEMENTATION OF ISO55000 IN SMALL AND MEDIUM ENTERPRISES: REQUIREMENTS AND CONSTRAINTS.	WORLD CONGRESS ON ENGINEERING ASSET MANAGEMENT (WCEAM 2018)
DEVELOPING ASSET OPERATIONS AND MAINTENANCE STRATEGY TO DEAL WITH IMPACT OF COVID-19	WORLD CONGRESS ON ENGINEERING ASSET MANAGEMENT (WCEAM 2021)

Table 6.1 Publications

My PhD Research Journey: The Intrigues, Rigour and Sense of Fulfilment.

Before I embarked on my PhD journey, I knew it wouldn't be easy. I was certain that there would be moments of despair, frustration, ups and downs in both my research and personal life. Reality did not proved me wrong as there were ups and downs, left, rights and centre, a mixture of thought and diverse feelings. I was faced with several challenges at different stage of my program but I remained determined to get my research degree; in the end, it all worked out in a distinctive way. My PhD was an extension of my Master's, with dissertation on Facilities maintenance management in oil and gas industry using computer-based system. During that research, the motivation to go in depth was to understand how companies manage their asset, which was borne from seeing challenges faced by companies during fieldwork.

I was offered admission as a PhD student in the university, after my proposal defence. At the start of my PhD, I spent months reading and searching for literature relevant to my research, sometimes in the library, university office, or at home. Studying entails hunting, which can be early in the morning or late at night, with colleagues or alone. The experiences from my Masters degrees may have equipped me for my PhD research; but still failed to prepare me for all challenges I faced. The challenges were enormous and diverse. For example, being a relatively new concept, there was severe lack of secondary data on ISO 55000, which required even harder searches from different online and physical libraries to gather as much information about ISO 55000 no matter how small. Then came the challenge of primary data collection; initially, this research was designed to be mixed method, after contacts had been made via supervisors and companies willing to be interviewed. The height of Brexit and uncertainty it brought, companies could not find suitable time to participate in the study. Thus, I had to redesign the entire study and change from the initially planned mixed study to quantitative study. This decision was further strengthened since the Research Questions could be answered quantitatively although I wanted in-depth information the qualitative brings. Then came the challenge of recruiting participants for the questionnaire study, with help of colleague, friends and contacts, I was able to get participants for the study. Given that data security is still topical, the study was designed to give participants confidence that their identities will be protected. By using Google form as the template, the participants' identities were protected since all I needed was just their email address to send it off and when they submit it comes without their identity showing. There was also challenge with the data analysis as the first SPSS version expired during the course of analysis and needed to be upgraded and the new version was quite

different from the older version and failed to retain data previously saved on the drive. Luckily, I had developed the habit of saving every process in an external drive thus avoiding a disaster; the data collection process strengthened my research design and provided answers to my research questions.

The most exciting part of my research was visiting organisations and interacting with the staffs, I observed their activities, reactions and listened to their views. The best way to "test" research ideas is sharing it with colleagues and those in the field; discussing my research boost my confidence and improved my speaking ability in conferences. Conferences also gave me the opportunity to explore other culture, meet people in my field, and broadened my research horizons and I felt inspired. There was also little support in terms of showcasing my work in external conferences, as there was no funding available in the university; But with the support of my family funding me and supervisor's encouragement, I was able to present part of my findings in several conferences and articles despite these challenges. Some of these conferences attended include ***'Identifying Organisational Requirements for the Implementation of an Advanced Maintenance Strategy in Small to Medium Sized Enterprises (SME)' at Euro Maintenance 2016; 'Achieving Efficient Asset Maintenance through ISO 55000' Presented at OMAINTEC 2017; 'The role of ISO 55000 Standard in Asset Integrity' presented at COMADEM 2017; 'Assessing The Effectiveness Of ISO 55000 Standard In Small To Medium Sized Enterprises (SMEs)' presented at Africa maintenance & reliability conference (AMRC) 2016; and 'ISO55000 Standard as A Driver for Effective Maintenance Budgeting' presented and published at INCOME-II-2017.***

During my writing stage, I saved all drafts on my computer so I can keep trail of all feedback I received and the progress made. Throughout my PhD life, I saved more than 20 drafts! Even when I felt I was close to the end, the file "Ibifuro's thesis" was saved again as "Ibifuro's thesis_2" and again as "Ibifuro's thesis_3" and again as… "Furo's thesis-01"; Thus it seemed like a never-ending practice which made me believe that PhD is more about reworking and rewriting your ideas rather than writing them down in the first place. After lots of studying, writing and rewriting, the day of my viva thesis came; it was truly fulfilling for me to defend my thesis.

Through the journey, I had points that I felt overwhelmed by challenges to the point of almost giving up but the Money invested, friends, family and colleagues motivated me to keep

pushing. Coming from a strong Christian background, my Family and Friends encouraged and prayed for me constantly, calling and texting to keep me on track with my purpose. My Supervisor supported me in arriving at the final destination of my PhD journey. While these check-ups can increase pressure, it also reminded me that there are many people trusting on my abilities to get the work done and overcoming these challenges; I will forever be grateful for providing me all the required support. My future beckons...

REFERENCE LIST

1. Aberdeen Group (2006) 'The asset management benchmark report - Moving toward zero downtime', AberdeenGroup, Inc., Boston.
2. Agarwal, R., Echambadi, R., Franco, A. & Sarkar, M.B. (2004) 'Knowledge transfer through inheritance: spinout generation, development and survival', Academy of management, vol 47, no. 4, pp. 501-522.
3. Alegre, H., Baptista, J.M., Cabrera Jr, E., Cubillo, F., Duarte, P., Hirner, W., Merkel, W. & Parena, R. (2006) Performance indicators for water supply services, 2nd edn, London: IWA,.
4. Alegre, H., 2016. Performance indicators for water supply services. s.l., IWA publishing.
5. Alfatih, M. S., Leong, M. S. & Hee, L. M., 2015. Definition of engineering asset management: a review. Applied Mechanics and Materials, Volume 773, pp. 794-798.
6. Allin, D. et al., 2019. The Role of Operations and Maintenance in Asset Management. s.l. S.n.
7. Al Mahrouq, M. (2010) 'Success Factors of Small and Medium – Sized Enterprises (SMEs)'. The Case of Jordan. Anadolu University Journal of Social Sciences., vol 10, no. 1, pp. 89-90.
8. Al Marzooqi, F., Hussain, M. & Ahmad, S., 2019. Performance of physical asset management using the analytic hierarchy process. Prop. Manag. Prop. Manag, Volume 37, p. 327–345.
9. Almeida, M. d. C., Brito, R. S., Jorge, C. & Cardoso, M. A., 2021. "Performance Assessment System to Wastewater Utilities Strategic Planning. Water, 13(18), p. 2489.
10. Almeida, N. M. d., Vieira, J., Silva, J. G. & Castro, C. e., 2021. The impact of asset management development programs in infrastructure organizations," in Sustainability and Automation in Smart Constructions. Proceedings of the International Conference on Automation Innovation in Construction (CIAC-2019), pp. 247-258.
11. Al-Najjar, B. & Alsyouf, I. (2000) 'Improving effectiveness of manufacturing systems using total quality maintenance', Integrated Manufacturing Systems, vol 11, no. 4, pp. 267-276.
12. Alsyouf, L. (2007) 'The role of maintenance in improving companies productivity and profitability', International Journal of Production Economics, vol 105, no. 1, pp. 70-78.
13. Alsyouf, I., Alsuwaidi, M., Hamdan, S. & Shamsuzzaman, M., 2018. Impact of ISO 55000 on organisational performance: Evidence from certified UAE firms. Total Qual. Manag. Bus, p. 1–19.
14. Amadi-Echendu, J.E., Willet, R., Brown, K., Hope, T., Lee, J., Mathew, J., Vyas, N. & Yang, B.S. (2010) 'What is Engineering Asset Management. Part 1, Engineering Asset Management Review.' Springer.
15. Amadi-Echendu, J., Willett, R., Brown, K., Lee, J., Mathew, J., Vyas, N. & Yang, B.S. (2007) 'what is engineering asset management?', 2nd World Congress on Engineering Asset Management and the 4th International Conference on Condition Monitoring, Harrogate, United Kingdom, vol 2007, pp. 116–129.
16. Amadi-Echendu, J.E., et al., What is engineering asset management? 2010: Springer.
17. Amin, R. A., 2016. Condition-based maintenance: innovation in building maintenance management, University College London: Thesis.
18. Arteaga-Ortiz, J., & Fernandez-Ortiz, R. (2010). Why Don't We Use the Same Export Barrier Measurement Scale? An Empirical Analysis in Small and Medium-Sized Enterprises. *Journal of Small Business Management,* 48(3), 395-420.

19. Ayu, K. & Yunusa-Kaltungo, A., 2020. A holistic framework for supporting maintenance and asset management life cycle decisions for power systems Energies. 13(8), p. 1937
20. Barry, D. (2011) 'Asset management excellence, chap.', in Asset management excellence, Taylor and Francis Group.
21. Bartholomew, D., Knott, M., & Moustaki, I. (2011). Latent variable models and factor analysis: A unified approach (3rd ed.). A John Wiley and Sons, Ltd: Wiley.
22. Beaver, G. & Jennings, P. (1995) 'Picking winners: the art of identifying successful small firms', The International Review of Strategic Management, vol. 6, no. 4, pp. 91-106.
23. Bessant, J. (2003) High involvement innovation, Chichester: John Wiley and Sons.
24. Bettis-Outland H, Cromartie JS, Johnston WJ & Borders AL (2010). The return on trade shows information (RTSI): a conceptual analysis. The Journal of Business & Industrial Marketing 25(4): 268.
25. Blanchard, B.S. & Fabrycky, W.J. (2006) Systems Engineering and Analysis, 4th edn, Prentice Hall.
26. Botha, A. (2014) 'Political socialization and terrorist radicalisation among individual who joined Al- shabaab in Kenya', Studies in Conflict and Terrorism, vol 37, no. 11, pp. 895-919.
27. Braaksma, A.J.J. & VEPWHM, K.W. (2011) 'A review of the use of asset information standards for collaboration in the process industry.' vol 62, no. 3, pp. 337–350.
28. Braaksma, A.J.J. (2012) 'Design of a Maintenance Feedback Analysis (MFA) method for continuous FMEA-based maintenance, in: Asset information for FMEA-based maintenance, PhD dissertation, Faculty of Economics and Business, SOM,' University of Groningen.
29. Bryman, A., & Bell, E. (2011). *Business research methods*. Oxford University Press.
30. Burkett M., Kemmeter, J. & O'Marah, K. (2002) 'Product Lifecycle Management: What's real now?' AMR Research Report.
31. Burn, L.S., Davis, P., DeSilva, D., Marksjo, B.S.N. T & Geehman C. (2007) 'Plastics Pipes XI, München, Germany.'
32. Burnett, S. & Vlok, P.-J., 2014. A simplified numerical decision-making methodology for physical asset management decisions. South African Journal of Industrial Engineering, 25(1), pp. 162-175.
33. Burns, P. (2016) Entrepreneurship and Small Business, Palgrave Macmillan Limited.
34. Burns, P 2010, 'Asset management strategy: leadership and decision making.' Asset management: whole management of physical aspect.
35. BSI & PAS55-1 (2008) 'Asset Management: Specification for the Optimized Management of Physical Assets', British Standards Institute, London, United Kingdom.
36. BSI, BSI (2008) 'PAS 55 asset management- Specification for the optimized management of physical assets'.
37. BSI, BSI2P-1 (2008a) 'Specification for the optimised management of physical assets.'
38. BSI, BSI (2014) 'technical standards '.
39. Cagliano, R. & Spina, G. (2000) 'Advanced Manufacturing Technologies and Strategically Flexible Production', J. of Operations Management, vol 18, pp. 169-190.
40. Cansız, M. (2008) 'Türkiye'de Kobiler ve KOSGEB, DPT Uzmanlık Tezleri, Ankara', vol 2782, p. 5.
41. Chapman, R. & Hyland, P. (2000) 'Strategy and continuous improvement in small-to-medium Australian manufacturers', Integrated Manufacturing Systems, vol 11, no. 3, pp. 171-179.

42. Chen J, Sohal AS, Prajogo DI (2013) Supply chain operational risk mitigation: a collaborative approach. Int J Prod Res 51(7): 21862199. https://doi.org/10.1080/00207543.2012.727490
43. Chiarini, A., 2017. Risk-based thinking according to ISO 9001: 2015 standard and the risk sources European manufacturing SMEs intend to manage. TQM J., Volume 29, p. 310–323.
44. Chompu-inwai, R., Tipgunta, S. & Sunawan, A. (2008) 'Implementation of total productive maintenance in healthcare: A pilot study, Service systems and service management', IEEE, pp. 1-6.
45. Chowdhury P, Lau KH, Pittayachawan S (2019) Operational supply risk mitigation of SME and its impact on operational performance: a social capital perspective. Int J Oper Prod Manag 39:478–502
46. Choy, D. & Siam, Y. (2011) TPM Implementation Experiences Maintenance Resources.http://www.maintenanceresources.com/referencelibrary/ezine/tpmimplementation.htm, [Online] (Accessed 29th April 2016)
47. Clarke, V. and Braun, V. (2013). Teaching thematic analysis: overcoming challenges and developing strategies for effective learning. *The Psychologist*, 26(2), pp. 120-123.
48. Coetzee, J.L. (2000) 'A holistic approach to the maintenance problem', Journal of Quality in maintenance engineering, vol 5, no. 3, pp. 276-280.
49. Corbett, C.J., Montes, M.J., Kirsch, D.A. & Alvarez-Gil, M.J. (2002) 'ISO 9000 certification pay? ISO Management Systems', pp. 31-40.
50. Crespo Marquez, A.A.J.N.D.G. (2006) 'Contemporary maintenance management: process, framework and supporting pillars', vol 34, no. 3, pp. 313-326.
51. Creswell, W. J., (2014): Research Design: Qualitative, Quantitative and Mixed Methods Approaches. 4thedition. London Sage.
52. Cromwell, J., Reynolds, H. & Young, K. (2002) 'Cost of Infrastructure Failure.' AwwaRF, Denver.
53. Cuatrecasas, L. & Torrel, F. (2010) TPM en un entorno Lean Management., Profit Editorial I., S. L., Barcelona, España.
54. Cuevas, C.R., Hanson, M., Fafchamps, P.M. & Sirvastava, P. (1993) 'Case studies of Enterprise Finance in Ghana. Washington D.C.: The World Bank'.
55. Dadfar, H., Dahlgaard, J.J., Brege, S. & Alamirhoor, A. (2013) 'Linkage between organisational innovation capability, product platform development and performance', Total Quality Management, vol 24, no. 7, pp. 819–834.
56. De Jonge, B. (2014) 'Optimality criteria for age-based maintenance planning under uncertainty in the lifetime distribution. In: 8th IMA international conference on modelling in industrial maintenance and reliability', Oxford, United Kingdom.
57. Dieffaga, T.M.S. & Maiga, S. (2013) 'Materio vigilance and improvement of the maintenance of the biomedical equipment by the implementation of strategies for the equipment: case study of the hospital GABRIEL TOURE OF MALI', Antimicrobial Resistance and infection control, vol 2, no. 1, p. 360.
58. Dobni, C.B. (2008) 'The DNA of Innovation', Journal of Business Strategy, vol 29, no. 2, pp. 43-50.
59. Douglas, E. P., Koro-Ljungberg, M., & Borrego, M. (2010). Challenges and promises of overcoming epistemological and methodological partiality: Advancing engineering education through acceptance of diverse ways of knowing. *European Journal of*

Engineering Education, 35(3), 247–257. DOI: https://doi.org/10.1080/03043791003703177

60. Easterby-Smith, M, Thorpe, R & Jackson, P 2014, Management Research, 4th edn, SAGE, London.
61. Edward, R. (2010) 'Asset Management in the rail and utilities sectors in: Asset management: whole life management of physical aspectd', Thomas Telford, London.
62. Edward, D.J., Holt, G.D. & Harris, F.C. (1998) 'Predictive Maintenance Techniques and their relevance to construction plant', Quality in Maintenance Engineering, vol 4, no. 1, pp. 25-37.
63. EL-Akruti, K 2012. 'The strategic Role of Engineering Asset Management in Capital intensive Organisations.' Mechanical Engineering.
64. Ellison, D. (2001) 'Distribution Infrastructure Management:' Answers to Common Questions. Project #2629. Denver, colo.: AwwaRF.
65. Emmanouilidis, C. & Komonen, K., 2013. Physical asset management practices in industry: Comparisons between Greece and other EU countries. In Advances in Production Management Systems. Sustainable Production and Service Supply Chains; New York, NY, USA, Springer.
66. Endrenyi, J., Aboresheid, S., Allan, R., Anders, G., Asgarpoor, S., Billinton, R., Chowdhury, N., Dialynas, E., Fipper, M. & Fletcher, R. (2001) 'The Present status of maintenance strategies and the impact of maintenance on reliability', PowerSystems, IEEE Transactions on, vol 16, no. 4, pp. 638-646.
67. Feilden, B.M. (2003), 'Conservation of Historic Building'.
68. Ferreira LA 2012, 'Maintenance and Asset Management Two Sides of the Same Coin'.
69. Field, A. (2009) Discovering Statistics Using SPSS, 3rd edn, London: Sage Publications Ltd.
70. Gagné. P., & HGR (2006) 'Measurement model quality, sample size, and solution propriety in confirmatory factor models.' Multivariate Behavioral Research, vol 41, pp. 65–83.
71. Gaha, M. et al., 2021. Global methodology for electrical utilities maintenance assessment based on risk informed decision making. Sustainability MDPI, Volume 16, p. 13.
72. Gibbons, P.T. & O'Connor, T. (2005) 'Influences on Strategic Planning Processes Among Irish SMEs', Journal of Small Business Management, vol 43, no. 2, pp. 170–186.
73. Gibson, B. & Casser, G. (2005) ''Longitudinal Analysis of Relationships between Planning and Performance in Small Firms', Small Business Economics', vol 25, no. 3, pp. 207-222.
74. Gonzalez-Loureiro, M.; Pita-Castelo, J. A model for assessing the contribution of innovative SMEs to economic growth: The intangible approach. Econ. Lett 2012, 116, 312–315. doi: 10.1016/j.econlet.2012.03.028.
75. Graves, C. & Thomas, J. (2006) 'Internationalization of Austrailian family businesses'. A managerial capabilities perspective. Family business Review, vol 19, no. 3, pp. 207-224.
76. Grigg, N.S. (2006) 'Condition assessment of infrastructure systems', Journal of Infrastructure Systems, vol 12, no. 3, pp. 147-153.
77. Guertler B, Spinler S (2015) Supply risk interrelationships and the derivation of key supply risk indicators. Technol Forecast Soc Change 92:224236. https://doi.org/10.1016/j.techfore.2014.09.004
78. Gulati R. (2009) Maintenance and reliability, best practices. Industrial Press Inc, New York.

79. Gupta, STPCASAK (2011) 'TPM Concept an Implementation Approach. Maintenance World', pp. http://www.maintenanceworld.com/articles/sorabh/research_pap.
80. Hair Jr, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. 2014. *Multivariate data analysis* (7th ed.). London, UK: Prentice Hall.
81. Hair, J., B.W.C, BBJ, & ARE (2010) Multivariate data analysis, 7th edn, Pearson Education International. , Upper saddle River, New Jersey.
82. Hargadon, A. & Sutton, R.I. (2000) 'Building Innovation Factory', Harvard Business Review, vol 78, no. 3, pp. 157–66.
83. Harlow, V.K. (2005) '"Risky business: two case studies in asset risk management",', Water asset management international, vol 1, no. 1, p. 5.
84. Harlow V. K. and Stewart, D. (2006) 'Condition assessment: should you risk it?' Water asset management international, vol 2, no. 3, p. 4.
85. Hartman, DGAAREW (2003). 'Rising above sweatshops: Innovative Management Approaches to Global Labor Practices'.
86. Hastings, N.A.J (2010) Physical asset management, Springer.
87. Hastings N.A. & Hodkiewicz M.R. (2009) 'Performance indicators for process plant', Asset Management Conference Proceedings.
88. Haversjo, T. (2000) 'The financial effects of ISO 9000 registration for Danish companies', Managerial Auditing Journal, vol 15, no. 1, pp. 47-52.
89. Hernon, P., ANDA (2001) 'Service quality: a concept not fully explored', Library Trends, vol 49, no. 4, pp. 687-708.
90. Hodkiewicz MR 2013, 'Engineering Asset Management-systems', 8th world congress on engineering asset management, pp. 427-38.
91. Holmes, P, HAASI 2010. An analysis of new firm survival using a hazard function.
92. Howard, D. & Hine, D. (1995) 'The Population of Organisations Life Cycle (POLC)', Implications for small business assistance programs.
93. Hutcheson G., & SN (1999). The multivariate social scientist: introductory statistics using generalized linear models, London: Sage Publication.
94. IAM (2009) ' PAS 55 assessment methodology. Tech. Rep., Institute of Asset Management.'
95. IAM, IOAM (2015) 'Asset Management - An Anatomy.'
96. Islam, M.A., Khan, M.A., Obaidullah, AZM & Alam, MS (2011) 'Effect of entrepreneur and firm characteristics on the business success of small and medium enterprises (SMEs) in Bangladesh', International Journal of Business and Management, vol 6, no. 3, p. 289.
97. ISO (2014) 'ISO 55000, ISO55001, and ISO55002 standards. (1st Edn), ©ISO (2014)'.
98. ISO, I5 (2014a) 'Asset Management – Overview, principles and terminology,'
99. ISO 55000 (2014), 'Asset management- Overview, principles and terminology'.
100. ISO 55002 (2014) 'International standard for asset'.
101. ISO55000 (2014) 'Asset management – Overview, principles and terminology.' International Standards Organization.
102. Îu, A.M., Oprean, C., Rulea, A.S., Brânz, A., 2015. *The role of intangible assets in the knowledge based economy*, In: Proceedings 2014 International Conference on Production Research - Regional Conference Africa, Europe And The Middle Eastand 3International Conference on Quality and Innovation in Engineering and Management, ICPR-AIEM 2014, ISBN: 978-973-662-978-5.

103. Jackson, D.L. (2001) 'Sample size and number of parameter estimates in maximum likelihood confirmatory factor analysis: 'A Monte Carlo investigation. Structural Equation Modeling, vol 8, pp. 205–223.
104. Jassawalla, A.R. & Sarshittal, H.C. (2002) 'Cultures that support product-innovation processes', Acad. Manag. Exec, vol 16, pp. 42-54.
105. Jinjarak, Y.; Wignaraja, G. An Empirical Assessment of the Export—Financial Constraint Relationship: How Different are Small and Medium Enterprises? *World Dev.* **2016**, *79*, 152–163. [Google Scholar] [CrossRef]
106. Jocumsen, G. (2004) ''how do Small Business Managers Make Strategic Marketing Decisions? ', A Model of Process', European Journal of Marketing, vol 38, no. 5/6, pp. 659-674.
107. Jorge, C., Almeida, M. d. C. & Covas, D., 2021. "Performance Assessment System for Energy Efficiency in Wastewater Systems," Water, p. 10.3390/w13131807.
108. Jung, C.-M., Ray, P. & Salkuti, S. R., 2019. Asset management and maintenance: a smart grid perspective. International Journal of Electrical and Computer Engineering (IJECE), 9(5), pp. 3391-3398.
109. Kaminski, V. (2012) 'Acreditation-A Roadmap to Healing in Newfoundland and Labrador ', Omentum Quaterly, vol 4, no. 1, pp. 10-3.
110. Kapurubandara, M. & Lawson, R. (2006), '"Barriers Adopting ICT and E-commerce with SMEs in Developing Countries', Exploratory Study in Sri Lanka", Collecter, Adelaide, [online].
111. Karuppiah K, Sankaranarayanan B, Ali SM, Chowdhury P, Paul SK (2020). An integrated approach to modeling the barriers in implementing green manufacturing practices in SMEs. J Clean Prod 265:121737. https://doi.org/10.1016/j.jclepro.2020.121737
112. Kazmierczak, J.A.L. & Dabrowski, M. (2012) 'Use of geospatial information for supporting maintenance management in a technical network system', Proceedings of 21th european congress on maintenance and asset management "Euromaintenance 2012", pp. 287-297.
113. Kelley, D.J., Gina, C.O., Neck, H. & Peters, L. (2011) 'Building an organizational capability for radical innovation: The direct managerial role', Journal of Engineering and Technology Management, vol 28, no. 4, pp. 249-267.
114. Khan SAR, Sharif A, Golpîra H, Kumar A (2019). A green ideology in Asian emerging economies: from environmental policy and sustainable development. Sustain Dev 27:1063–1075. https://doi.org/10.1002/sd.1958
115. Khan SAR, Zhang Y, Kumar A, Zavadskas E, Streimikiene D (2020) Measuring the impact of renewable energy, public health expenditure, logistics, and environmental performance on sustainable economic growth. Sustain Dev in press 28:833–843.
116. Khayal, O. & Suleiman, M. E., 2024. Industrial Maintenance First Edition. 11 April, p. 108.
117. Kiwelu, M. (2009) Development of an Asset-management Implementation Reference Model and Effective Change management Strategies for Transportation Agencies, University of New Brunswick publications, Canada.
118. Knackstedt, T. (2011) 'What is a maintenance strategy?' Kwaliteg. http://www.kwaliteg.co.za/.
119. Knudson, M, GS, SR, WC (2006) 'Asset management condition assessment for Stockton: To test or not to test', Water Environment Foundation: WEFTEC, October 2006, Dallas TX, Water Environment, p. 4226.

120. Kusuma, N. W. & Muttaqin, N. N. u. L., 2022. Asset Management Based on Risk Control and Information Systems. Jurnal Sistem Teknik Industri.
121. Lance, C.E, ARJV (2009) Statistical and Methodological Myths and Urban Legends, Routledge, London.
122. Lavy S, GJAADMK 2010, 'Establishment of KPIs for facility performance measurement'.
123. Lee, S.M. and Trimi, S. (2021) Convergence Innovation in the Digital Age and in the COVID-19 Pandemic Crisis. Journal of Business Research, 123, 14-22. https://doi.org/10.1016/j.jbusres.2020.09.041
124. Lee S, Park G, Yoon B, Park J (2010) Open innovation in SMEs: an intermediated network model. *Research Policy* **39,** 290–300.
125. Lightfoot, H.W., BTASP, (2011) '"Examining the information and communication technologies enabling servitized manufacture",' Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, vol 225, no. 10, pp. 1964-1968.
126. Lima, E. C., 2019. Improving Asset Management under a Regulatory View, Reliability Engineering & System. Safety, Volume 190, pp. 1- 11.
127. Liu, M.M.L & T, Z (2012) 'Empirical Research on China's SMEs Technology Innovation', Engineering Strategy. Systems Engineering Procedia, vol 5, pp. 372–378.
128. Lloyd, C 2010, 'Assuring the competence of asset management staff in', Asset Management: whole life management of physical aspects.
129. Ma, Z., Zhou, L. & Sheng, W., 2014. Analysis of the new asset management standard ISO 55000 and PAS 55. International Conference on Electricity Distribution (CICED): IEEE, pp. 1668-1674.
130. Ma, L. (2007) 'Condition monitoring in engineering asset management.' Sapporo, Japan, In Asia-Pacific vibration conference (APVC).
131. Madu, C. (2000) 'Competing through maintenance strategies', International Journal of Quality& Reliability Management, vol 17, no. 9, pp. 937–948.
132. Malkin, R. & Keane, A. (2010) 'Evidence-based approach to the maintenance of laboratory and medical equipment in resource-poor settings', Medical Biological Engineering and Computing, vol 48, no. 7, pp. 721-726.
133. Marlow D. & Burn, S. (2008) 'Effective Use of Condition Assessment within Asset Management. Jour. AWWA, 100:1:54.' AWWA, vol 54, no. 1, p. 100.
134. Martensen, A., Grønholdt, L., Bendtsen, L. & Jensen, M.J. (2007) 'Application of a model for the effectiveness of event marketing. ', Journal of Advertising Research, vol 47, no. 3, pp. 283-301.
135. Matichich, M., Allen, J. & Allen, R. (2006a) '"Asset management planning and reporting options for water utilities"', American water works association journal, vol 98, no. 1, pp. 80-87.
136. McGlynn J. & Knowlton, F. (2011) 'Asset management excellence,' in chap. Asset classes and the world of life-cycle asset management, Taylor and Francis Group.
137. Measson, N., & Campbell-Hunt, C. (2015). How SMEs use trade shows to enter global value Chains. *Journal of Small Business and Enterprise Development, 22*(1), 99–126.
138. Mendy J., & Rahman M. (2019). Application of human resource management's universal model: An examination of people versus institutions as barriers of internationalisation for SMEs in a small developing country. *Thunderbird International Business Review*, 61(2), 363–374.

139. Mertens, W., Pugliese, A. & Recker, J. (2017). Quantitative Data Analysis: A Companion for Accounting and Information Systems Research. Switzerland: Springer International Publishing.
140. Mikolaj, J., Trojanová, M. & Pepucha, L. (2012) 'Global trends on road administration based on Asset management. ', IFME Word Congress on Municipal Engineering, pp. 140-141.
141. Minnaar, J., Basson, W. & Vlok, P. (2013) 'Quantitative methods required for implementing PAS 55 or the ISO 55000 series for asset management.' South African Journal of Industrial Engineering, vol 24, no. 3, pp. 98-111.
142. Mishra, R. (2020). COVID-19 and Its Impact on MSME in India. Retrieved May 29, 2020, from https://www.outlookindia.com/outlookmoney/talking-money/covid-19-and-its-impact-on-msme- in-india-4683.
143. Mitchell, J.S. (2006) Publicly Available Specification (PAS) 55-1 & 55-2, Physical Asset Management Handbook, 4th edn, British Standards Institution.
144. Moglia, M., Davis, P. & Burn, S. (2008) 'Exploration of a Physical Probabilistic Model for Cast-Iron Pipe Failure Prediction.' Reliability Engrg. & System Safety, 93:885.
145. Monreal-Pérez, Joaquín, Antonio Aragón-Sánchez, and Gregorio Sánchez-Marín. 2012. A Longitudinal Study of the Relationship between Export Activity and Innovation in the Spanish Firm: The Moderating role of Productivity. *International Business Review* 21: 862–77. [**Google Scholar**] [**CrossRef**]
146. Moktadir MA, Ali SM, Paul SK, Shukla N (2019) Barriers to big data analytics in manufacturing supply chains: a case study from Bangladesh. Comput Ind Eng 128:1063–1075. https://doi.org/10.1016/j.cie.2018.04.013
147. Moktadir MA, Dwivedi A, Rahman A, Chiappetta Jabbour CJ, Paul SK, Sultana R, Madaan J (2020) An investigation of key performance indicators for operational excellence towards sustainability in the leather products industry. Bus Strateg Environ in press.
148. Moon K, Blackman D. A guide to understanding social science research for natural scientists. Conserv Biol. 2014 Oct; 28(5): 1167-77. doi: 10.1111/cobi.12326 Epub 2014 Jun 24. PMID: 24962114.
149. Moro, A. & FM & KT (2014) 'How do banks assess entrepreneurial competence? The voluntary information disclosure.' International Small Business journal, vol 32, no. 5, pp. 525-544.
150. Muchiri, L., Pintelon, L., Gelders, H. & Martin (2011) 'Development of maintenance function performance measurement framework and indicators', International Journal of Production Economics, vol 131, no. 1, pp. 295–302.
151. Murphy, M. (1996) 'Small Business Management', Pitman.
152. Mutuku C.K. and Mathooko, P. (2014) 'Effects of organizational communication on employee motivation: A case study of Nokia Siemens Networks Kenya.' International Academic Journal of Information Sciences and Project Management, vol 1, no. 3, pp. 28-62.
153. Mutlu Öztürk, H. & Öztürk, H. K., 2019. Maintenance and maintenance management systems in accommodation. Journal of Achievements in Materials and Manufacturing Engineering, 96(2), p. 83–93.
154. Nelson, T. (2011) International Infrastructure Management ManuaL Asset Management Support (NAMS), 2011th edn, New Zealand.

155. Neuhäusler P (2012). The use of patents and informal appropriation mechanisms: differences between sectors and among companies. *Technovation* **32,** 681–693.
156. OECD. Interim Economic Assessment Coronavirus: The world economy at risk; 2020.
157. OECD (2010) *Innovative SMEs and Entrepreneurship for Job Creation and Growth:'Bologna + 10' High-Level Meeting on Lessons from the Global Crisis and the Way forward to Job Creation and Growth.* OECD Publishing, Paris.
158. OECD (2011) *Intellectual Assets and Innovation: The SME Dimension, OECD Studies on SMEs and Entrepreneurship*. OECD Publishing, Paris.
159. OECD (2001) 'Asset Management for the Roads Sector'.
160. OECD, OFEC-OAD (2005) 'Annual Report'.
161. O'Regan, N. & Ghobadian, A. (2002) ''Effective Strategic Planning in Small and Medium Sized Firms', Management Decision,' vol 40, no. 7, pp. 663-671.
162. O'Regan, N. & Ghobadian, A. (2004) ''Re-visiting the Strategy-Performance Question:An Empirical Analysis',', International Journal of Management and Decision Making, vol 5, no. 2/3, pp. 144-170.
163. Oxford (2014) 'Dictionary'.
164. Pallant, J. (2010) SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS for Windows, 4th edn, Open University Press.
165. Panegossi, A. C. G. & Silva, E. C. C. d., 2021. "Asset Management Policy for Equipment Replacement," Sao Paulo, Brazil, pp. 2401-2412, pp. Sao Paulo, Brazil, 2021, pp. 2401-2412.
166. Parida, A., 2016. Asset performance measurement and management: Bridging the gap between failure and success. In Proceedings of the EuroMaintenance. Athens, Greece, s.n.
167. Parnell G.S., D. P. H. D., 2011. Decision making in systems engineering and management.
168. Parkes, D. (1978) 'Terotechnology handbook. London: Her Majesty's Stationery Office.'
169. PAS55-1 (2008,) Asset management: Specification for the optimized management of physical assets. British Standards Institution., UK.
170. Patidar, L., Soni, V. & Soni, P., 2017. Maintenance strategies and their combine impact on manufacturing performance. Int. J. Mech. Prod. Eng. Res. Dev, Volume 7, p. 13–22.
171. Paul SK, Asian S, Goh M, Torabi SA (2019c) Managing sudden transportation disruptions in supply chains under delivery delay and quantity loss. Ann Oper Res 273:783–814.
172. Paul SK, Sarker R, Essam D, Lee PTW (2019b). A mathematical model- ling approach for managing sudden disturbances in a three-tier manufacturing supply chain. Ann Oper Res 280:299–335.
173. Paul SK, Chowdhury P (2020a). A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19. Int J Phys Distrib Logist Manag 1-22.
174. Paul SK, Chowdhury P (2020b) Strategies for managing the impacts of disruptions during COVID-19: an example of toilet paper. Glob J Flex Syst Manag 21:283–293.
175. Pedersen, T. & Schjølberg, P., 2020. The Economic Dimension of Implementing Industry 4.0 in Maintenance and Asset Management. Advanced Manufacturing and Automation IX. Springer, Singapore, Volume 634, pp. 299-306.
176. Pederzoli C, Thomä G, Torricelli C (2013) Modelling Credit risk for Innovative SMEs: the role of Innovation Measures. *Journal of Financial Services Research* **44,** 111-129.
177. Pett, M.A., LNR &SJJ (2003) Making Sense of Factor Analysis: The use of factor analysis for instrument development in health care research. Sage Publications Inc.; California.

178. Peres, W. & Stumpo, G. (2000) 'Small and medium-sized industrial enterprises in Latin America and the Caribbean under the new economic model', World Development, vol 28.
179. Philip M 2011, 'Factors Affecting Business Success of Small & Medium Enterprise (SMEs)', Amity Global Business Review, vol 6, no. 1, pp. 118-136.
180. Pinjala, S.K., LPAAV (2006) 'An empirical investigation on the relationship between business and maintenance strategies', International Journal of Production Economics, vol 104, pp. 214-29.
181. Pintelon, L. & Parodi-Herz, A. (2008) Maintenance: an evolutionary perspective, Complex System Maintenance, Spinger-Verlag, London.
182. Plant Services 2010, 'Effective planning and Scheduling', 2010.
183. Popescu, N.E. Entrepreneurship and SMEs Innovation in Romania. In Proceedings of the 21st International Economic Conference of Sibiu 2014, Iecs 2014 Prospects of Economic Recovery in a Volatile International Context: Major Obstacles, Initiatives and Projects, Sibiu, Romania, 16–17 May 2014; Volume 16, pp. 512– 520. doi: 10.1016/S2212-5671 (14)00832-6.
184. Port, T., Ashun. J. & Callaghan T.J. (2011) 'Asset management excellence, chap.', A framework for asset management. Taylor and Francis Group., pp. 23-48.
185. Quazi, H.A. & Padibjo, S.R. (1998) 'A journey towards total quality management through ISO certification: a study on small and medium-sized enterprises in Singapore', Journal of Quality and Reliability Management, vol 15, no. 5, pp. 364-371.
186. Rajani, B. & Kleiner, Y. (2007) 'Quantifying Effectiveness of Cathodic Protection in Water Mains:' Case Studies. Jour. Infrastructure Systems 13:1:1
187. Rao, H. & Drazin, R. (2002) 'Overcoming resource constraints on product innovation by recruiting talent from rivals', Academy of Management, vol 45, no. 3, pp. 491-507.
188. Rassenfosse, D.G. (2012) 'Intangible Assets and Productivity Growth. Report for the Australian Government Department of Industry, Science,' Research and tertiary Education.
189. Ratnayake, R.C. & Markeset, T. (2010a) 'Technical integrity management: measuring HSE awareness using AHP in selecting a maintenance strategy', Journal of Quality maintenance Engineering, vol 16, no. 1, pp. 44-63.
190. Ratnayake, R., 2013. Sustainable Asset Performance: The Role of PAS 55 1&2 and Human Factors. Int. J Sustain. Eng., Volume 6, p. 198–211.
191. Reed, I. A. (2010). Epistemology contextualized: Social-scientific knowledge in a post positivist era. Sociological Theory, 28(1), 20–39. DOI: https://doi.org/10.1111/j.1467-9558.2009.01365.x
192. Revilla, A.J. & Fernandez, Z. (2012) '• the relation between firm size and R&D productivity in different technological regimes', Technovation, vol 32, pp. 609-623.
193. Rødseth, H., RJ, E., Z, L. & J, L., 2020. Smart Maintenance in Asset Management. Application with Deep Learning. Advanced Manufacturing and Automation IX, Volume 634, pp. 608-615.
194. Ropega J, 2011. The Reasons and Symptoms of Failure in SME (sic). International Advanced Ecomic Research, Volume 17, pp. 476-483.
195. Rugsveen, N.M. (2014) M&R Strategy – changing the game [ppt] Statoil Internal Document.

196. Ruitenburg, R, BAJJ, DVLAM (2014) 'A multidisciplinary approach for the identification of impacts on the useful remaining lifetime of assets. In: 3rd International conference on through-life engineering services,' Cranfield University, United Kingdom.
197. Rujirawanich, P., Addison, R. & Smallman, C. (2011) 'The effects of cultural factors on innovation in a Thai SME', Management Research Review, vol 34, no. 12, pp. 1264-1279.
198. Saini, D. & Budhwar, P. (2008) 'Managing the Human Resource in Indian SMEs: The Impact of Indigenous Realities on Effectiveness', Journal of World Business, vol 43, no. 4, pp. 475-485.
199. Sandu, G., Varganova, O. & Samii, B., 2022. "Managing physical assets: a systematic review and a sustainable perspective," International Journal of Production Research, pp. 1-23
200. Saranga, H. & Knezevic, J. (2000) '"Reliability prediction for condition based maintained systems",' Reliability Engineering and System Safety, vol 71, no. 2, pp. 219-224.
201. Sauer, N.C. and Kauffeld, S. (2015) the ties of meeting leaders: a social network analysis. *Psychology*, 6, 54656. https://doi.org/10.4236/psych.2015.64039
202. Saunders MNK, Lewis P and Thornhill A (2015) Research Methods for Business Students. 7th ed. Harlow: Pearson Education UK.
203. Schroder & Sohal (1999) 'Organizational characteristics associated with AMT adoption.' International Journal of Operations & Production Management, vol 19, no. 12, pp. 1270-1291.
204. Schuman C. A. and Brent, A.C. (2005) 'Asset life cycle management: towards improving physical asset performance in the process industry', Schuman, C. A. and Brent, A. C. (2005) Asset life cycle management: towards improving physical as International Journal of Operations & Production Management, vol 25, no. 6.
205. Segal S, Gerstel D (2020); the Global Economic Impacts of COVID-19.
206. Sekaran, U. & Bougie, R. (2016). Research Methods for Business: A Skill Building Approach. John Wiley & Sons: West Sussex, United Kingdom.
207. Shams ur, R. (2001) 'A Comparative Study of TQM Practice and Organisational Performance of SMEs with and without ISO 9000 Certification', Int. J. Qual. Reliab Manag, vol 18, no. 1, pp. 35-49.
208. Sidik, I.G. (2012) Conceptual Framework of Factors Affecting SME Development: Mediating Factors on the Relationship of Entrepreneur Traits and SME Performance. Procedia Economics and Finance, 4, 373-383.
209. Simões, J., Gomes, C. & Yasin, M., 2016. Changing role of maintenance in business organisations: Measurement versus strategic orientation. Int. J. Prod. Res. 2, Volume 54, p. 3329–3346.
210. Singh, R.K., SKGASGD (2007) 'Interpretive structural modelling of factors for improving competitiveness of SMEs', International Journal of Productivity and Quality Management, vol 4, no. 2, pp. 423-440.
211. Singh, K. (2007) 'Quantitative Social Research Methods, London, SAGE', SAGE, London.
212. Sinha, D.P.K. (2008) Manufacturing and Operations Management, Prakashan.
213. Skarzynski, P. & Gibson, R. (2008) Innovation to the Core, Boston, Harvard Business School Publishing.
214. Small, M.H. & Yasin, M.M. (1997) 'Advanced manufacturing technology: Implementation policy and performance', Journal of Operations Management, vol 15, pp. 349-370.
215. Smith, R. (2012) '5 Ways to measure your preventive maintenance program.'

216. Smith, R. & Hawkins, B. (2004) Lean maintenance, Elsevier Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP, UK.
217. Snitkin, S. (2003) 'Collaborative asset lifecycle management vision and strategies. Tech. Rep., ARC Advisory Group.'
218. Suhi SA, Enayet R, Haque T, Ali SM, Moktadir MA, Paul SK (2019) Environmental sustainability assessment in supply chain: an emerging economy context. Environ Impact Assess Rev 79:106306.
219. Stam, E., Hartog, C., Van Stel, A. & Thurik, R. (2011) Ambitious Entrepreneurship and Macro-Economic growth. In: Minniti, M. (ed.) The Dynamics of Entrepreneurship Evidence from the Global Entrepreneurship Monitor Data, Oxford University Press. Oxford.
220. Stella K 2011, 'Consultative forum on the proposed market for SME', Nairobi.
221. Stenstr̈om, C., Parida, A., Kumar, U. and Galar. D. (2013) Performance indicators and terminology for value driven maintenance. Journal of Quality in Maintenance Engineering, vol. 19, no. 3, pp. 222-232
222. Strategic Asset Management Framework' (2017) A Guide for Managing South Australian Government Buildings.
223. Swamidass, P.M. (1995) 'Making Sense out of Manufacturing Innovations'.
224. Telang, A. (2010) Comprehensive Maintenance Management. PHI Learning Private Limited, New Delhi.
225. Temple-Bird, C.M.R. & Bloom, G. (1995) 'Medical equipment in Botswana: A framework for management for development', World Health Organisation.
226. Tharenou, P., SAM, M.C. (2007) ' A review and critique of research on training and organizational-level outcomes', Human Resource Management Review, pp. 251–273.
227. The British Standards Institution (2019) https://www.bsigroup.com/en-GB/about-bsi/
228. Thomä, J. & Bizer, K. (2013) 'To protect or not to protect? ', Modes of appropriability in the small enterprise sector. Research Policy, vol 42, pp. 35-49.
229. Ţîţu, A.M. Răulea, A.S,& Ţîţu,Ş.(2015). Innovation a challenge for the 21stCenturyManagers. *Procedia Economics and Finance*, 27 (15), 126 135.doi: 10.1016/S2212-5671 (15) 00981-8
230. Toffler, A. & Toffler, H. (2006) Revolutionary wealth: how it will be created and how it will change our lives. Alfred Knopf, New York, NY.
231. Too, E.G. (2010) 'A framework for strategic infrastructure asset management, Definitions, concepts and scope of engineering asset management ', pp. 31-62.
232. Torbay Council (2018) 'www.torbay.gov.uk/Democratic Service'.
233. Trojanová, M. & Pitoňák, M. (2014) 'Asset management – a new method for management of the road economy', International Scientific Publication, Economy & Business, vol 4, pp. 195-208.
234. Tsagkaraki, M. I., 2014. An exploratory approach for evaluating the energy and personnel share of operation and maintenance costs for water utilities in selected emerging economies of Europe. Journal of Water Supply: Research and Technology—AQUA, 63(5), pp. 368-378.
235. Tucker, MAPM, 2008, 'Performance measurement in facilities management: driving innovation?' vol 26, no. 4, pp. 241-254.
236. Tuli, F. (2010). The basis of distinction between qualitative and quantitative research in social science: Reflection on ontological, epistemological and methodological

perspectives. *Ethiopian Journal of Education and Sciences*, *6*(1), 97–108. DOI: https://doi.org/10.4314/ejesc.v6i1.65384

237. Tumpa TJ, Ali SM, Rahman MH, Paul SK, Chowdhury P, Rehman Khan SA (2019) Barriers to green supply chain management: an emerging economy context. J Clean Prod 236:117617.
238. Turkstat (2013) 'www.turkstat.gov.tr.'
239. Urquhart, T. (2006b) '"Incorporating condition assessment into a comprehensive asset management programme",', Water environment foundation: WEFTEC, p. 4198.
240. V & S. Group (2006) 'Annual report'.
241. Venkatesh, J. (2009) 'An Introduction to Total Productive Maintenance', Plant Maintenance Resource Centre, pp. http://www.plant maintenance.com/articles/tpm_intro.shtml.
242. Vineyard, M, A-G.K, &M.J (2000) 'An evaluation of maintenance policies for flexible manufacturing systems; a case study.' Int J Oper Prod Man, vol 20, no. 4, pp. 409-426.
243. Viveros, P. C. M. A. B. M. L. G. J. P., 2015. Graphical Analysis for Operation Management: A Graphical Method to Support Operation Decision Making. Quality and Reliability Engineering International.
244. Waldron B 2011, 'Scope for Improvement- Project risk getting the right balance and outcomes'.
245. Walter, D.R. (1996) 'Health and safety strategies in Europe', Journal of Loss Prevention in the Process Industries, vol 9, no. 5, pp. 297 -308.
246. Wang, B., J., Fedele, B., Priden, A, Williams, T, Rui, L, Barnett, C, Granade, R, Helfrich, B, Stephenson & Lesueur, D 2010, 'Evidence-Based Maintenance: Part I: Measuring maintenance effectiveness with failure codes', Journal of Clinical Engineering, vol 35, no. 3, p. 132.
247. Wang, M., Sinclair, R. R., Zhou, L., & Sears, L. E. (2013). Person-centered analysis: Methods, applications, and implications for occupational health psychology. In R. R. Sinclair, M. Wang, & L. E. Tetrick (Eds.), Research methods in occupational health psychology: Measurement, design, and data analysis (p. 349–373). Routledge /Taylor & Francis Group. DOI: https://doi.org/10.4324/9780203095249
248. Wang, K. and Tao, W. (2019) Exploring the complementarity between product exports and foreign technology imports for innovation in emerging economic firms. *European Journal of Marketing*, 53, 224– 256. https://doi.org/10.1108/EJM-10-2017-0683.
249. Wang Y, Yu Y (2020) Flexible strategies under supply disruption: the interplay between contingent sourcing and responsive pricing. Int J Prod Res 58:1–22.
250. Wang, X., Wu, W., Yin, C., & Zhou, S. (2019). Trade credit, ownership and informal financing in China. *Pacific-Basin Finance Journal*, *57*, 101–177. https://doi.org/10.1016/j.pacfin.2019.101177.
251. Welford, R.J. & Gouldson, A.P. (1993) Environmental Management and Business Strategy, Rtman Publishing, London.
252. Wetzer, J. et al., 2019. Risk-Based Asset Replacement Policy for an Electrical Infrastructure. World Congress on Engineering Asset Management, Issue Springer, pp. 102-112.

253. White, L. and Millar, R.B. 2014. Quantitative Approaches. In V. Wright-St Clair, D. Reid, S. Shaw and J. Ramsbotham (Eds.), Evidence- based Health Practice. South Melbourne: Oxford University Press.
254. Williams, M & Sutton, C 2011, 'Challenges and Opportunities for Developing teaching in Quantitative Methods', Teaching Quantitative Methods, pp. 66-84.
255. Williamson pj, de Meyer (2012) an ecosystem advantage: How to successfully Harness the power of partners. *California Management Review* **55,** 24-46.
256. Wireman T 2013, 'Successfully Utilizing CMMS/EAM systems. Reliabilityweb.com'.
257. Woodhouse, J. (2006) '"PAS-55 - Asset Management: concepts & practices", 21st International Maintenance Conference, IMC-2006.
258. Woodhouse, J., (2010) 'Asset management in the oil and gas, process and manufacturing sectors.' In: Lloyd, C., Asset Management: Whole-life management of physical assets, pp. 27-49.
259. Woodhouse J 2010, 'Asset management the way forward', Whole-life management of physical assets.
260. Woodhouse, J pank (2013) 'ISO 55000 Standards for asset management.' The Woodhouse Partnership Ltd, United Kingdom.
261. Yang, J (2012), 'Innovation capability and corporate growth: An empirical investigation in China', Journal of Engineering and Technology Management, vol 29, no. 1, pp. 34-46.
262. Yukl, (G 2002), Leadership in Organizations, 5th edn, Prentice Hall, Upper Saddle River, NJ.
263. https://www.bsigroup.com/LocalFiles/en-GB/iso-55001/case-studies/BSI-ISO-55001-Case-Study-Scottish-Water-UK-EN.pdf
264. Zeng SX, Xie XM, Tam CM (2010) Relationship between cooperation networks and innovation performance of SMEs. *Technovation* **30,** 181-194.
265. Zheng, G., Zhu, L., Liu, C., and Chen, Y. (2019) TMT social capital, network position and innovation: the nature of micro-macro links. *Frontiers of Business Research in China*, 13, 3. https://doi.org/10.1186/s11782-019-0047-0

APPENDICES

SMEs: its definition, importance, activities and relevance in today's world

Questionnaire

1). What is the company size in terms of employee size

- ◯ <50
- ◯ between 51 and 250
- ◯ >250

2). Which industry does the company belong?

- ◯ Automobile
- ◯ Manufacturing
- ◯ Aerospace
- ◯ Marine
- ◯ Pharmaceutical
- ◯ Oil and Gas

3). Most Severe Problem being faced by your business is (check all that apply)

- ☐ Less acess to finance
- ☐ High cost of Production
- ☐ Poor infastructure
- ☐ Energy crisis

4). Who is the highest decision maker in your company?

- ◯ Executive Chairman
- ◯ MD/CEO
- ◯ General Manager
- ◯ Owner

Asset Maintenance

5). What is the company's main maintenance strategy? (check all that apply)

- [ ] Reactive
- [ ] Planned
- [ ] Preventive
- [ ] Predictive
- [ ] Corrective

6). Do you believe that this strategy to maintenance is the most appropriate method for the company?

- ○ Yes
- ○ No
- ○ I dont know

7). Does your organization have an existing maintenance plan?

- ○ Yes
- ○ No
- ○ i dont know

8). How is maintenance activity triggered? (check all that apply)

- [ ] Sudden failure
- [ ] Problems reported by operators
- [ ] Routine Inspection
- [ ] Condition monitoring
- [ ] Machine manufacturer's recommendation

9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance?

- ○ Yes
- ○ No
- ○ I dont know

10). If "Yes" list top three (3) KPIs for measuring your maintenance?

Your answer

Asset Management

14). Are there written processes for asset management and are they made accessible ?

- ○ Yes
- ○ No
- ○ I dont know

15). Asset management is centralized within your company?

- ○ Yes
- ○ No
- ○ I dont know

16). Do you perform Asset inventory activities?

- ○ Yes
- ○ No
- ○ I dont know

17). What type of asset do you track?

- ○ Capitalised
- ○ Expensed
- ○ Construction in progress (CIP)
- ○ I dont know

18). Some of the major barrier faced towards development and implementation of Asset Management process (current or in the past) include(s) (check all that apply)

- [ ] Executive commitment
- [ ] Staff commitment
- [ ] Resistance to change
- [ ] Lack of expertise and training
- [ ] Lack of resource (data, equipment)
- [ ] Availability of adequate tools

19). Company has a training/education/development vision to ensure that the long term asset management strategy can be delivered.

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

20). Can your company translate Asset Management Policy & Strategy into clear business objectives and Lifecycle Plans for specific assets as well as asset types.

- ○ Yes
- ○ No
- ○ I dont know

ISO 55000 (Asset Management)

21). Regarding your organization, how do you characterize top management's attitude to asset management?

- ○ Aloof
- ○ Passive interest
- ○ Active interest
- ○ Very receptive
- ○ Engage and driving the intiative
- ○ I dont know

22). Does your organisation have an ISO certification?

- ○ Yes
- ○ No
- ○ i dont know

23). If "Yes" Which ISO certification?

Your answer

24). Are you aware of ISO 55000?

- ◯ Yes
- ◯ No
- ◯ Maybe

25). Have you adopted ISO 55000?

- ◯ Yes
- ◯ No
- ◯ I dont know

26). Which of the following elements is your company's greatest need. (check all that apply)

- ☐ Organisation
- ☐ Leadership
- ☐ Plan
- ☐ Support
- ☐ Operation
- ☐ Performance Evaluation
- ☐ Improvement
- ☐ I dont know

27). We do have the organisational structure to comply with ISO 55000

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

28). Planning

	In Place	Not in place	I dont know
The organisation has planned actions to address risks and opportunities, taking into account how these risks and opportunities can change with time	◯	◯	◯

29). Asset Management objectives. your compamy 's

	In place	Not in place	I dont know
Objectives are measurable, monitored and communicated to relevant stakeholders.	◯	◯	◯
Are Asset management related risks considered by management .	◯	◯	◯
Do you have contingency plan	◯	◯	◯
Objectives are reviewed and updated as appropriate	◯	◯	◯

30). Support. does your company

	In place	Not in place	I dont know
Resources are provided for the implementation, maintenance and continual improvement of the asset management system.	◯	◯	◯
There is collaboration (Awareness and Information requirement)in all departments	◯	◯	◯

31). Performance Evaluation. does your company

	In place	Not in place	I dont know
Determines what asset needs to be monitored and measured	○	○	○
Evaluate and report on asset performance, asset management performance.	○	○	○
Practice routine inspection?	○	○	○

32). Internal Audit. does your company

	In place	Not in place	I dont know
Conducts internal audits to determine whether the asset management system conforms to organisation's objective.	○	○	○
Reviews its management decisions at planned intervals to ensure effectiveness.	○	○	○
Check if the Asset Management strategy is suitable.	○	○	○

33). Improvement. does your company

	In place	Not in place	I dont know
Reacts to nonconformity and corrects incident t	○	○	○
Have established preventive action to proactively fix failure	○	○	○
Evaluate its preventive action	○	○	○

SUBMIT

Appendix ii: Participant information sheet for Questionnaire respondents

PARTICIPANTS INFORMATION SHEET AND CONSENT FORM FOR THE QUESTIONNAIRE

Confidentiality declaration: Any information you provide during this interview will remain confidential and your identity will not be used without your written consent. The information and findings from this questionnaire will be used as supporting data for my research work at the University of Sunderland.

Name of Respondent (Optional): .....

Date of interview: .....

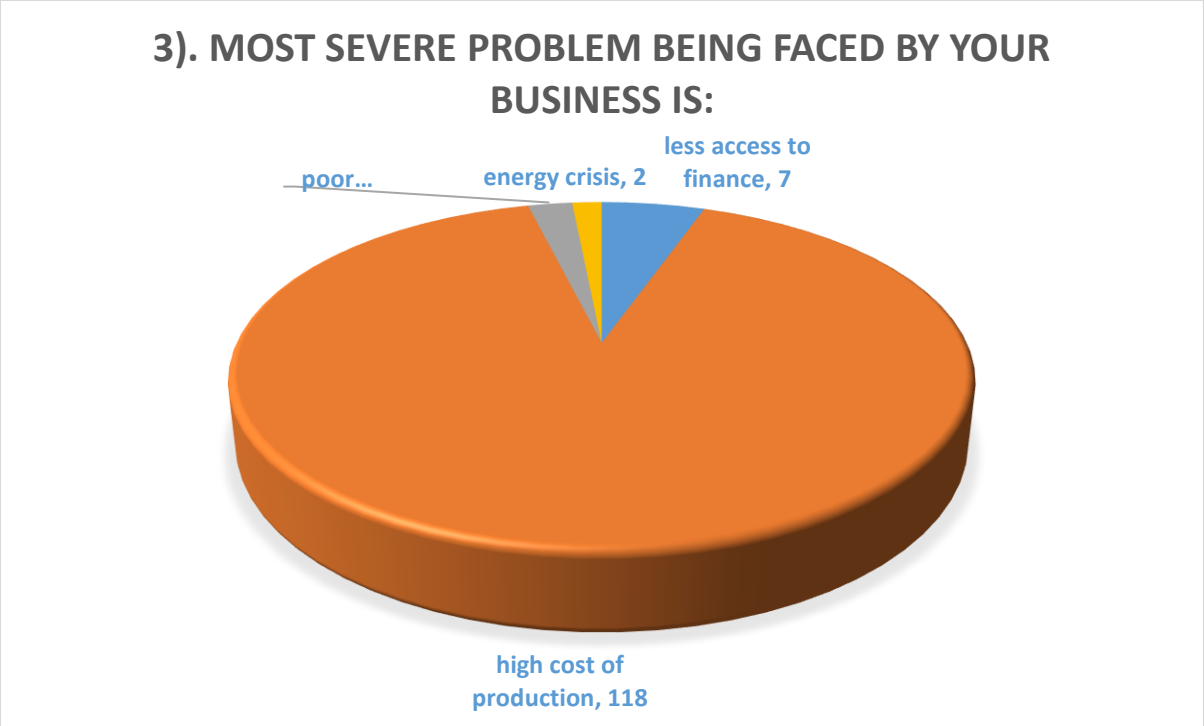
Contact information: .....

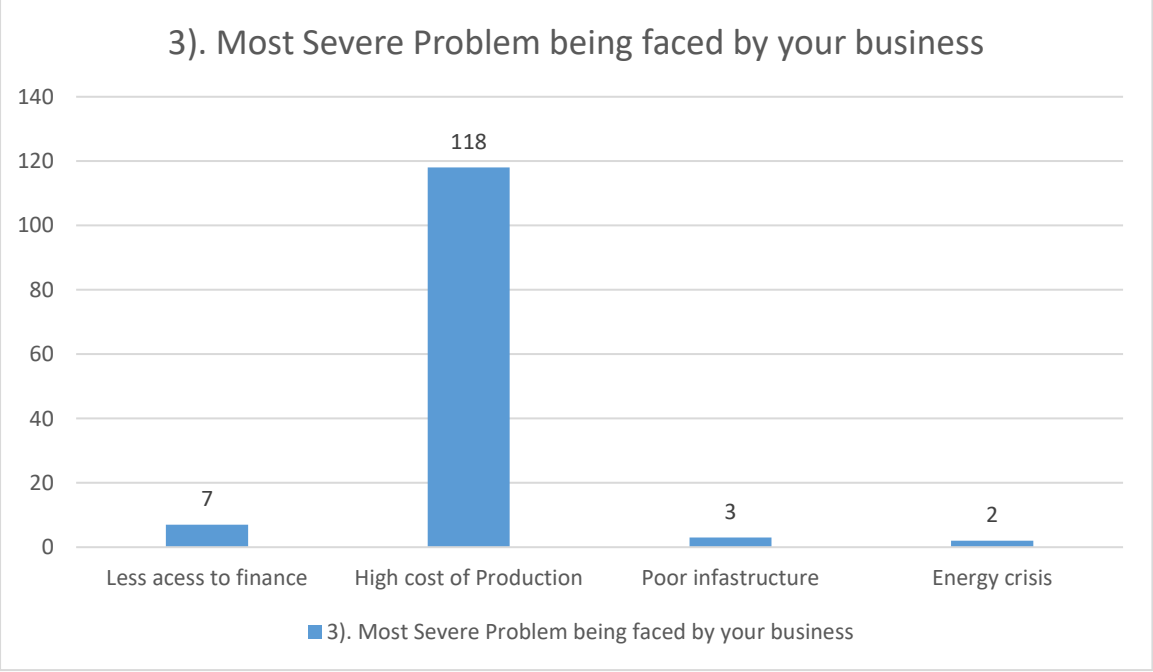
Purpose of the questionnaire: the purpose of the Questionnaire is to capture data on ISO55000, asset management and maintenance strategy of within SMEs.

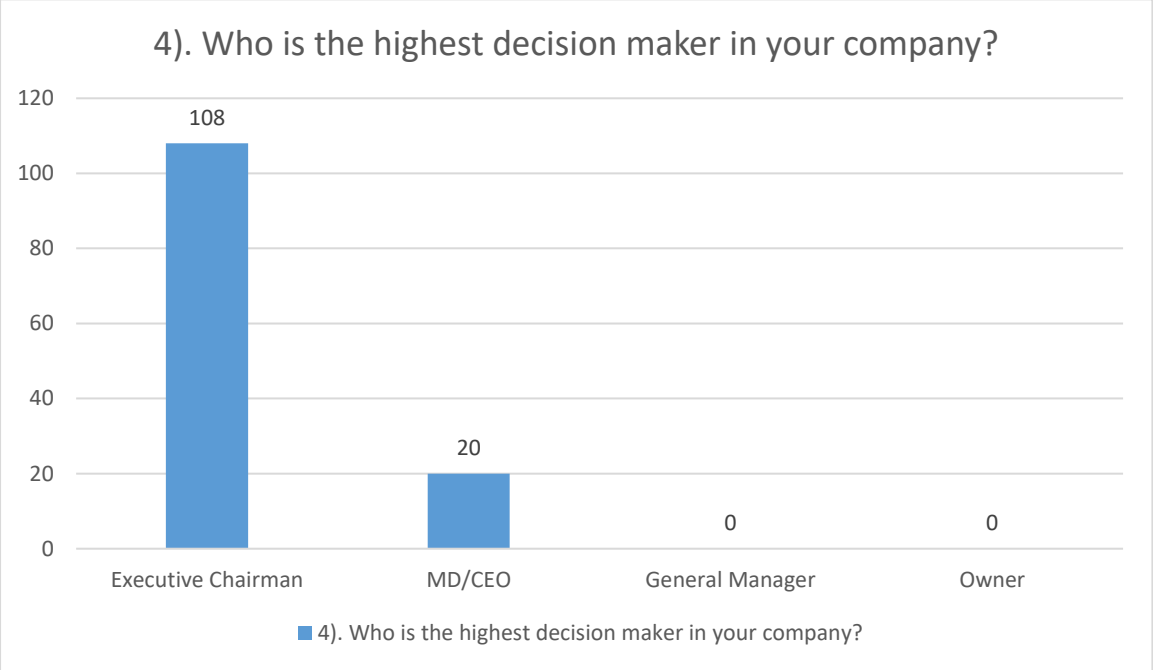
Themes of the study: The themes for the questionnaire questions were developed from the following key research themes, namely: ISO 55000, Operation, Maintenance strategy, Risk management, Planning, Decision-making process, Performance evaluation, Monitoring, KPI (Key Performance Indicator), organizational effectiveness, Top management, Organization's culture, Physical assets, Employees, Continual improvement, ISO certifications, Internal Audit, Routine inspection, Policy and Training.

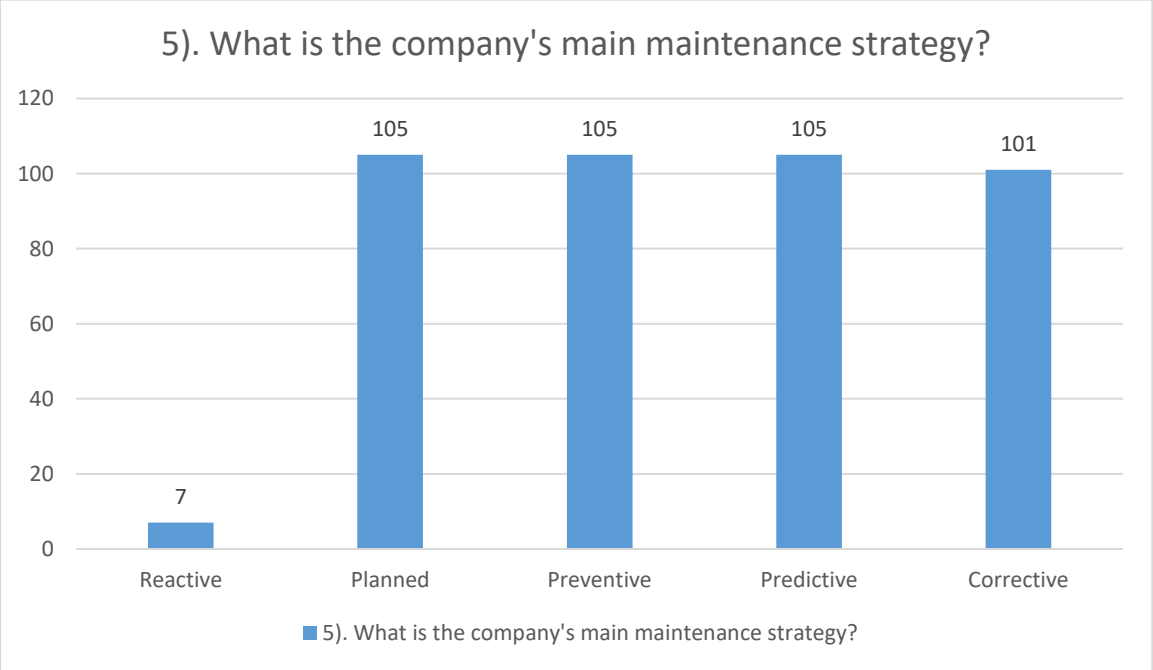
Thanks for your participation

Appendix iii: Frequency of response per question before in-depth analysis

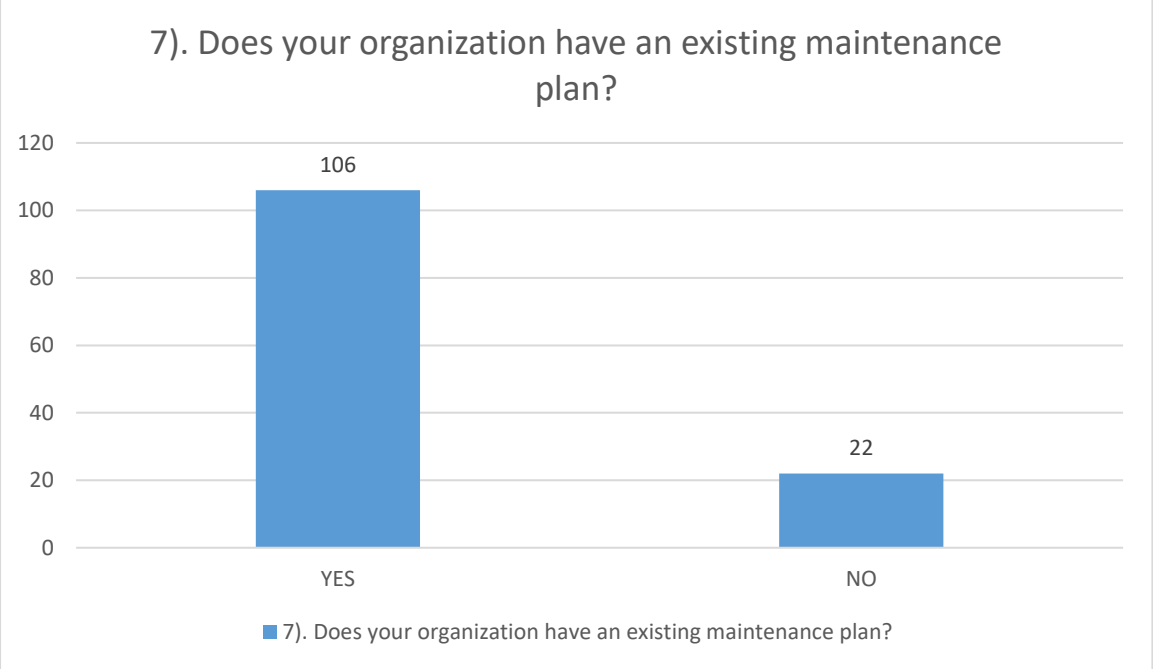


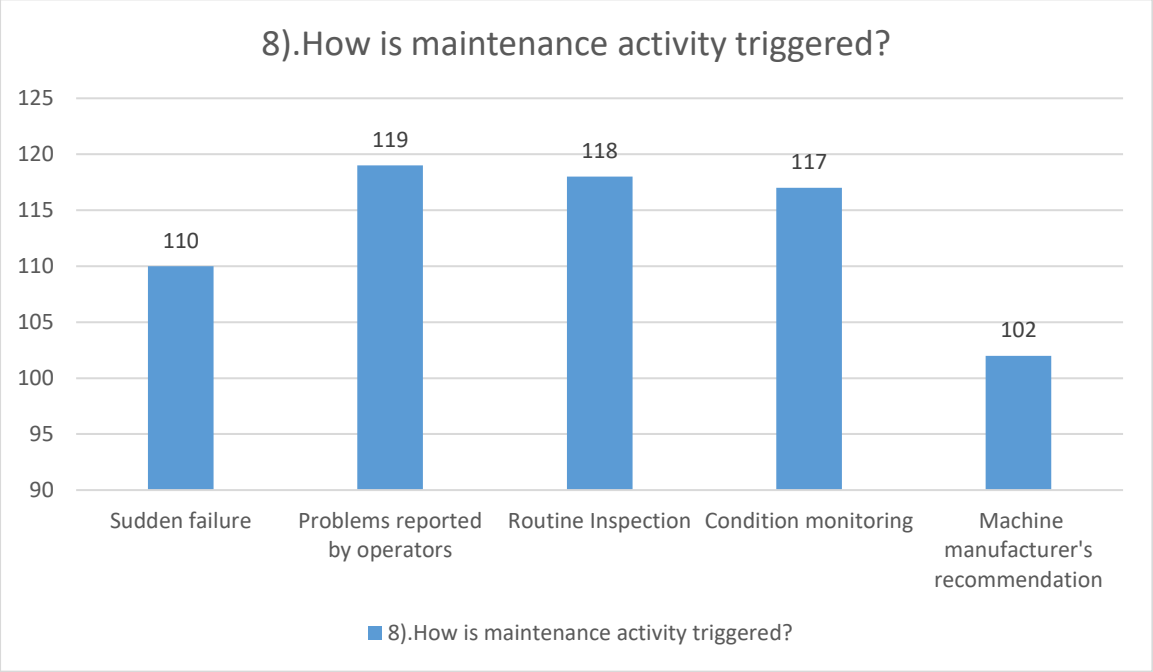


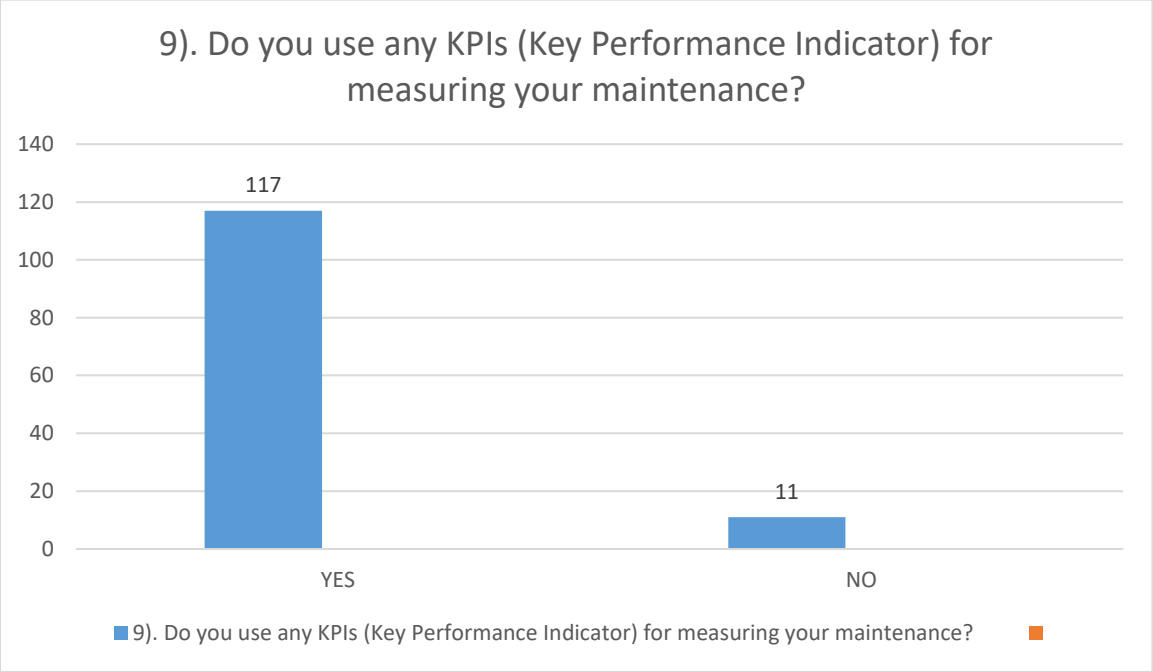

4). Who is the highest decision maker in your company?
120
100
80
60
40
20
0
108
20
0
0
Executive Chairman
MD/CEO
General Manager
Owner
4). Who is the highest decision maker in your company?

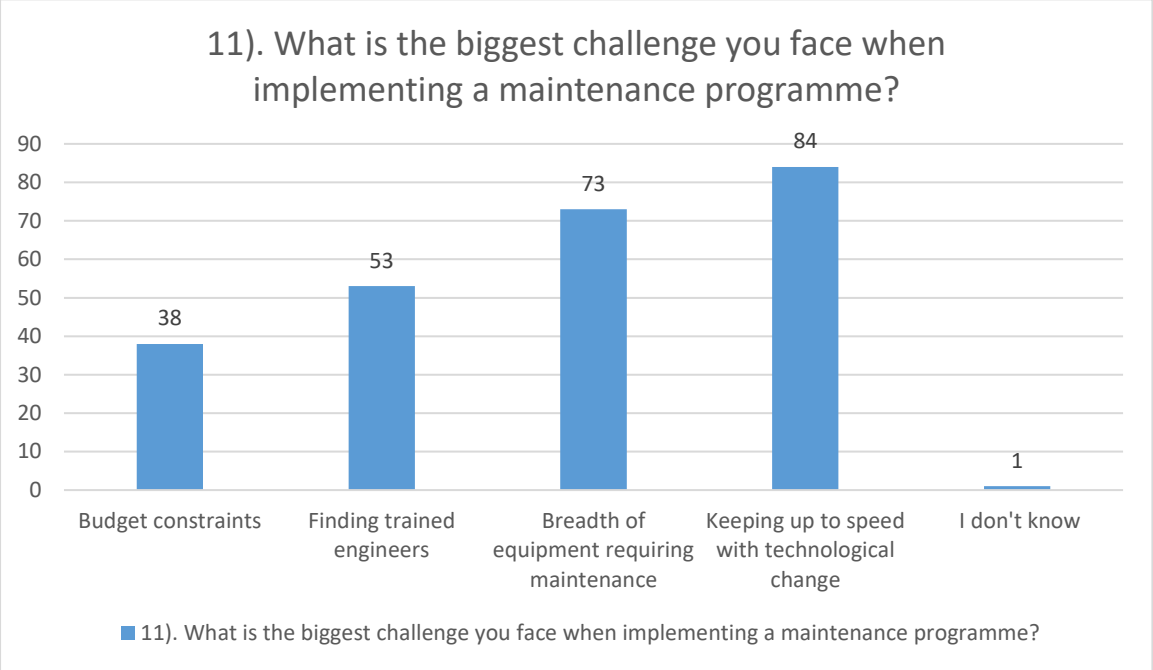

5). What is the company's main maintenance strategy?
120
100
80
60
40
20
0
7
105
105
105
101
Reactive
Planned
Preventive
Predictive
Corrective
5). What is the company's main maintenance strategy?

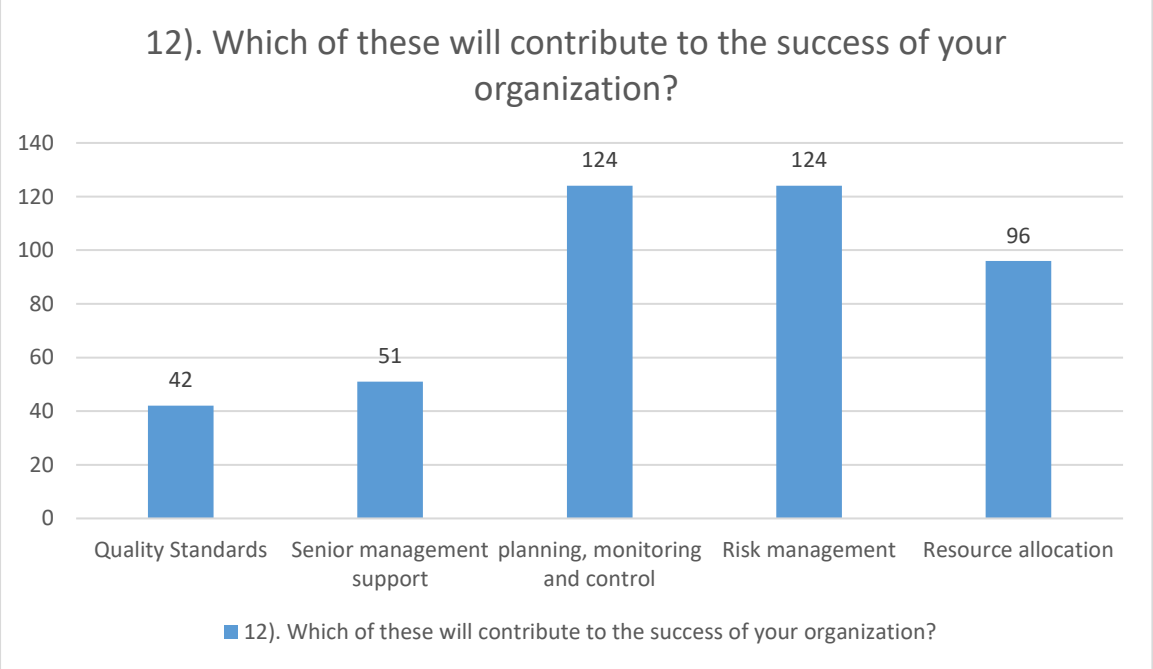
6). Do you believe that this strategy to maintenance is the most appropriate method for the company?
120
100
80
60
40
20
0
108
20
YES
NO
6). Do you believe that this strategy to maintenance is the most appropriate method for the company?

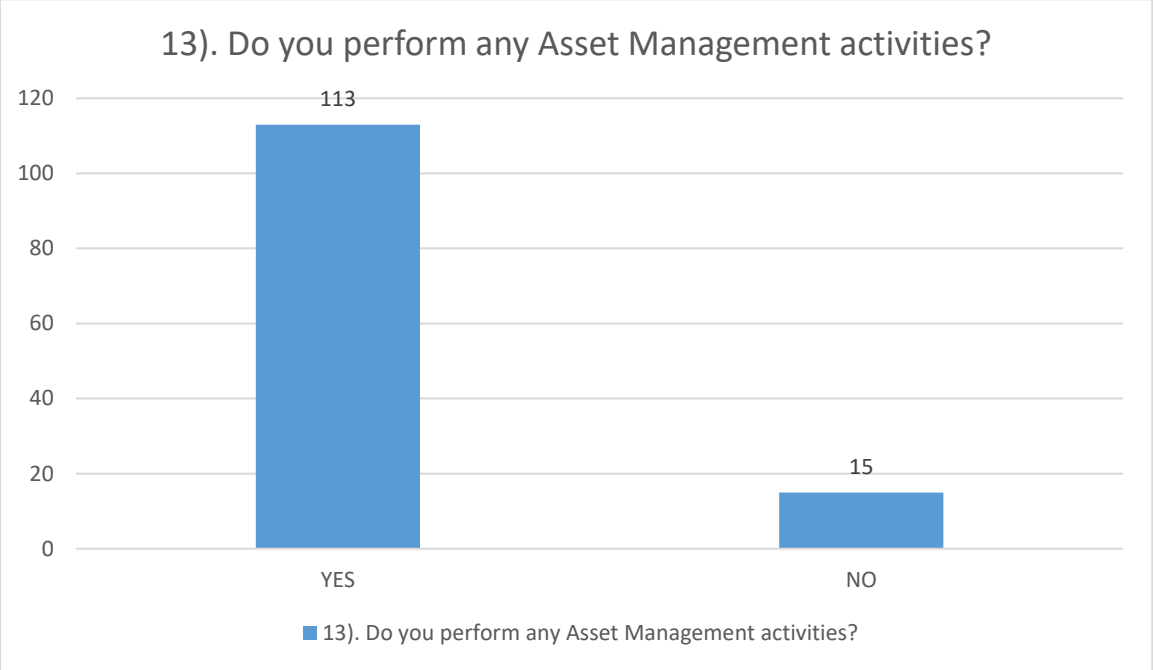

7). Does your organization have an existing maintenance plan?
120
100
80
60
40
20
0
106
22
YES
NO
7). Does your organization have an existing maintenance plan?

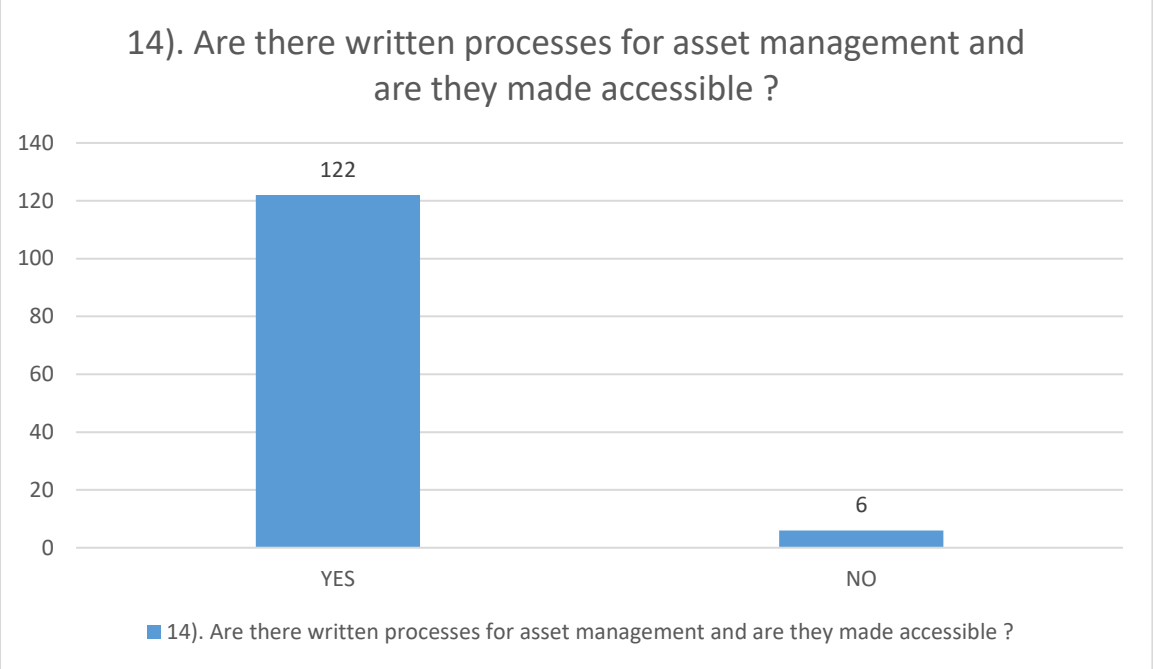

8).How is maintenance activity triggered?
125
120
115
110
105
100
95
90
110
119
118
117
102
Sudden failure
Problems reported by operators
Routine Inspection
Condition monitoring
Machine manufacturer's recommendation
8).How is maintenance activity triggered?

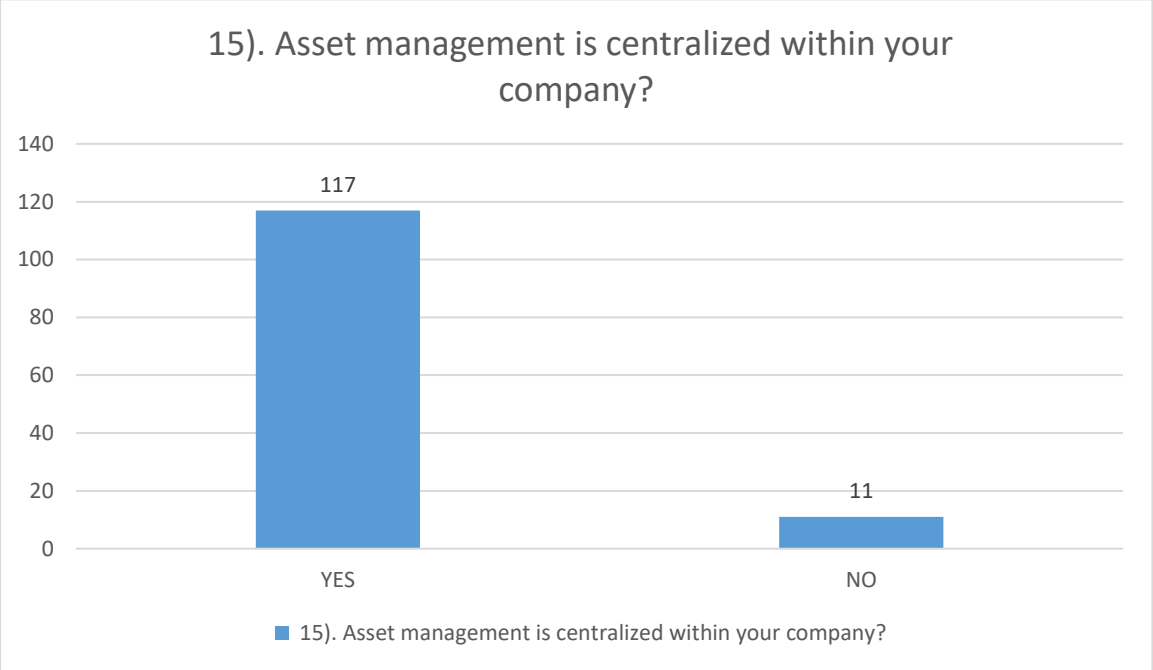

9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance?
140
120
100
80
60
40
20
0
117
11
YES
NO
9). Do you use any KPIs (Key Performance Indicator) for measuring your maintenance?

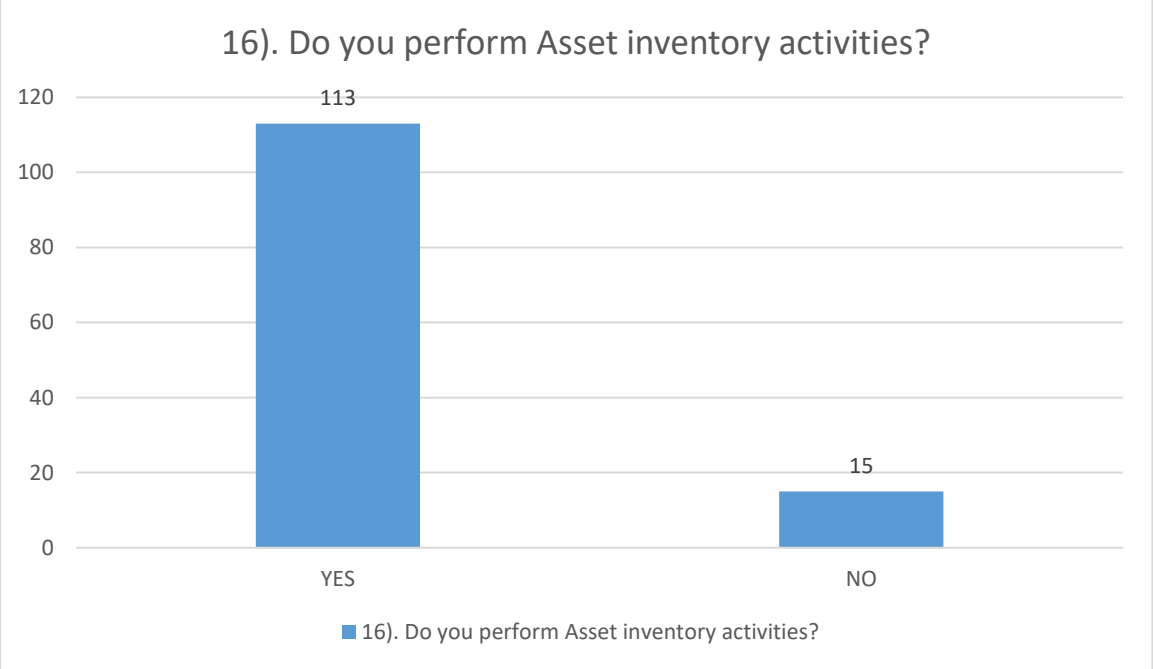

11). What is the biggest challenge you face when implementing a maintenance programme?
90
80
70
60
50
40
30
20
10
0
38
53
73
84
1
Budget constraints
Finding trained engineers
Breadth of equipment requiring maintenance
Keeping up to speed with technological change
I don't know
11). What is the biggest challenge you face when implementing a maintenance programme?

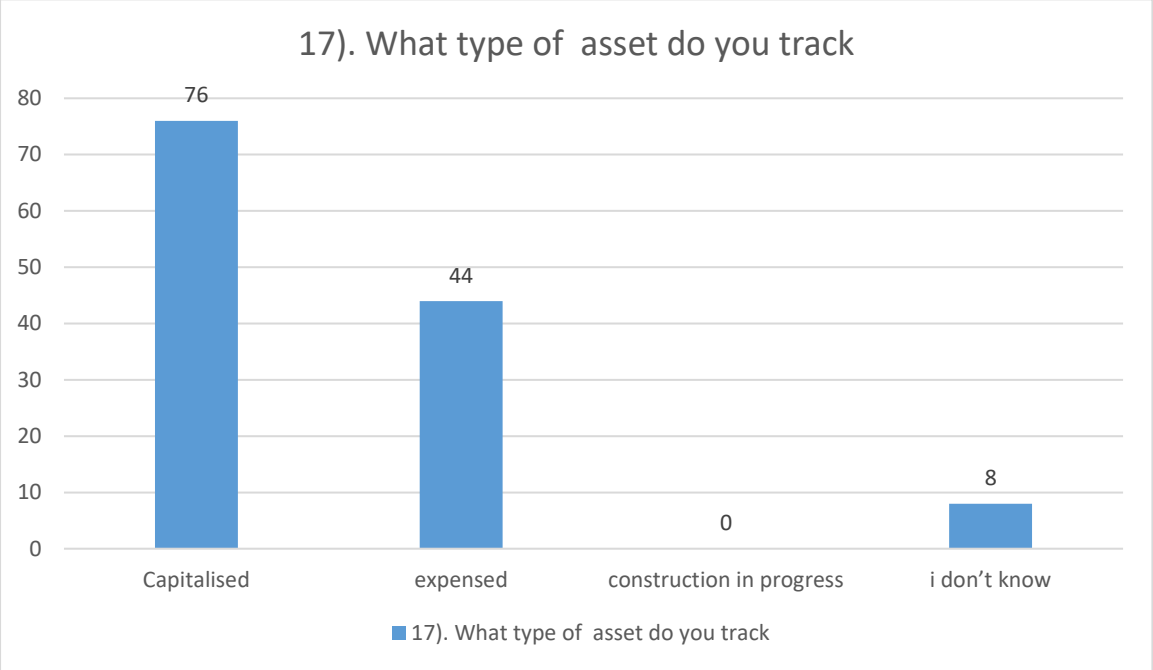

12). Which of these will contribute to the success of your organization?
140
120
100
80
60
40
20
0
42
51
124
124
96
Quality Standards
Senior management support
planning, monitoring and control
Risk management
Resource allocation
12). Which of these will contribute to the success of your organization?

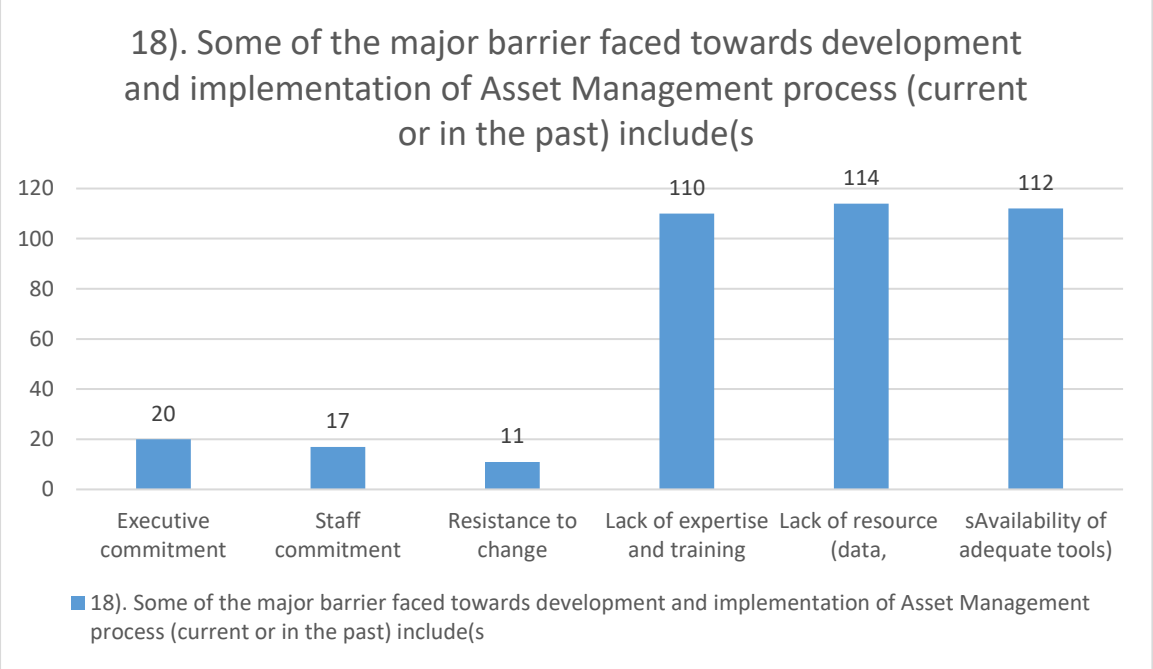

13). Do you perform any Asset Management activities?
120
100
80
60
40
20
0
113
15
YES
NO
13). Do you perform any Asset Management activities?

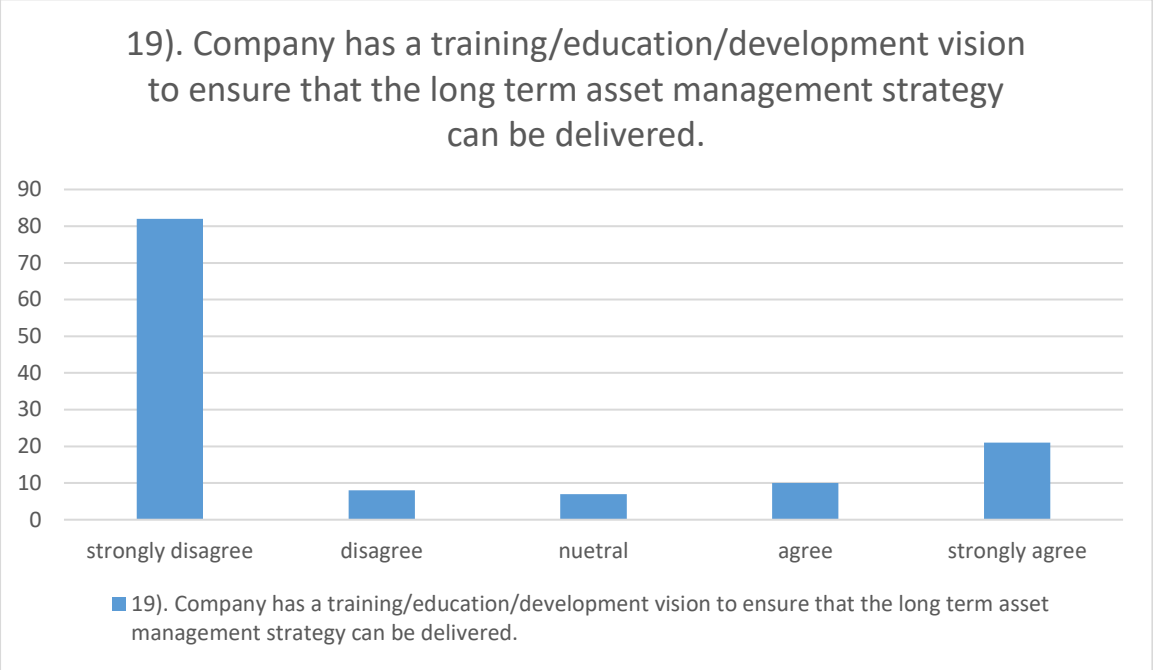

14). Are there written processes for asset management and are they made accessible ?
140
120
100
80
60
40
20
0
122
6
YES
NO
14). Are there written processes for asset management and are they made accessible ?

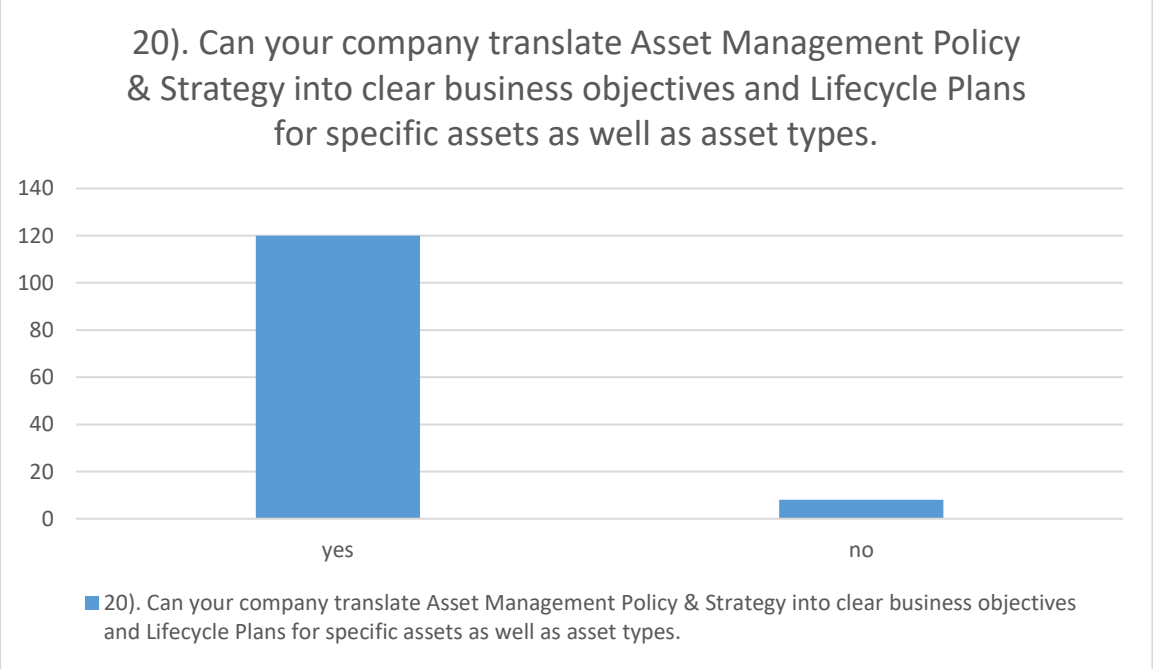

15). Asset management is centralized within your company?
140
120
100
80
60
40
20
0
117
11
YES
NO
15). Asset management is centralized within your company?

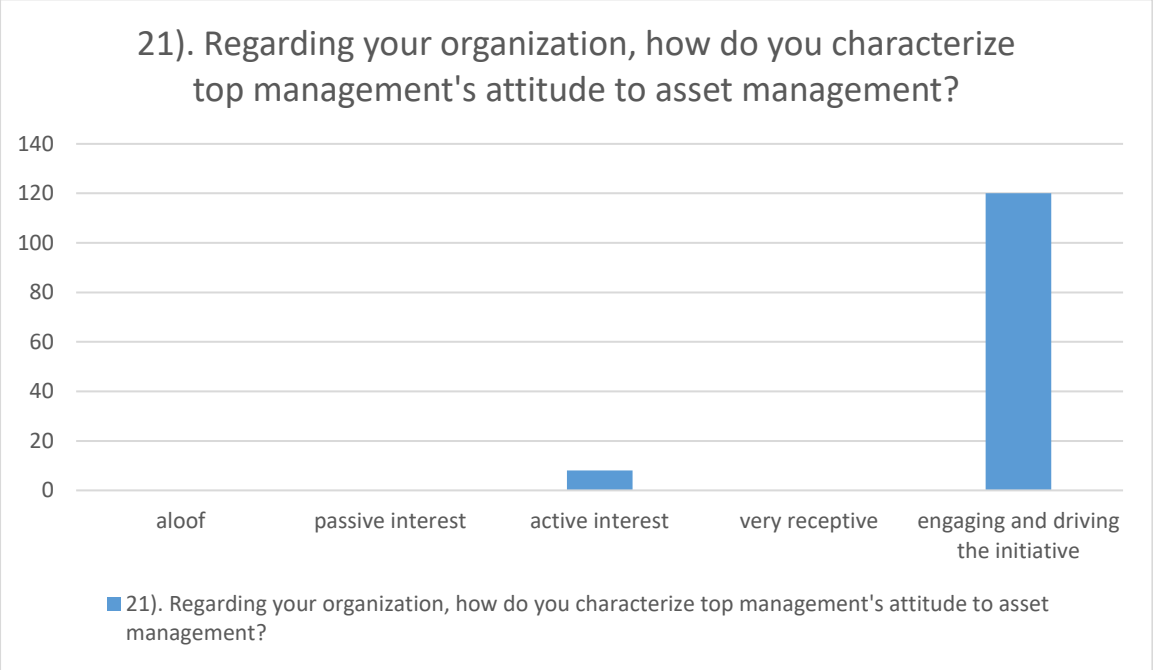

16). Do you perform Asset inventory activities?
120
100
80
60
40
20
0
113
15
YES
NO
16). Do you perform Asset inventory activities?


17). What type of asset do you track
80
70
60
50
40
30
20
10
0
76
44
0
8
Capitalised
expensed
construction in progress
i don't know
17). What type of asset do you track

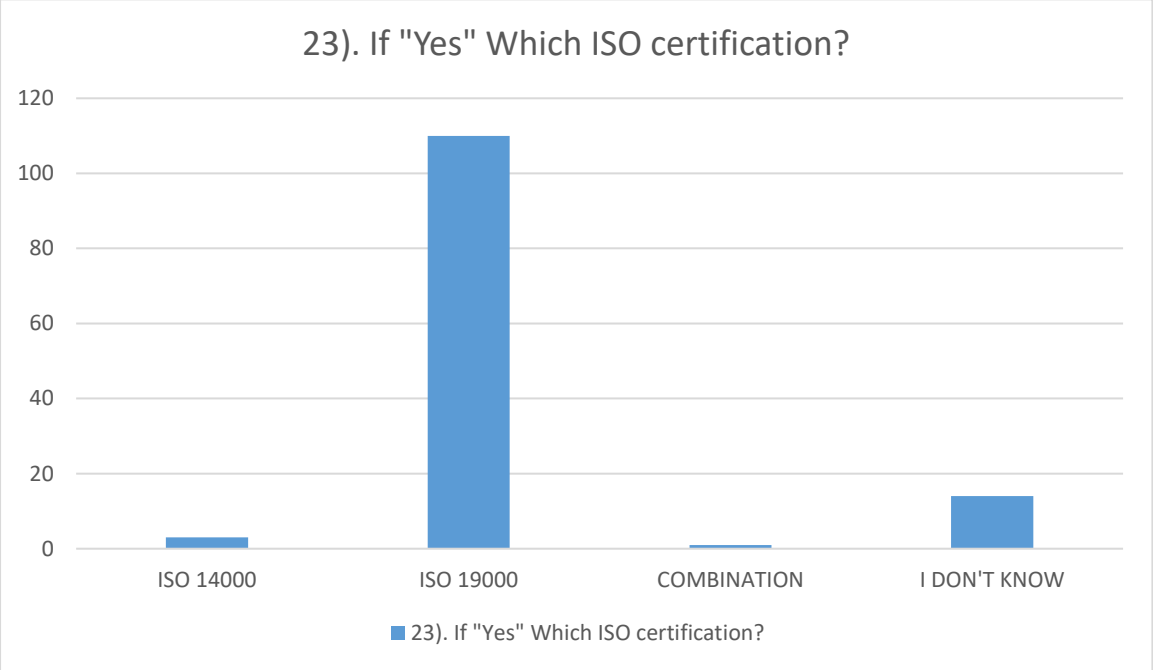

18). Some of the major barrier faced towards development and implementation of Asset Management process (current or in the past) include(s
120
100
80
60
40
20
0
20
17
11
110
114
112
Executive commitment
Staff commitment
Resistance to change
Lack of expertise and training
Lack of resource (data,
sAvailability of adequate tools)
18). Some of the major barrier faced towards development and implementation of Asset Management process (current or in the past) include(s

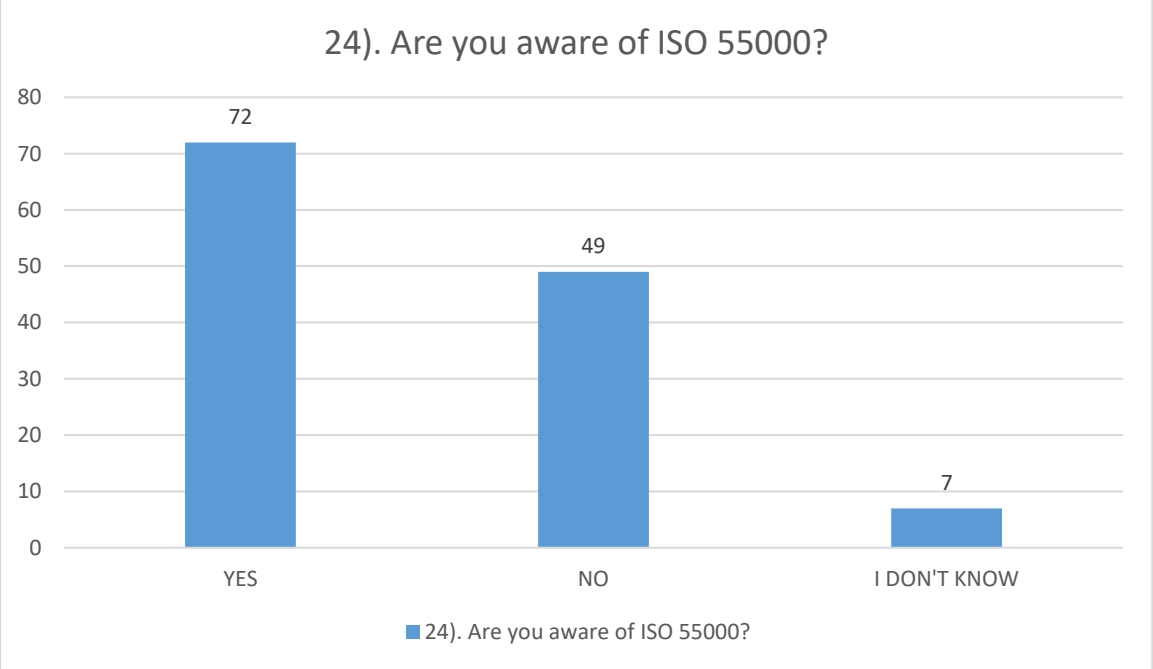

19). Company has a training/education/development vision to ensure that the long term asset management strategy can be delivered.
90
80
70
60
50
40
30
20
10
0
strongly disagree
disagree
nuetral
agree
strongly agree
19). Company has a training/education/development vision to ensure that the long term asset management strategy can be delivered.

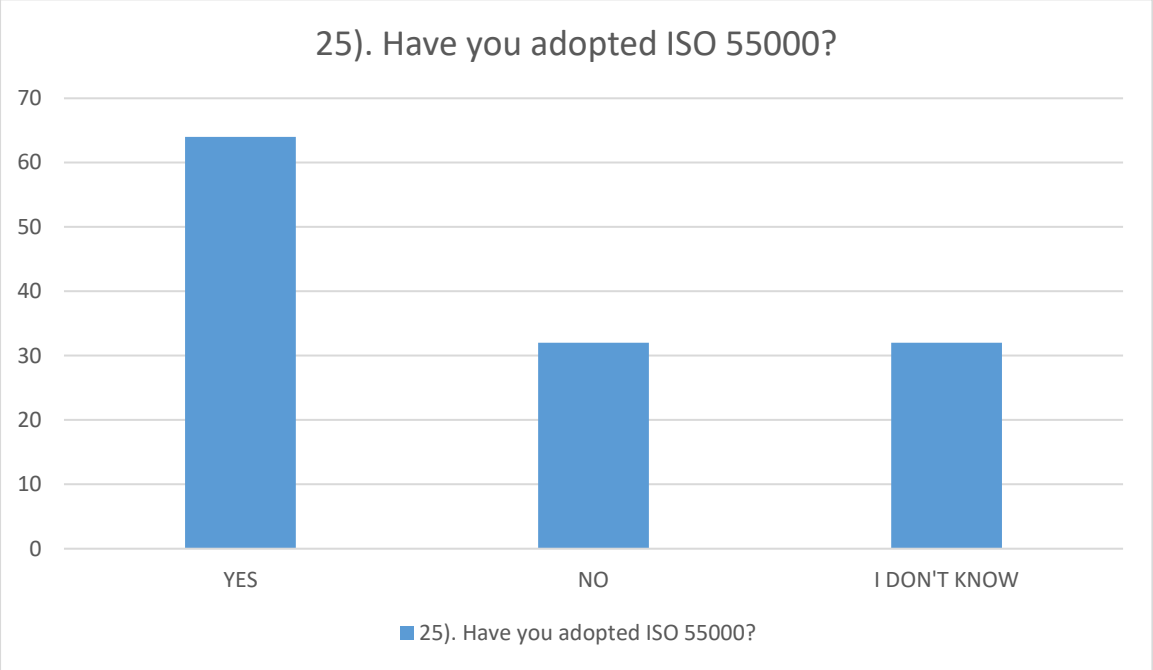

20). Can your company translate Asset Management Policy & Strategy into clear business objectives and Lifecycle Plans for specific assets as well as asset types.
140
120
100
80
60
40
20
0
yes
no
20). Can your company translate Asset Management Policy & Strategy into clear business objectives and Lifecycle Plans for specific assets as well as asset types.

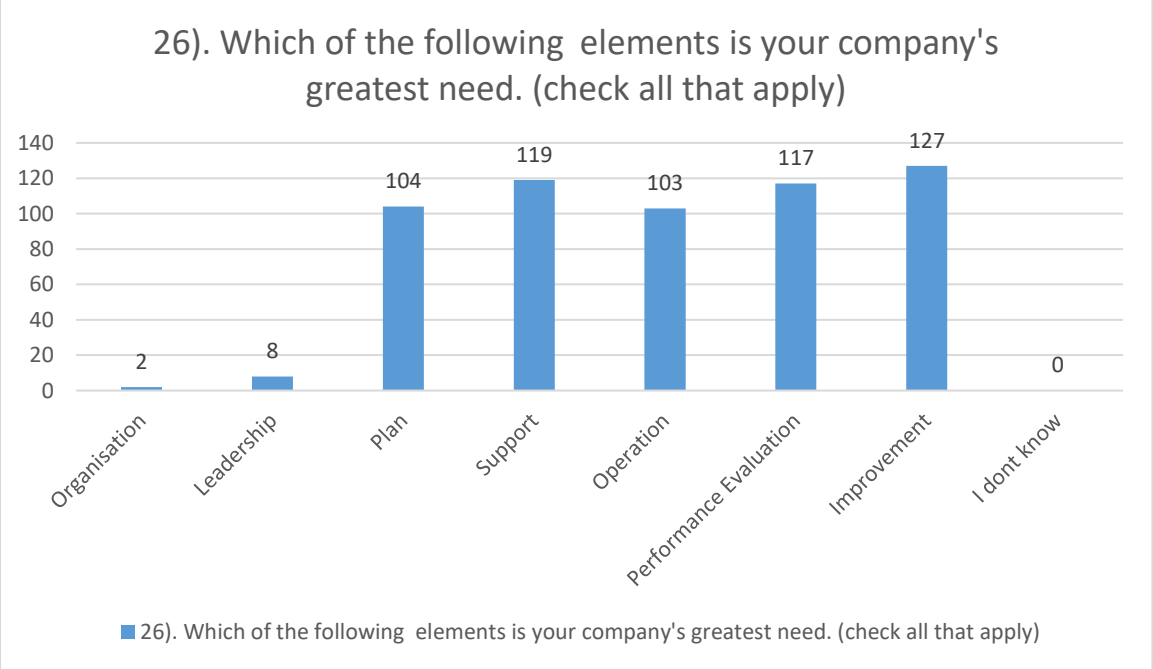

21). Regarding your organization, how do you characterize top management's attitude to asset management?
140
120
100
80
60
40
20
0
aloof
passive interest
active interest
very receptive
engaging and driving the initiative
21). Regarding your organization, how do you characterize top management's attitude to asset management?

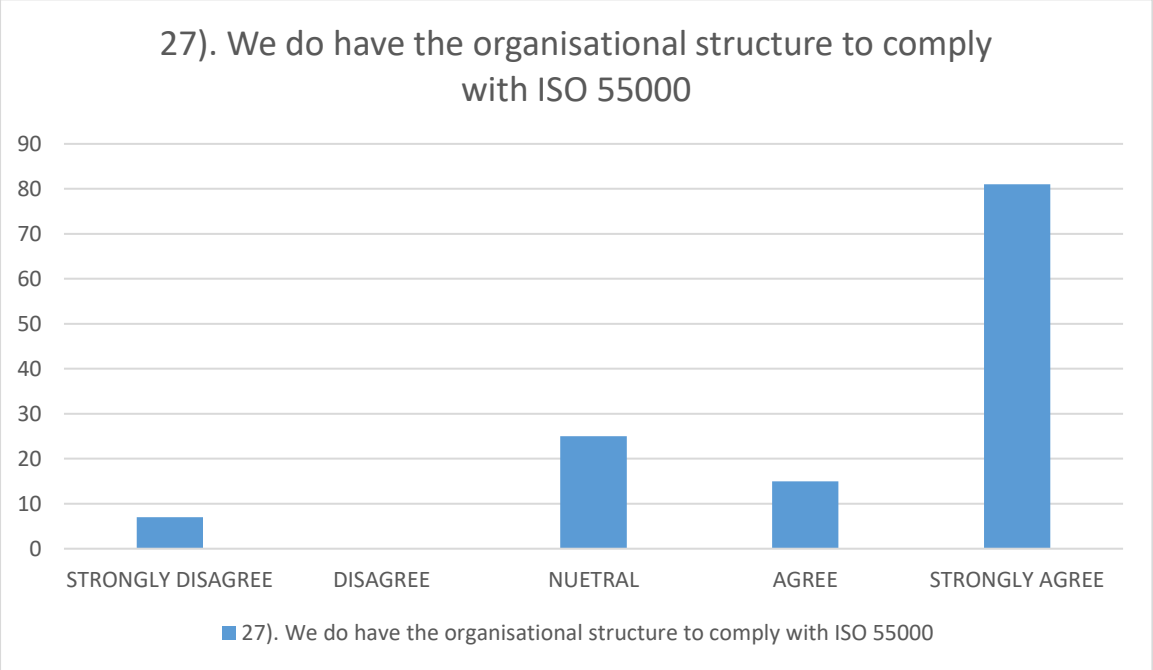
22). Does your organisation have an ISO certification?
120
100
80
60
40
20
0
yes
no
I don't know
22). Does your organisation have an ISO certification?


23). If "Yes" Which ISO certification?
120
100
80
60
40
20
0
ISO 14000
ISO 19000
COMBINATION
I DON'T KNOW
23). If "Yes" Which ISO certification?


24). Are you aware of ISO 55000?
80
70
60
50
40
30
20
10
0
72
49
7
YES
NO
I DON'T KNOW
24). Are you aware of ISO 55000?


25). Have you adopted ISO 55000?
70
60
50
40
30
20
10
0
YES
NO
I DON'T KNOW
25). Have you adopted ISO 55000?


26). Which of the following elements is your company's greatest need. (check all that apply)
140
120
100
80
60
40
20
0
2
8
104
119
103
117
127
0
Organisation
Leadership
Plan
Support
Operation
Performance Evaluation
Improvement
I dont know
26). Which of the following elements is your company's greatest need. (check all that apply)


27). We do have the organisational structure to comply with ISO 55000
90
80
70
60
50
40
30
20
10
0
STRONGLY DISAGREE
DISAGREE
NUETRAL
AGREE
STRONGLY AGREE
27). We do have the organisational structure to comply with ISO 55000

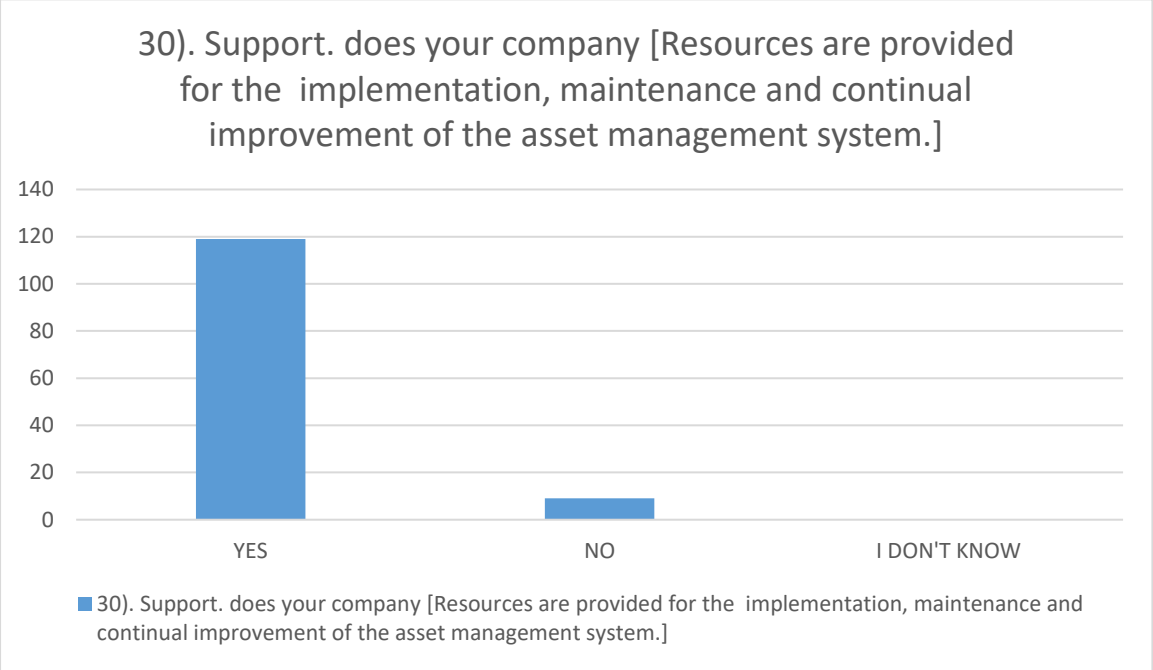
28). Planning [The organisation has planned actions to address risks and opportunities, taking into account how these risks and opportunities can change with time]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
28). Planning [The organisation has planned actions to address risks and opportunities, taking into account how these risks and opportunities can change with time]

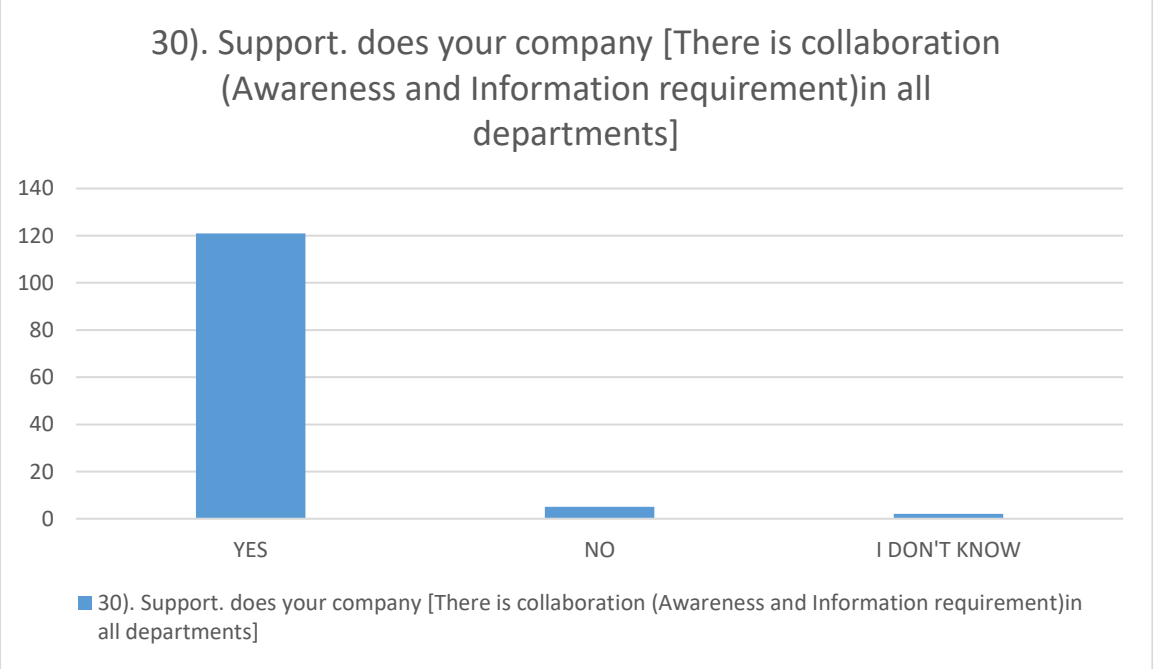
29). Asset Management objectives. your compamy 's [Objectives are measurable, monitored and communicated to relevant stakeholders.]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
29). Asset Management objectives. your compamy 's [Objectives are measurable, monitored and communicated to relevant stakeholders.]

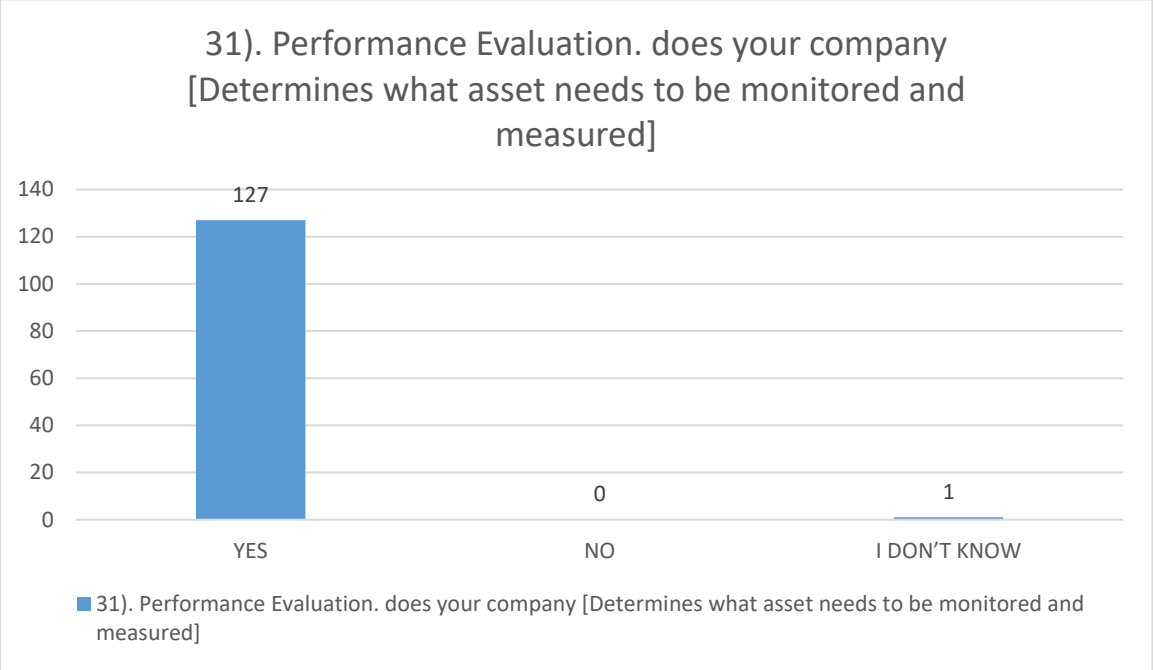
29). Asset Management objectives. your compamy 's [Are Asset management related risks considered by management .]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
29). Asset Management objectives. your compamy 's [Are Asset management related risks considered by management .]

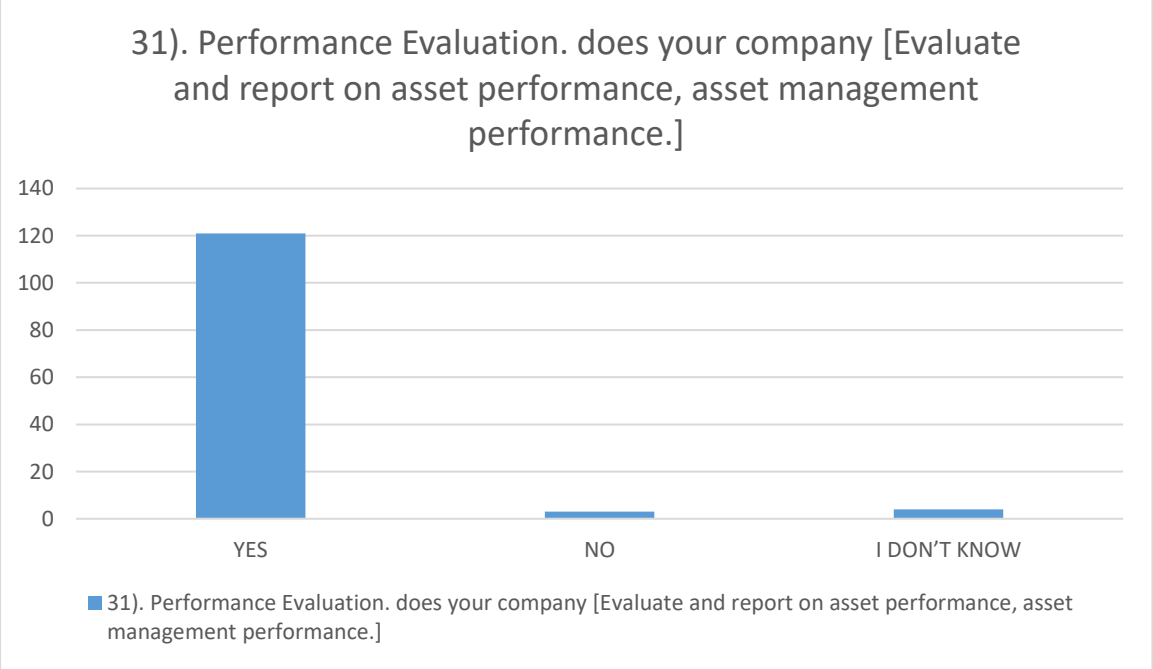
29). Asset Management objectives. your compamy 's [Do you have contingency plan]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
29). Asset Management objectives. your compamy 's [Do you have contingency plan]

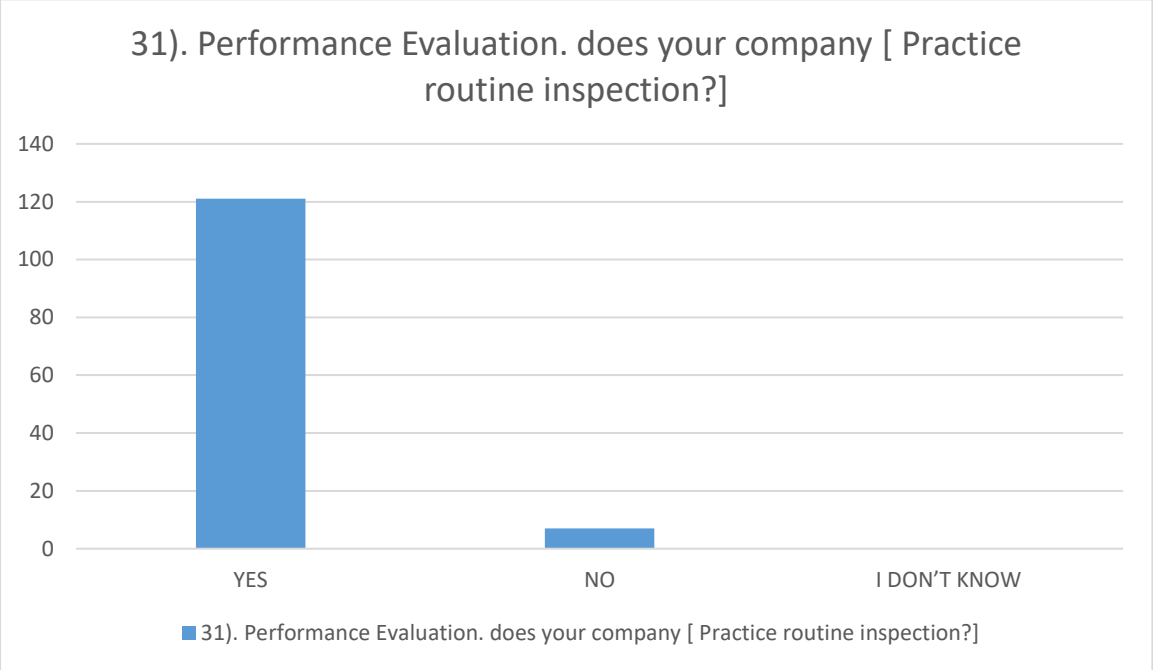
29). Asset Management objectives. your compamy 's [Objectives are reviewed and updated as appropriate]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
29). Asset Management objectives. your compamy 's [Objectives are reviewed and updated as appropriate]

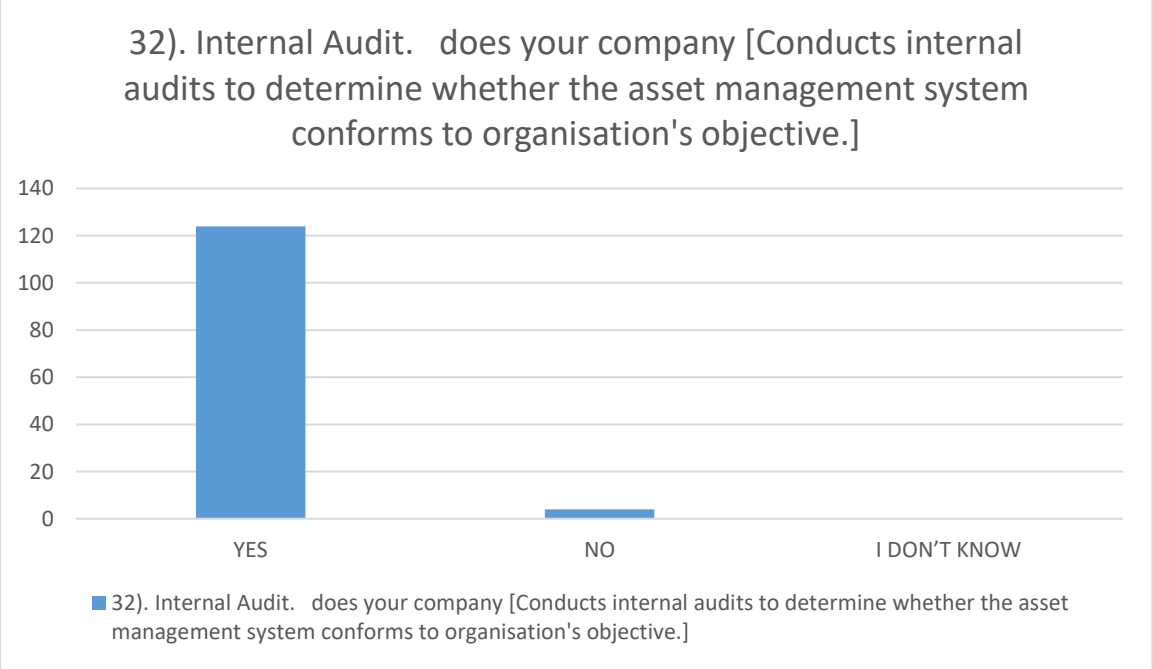

30). Support. does your company [Resources are provided for the implementation, maintenance and continual improvement of the asset management system.]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
30). Support. does your company [Resources are provided for the implementation, maintenance and continual improvement of the asset management system.]

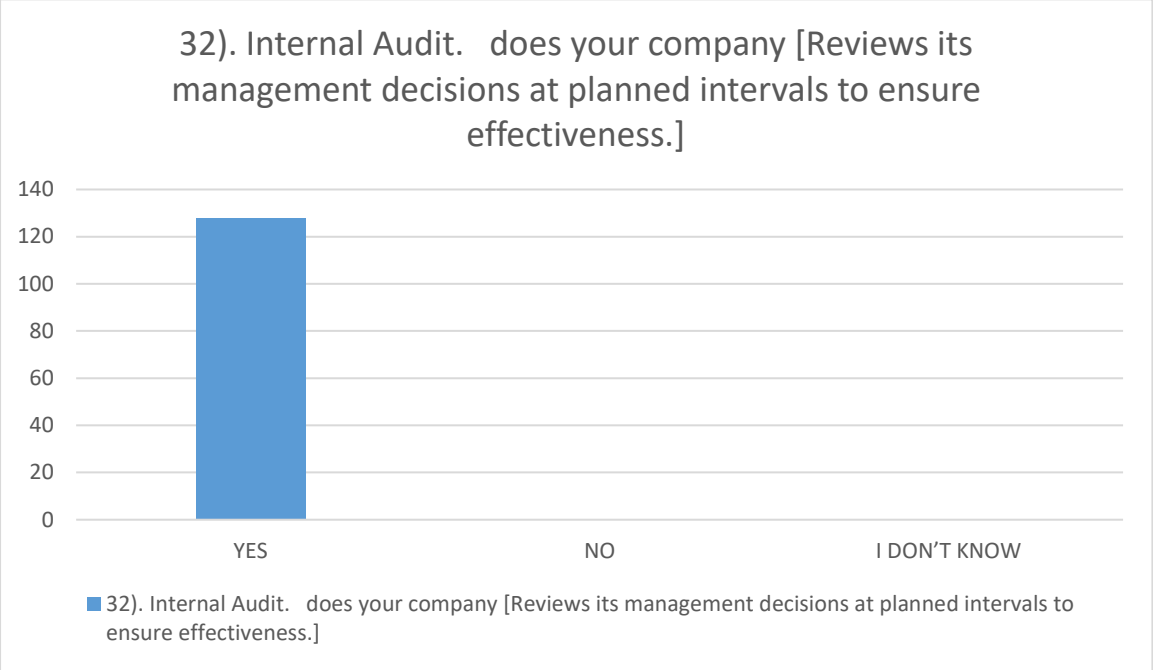

30). Support. does your company [There is collaboration (Awareness and Information requirement)in all departments]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
30). Support. does your company [There is collaboration (Awareness and Information requirement)in all departments]

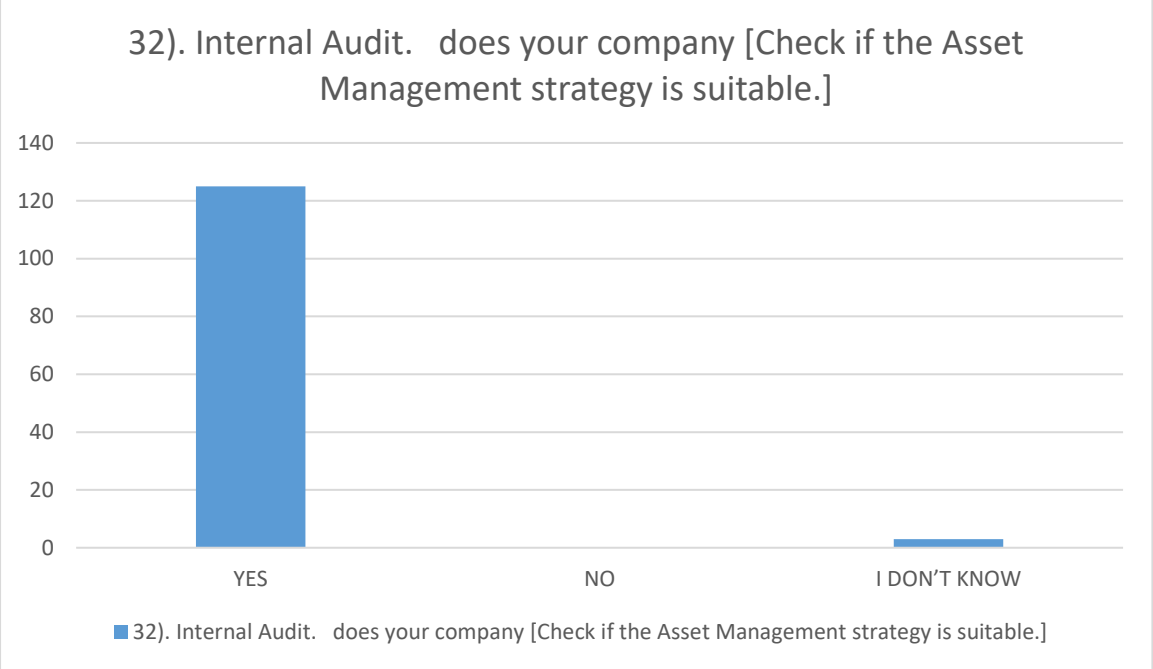

31). Performance Evaluation. does your company [Determines what asset needs to be monitored and measured]
140
120
100
80
60
40
20
0
127
0
1
YES
NO
I DON'T KNOW
31). Performance Evaluation. does your company [Determines what asset needs to be monitored and measured]

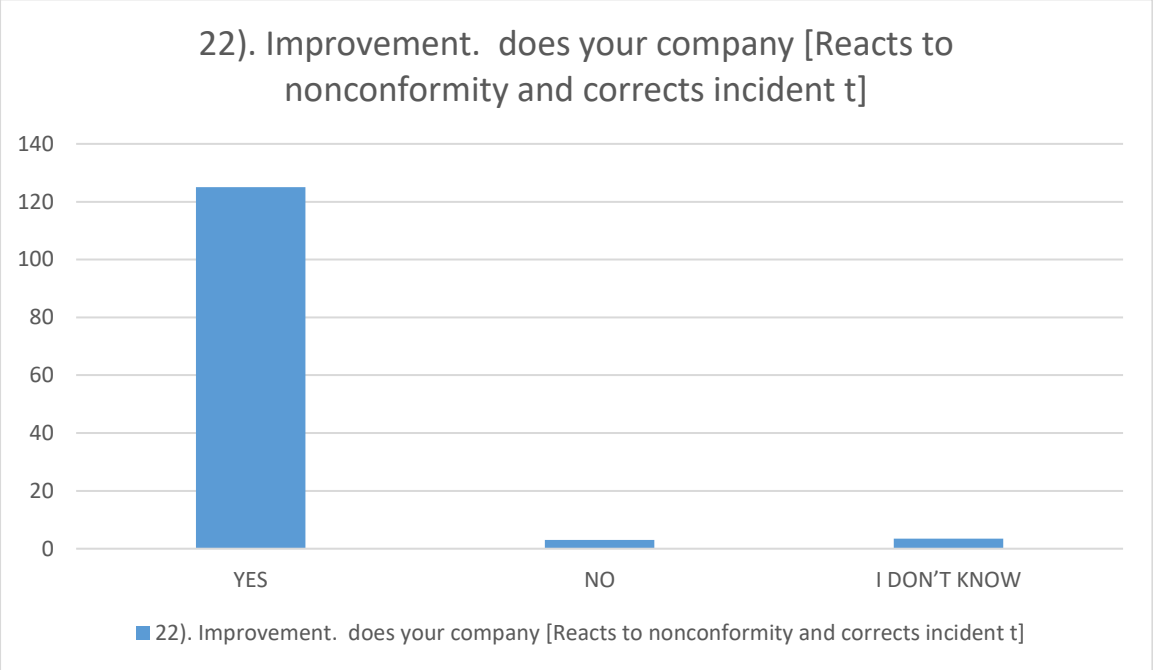

31). Performance Evaluation. does your company [Evaluate and report on asset performance, asset management performance.]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
31). Performance Evaluation. does your company [Evaluate and report on asset performance, asset management performance.]

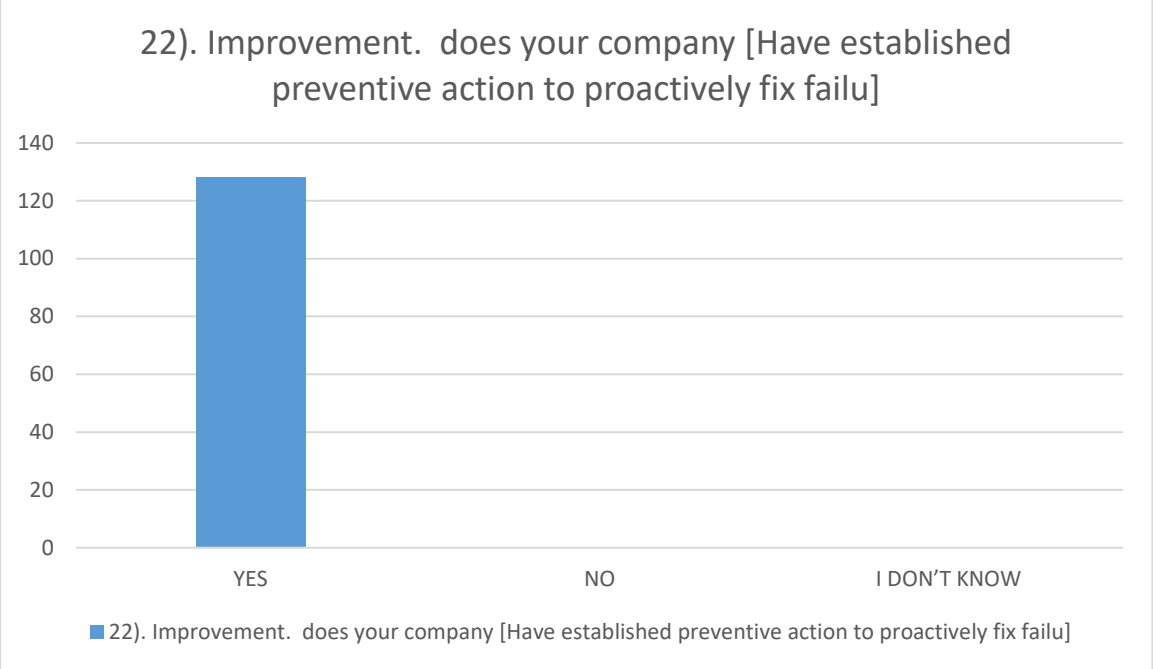

31). Performance Evaluation. does your company [Practice routine inspection?]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
31). Performance Evaluation. does your company [Practice routine inspection?]

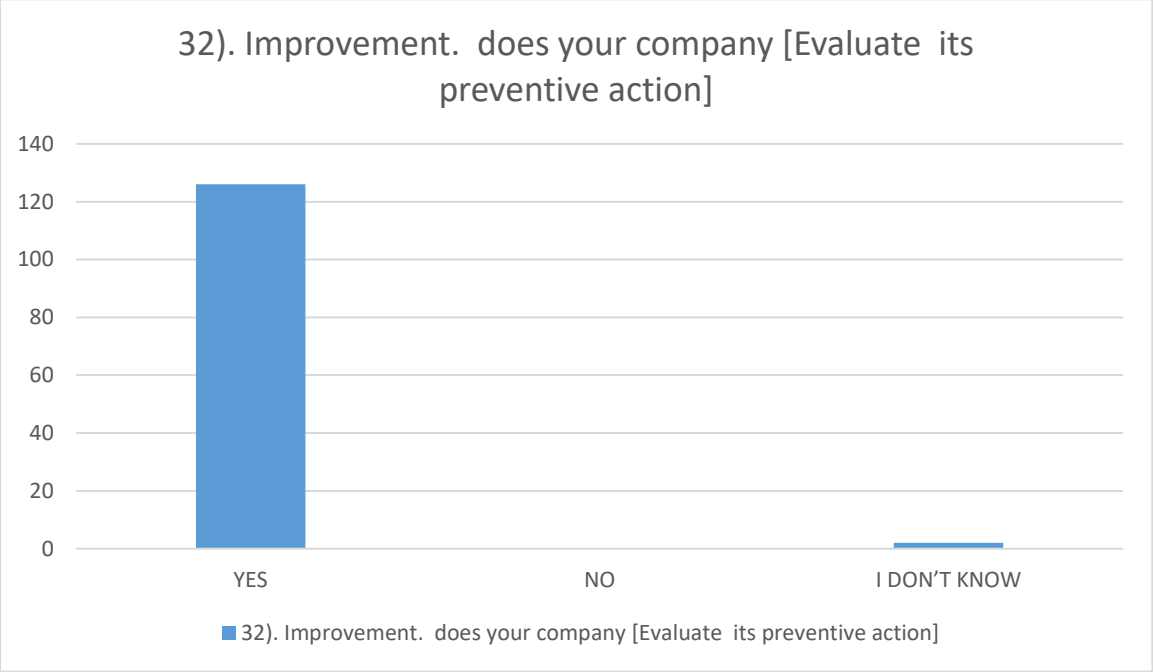

32). Internal Audit. does your company [Conducts internal audits to determine whether the asset management system conforms to organisation's objective.]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
32). Internal Audit. does your company [Conducts internal audits to determine whether the asset management system conforms to organisation's objective.]


32). Internal Audit. does your company [Reviews its management decisions at planned intervals to ensure effectiveness.]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
32). Internal Audit. does your company [Reviews its management decisions at planned intervals to ensure effectiveness.]


32). Internal Audit. does your company [Check if the Asset Management strategy is suitable.]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
32). Internal Audit. does your company [Check if the Asset Management strategy is suitable.]


22). Improvement. does your company [Reacts to nonconformity and corrects incident t]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
22). Improvement. does your company [Reacts to nonconformity and corrects incident t]


22). Improvement. does your company [Have established preventive action to proactively fix failu]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
22). Improvement. does your company [Have established preventive action to proactively fix failu]


32). Improvement. does your company [Evaluate its preventive action]
140
120
100
80
60
40
20
0
YES
NO
I DON'T KNOW
32). Improvement. does your company [Evaluate its preventive action]