Evaluating the fire protection systems' maintenance strategy of an air force base in the Limpopo Province

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ABSTRACT

This study aimed to evaluate the maintenance strategy of a fire protection system in an Air Force Base (AFB) situated in the Limpopo Province. As a specialised engineering discipline in South Africa, fire engineering and fire protection systems maintenance is not popular or familiar to many people. This discipline has been fully recognised by engineering professional bodies as to conform to the functional requirements of the National Building Regulations, SANS 10400 requirements.

The literature review explored the importance of fire protection systems concepts, definitions, and benefits as well as described fire protection system's related standards and codes regarding its applications. Research data was gathered by conducting a survey on Air Force Base employees who were directly impacted by the fire protection system maintenance function. A sample of five employees, from the Maintenance and Operations Department at AFB participated and responded to the semi-structured interview questionnaire, in August 2017. The respondents' responses were transcribed word-for-word by the researcher.

The empirical research done in this study supplemented the theory of fire protection system maintenance and maintenance strategy pertaining to the strategic role of the maintenance function within the AFB. The findings of this study revealed that the maintenance function and strategy at the AFB is perceived to be an important business management function which contributes positively towards the AFB's overall objectives.

The study recommends that the AFB's maintenance strategy must be fully implemented in order to improve maintenance and operational effectiveness of fire protection system.

Keywords: Evaluate, maintenance strategy, fire protection systems and Air Force Base

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NATURE AND SCOPE OF STUDY

1.1 INTRODUCTION

The infrastructure and the overall maintenance of any airport, or in this case air force base, is an important factor in ensuring the optimal operational effectiveness of the air force. The specific Air Force Base (AFB) under study is situated in the Limpopo Province and has recently experienced problems with the fire protection system. It is mandatory by law to maintain the fire protection systems of all AFBs in South-Africa, as stipulated in the National Key Point Maintenance Schedules (SANS 10400 T, 2011:46).

Kobes *et al.* (2010:2) stipulate that the possibility of a safe escape is the most crucial aspect of a building's fire safety features. The term *fire safety* refers to all action necessary in preventing a fire, limiting the spread of fire and smoke, extinguishing of a fire and the chance of a quick and safe exit. Fire safety policies reflect the way in which people think about this issue in both society at large and the political arena.

The overall maintenance and management within an AFB play an important role. It ensures that the lives of people and properties are protected. It is in the responsibility of the AFB management by ensuring that all fire protection systems are maintained in accordance with the South African National Standards (SANS) 10400 T as well as the National Fire Protection Association requirements (SANS 10400 T, 2011:46).

Schroll (2013:20) states that an understanding of the nature and scope of the fire loss problem is necessary to provide a basis for reducing fire losses. Fire losses offer valuable lessons in that it provides important information to prevent or reduce the impact of similar losses in future. However, common denominators exist in most incidents. Schroll (2013:21) further states that factors influencing the severity of a fire loss can be divided into three basic categories, namely factors that influence the start of a fire, factors that contribute to the growth and spread of a fire and factors that assist with the control or extinguishment of fires.

The AFB has many different operational systems such as electronics and electrical systems, water and waste systems and security system, to mention a few. This study focused on evaluating the maintenance strategy of a fire protection system in the AFB situated in the Limpopo province. The scope of the research project covered the following systems:

- Automatic Sprinkler Fire suppression/extinguishing system
- Carbon dioxide (CO2) gas fire suppression system
- Fire detection System
- Telemetry Equipment (Electronic System)
- Portable fire extinguishers
- The decommissioning of Halogenated hydrocarbon agents (Halon) gas suppression system and Hydro fluorocarbon (also known as FM 200) fire suppression installation.

Mckone and Weiss (2012:340) stated that, while the first four activities are essential to developing a company-wide maintenance system, much of the day-to-day maintenance planning and execution is performed by the production and maintenance personnel. As operators are trained in basic maintenance, they begin to inspect and maintain the equipment and perform basic maintenance tasks. This allocation of maintenance tasks to production operators frees up time for maintenance personnel to perform long-term improvement efforts and to plan maintenance interventions.

Tackling maintenance as a single existence will not tackle and solve all operational issues, but a systematically technique is considered to tackle some of the integration issues involving technical departments at the AFB. After evaluating the current fire protection service, the successful implementation of a revised fire protection maintenance strategy will ensure that AFB operations are operating more effectively and successfully. Thus, evaluating the maintenance strategy of the fire protection system becomes crucial in identifying certain shortcomings in the overall maintenance program.

1.2 PROBLEM STATEMENT

According to Kumar (2015:241), recent competitive trends have prompted management of manufacturing enterprises to look at the performance of each and every business function, including manufacturing and maintenance, for achieving competitive advantage. Poor organisational competencies in managing the maintenance function effectively can severely affect competitiveness by reducing throughput, increasing inventory and leading to poor due-date performance.

Borg *et al.* (2015:995) imply that the main objective of fire safety engineering is to develop and validate a fire safety maintenance strategy that protects people, property and the environment from fire effects. However, the project owner must deal with issues that might be in conflict with fire safety measures such as costs, functionality and flexibility of the overall design. The fire safety

engineer is supposed to balance these conflicts while also taking the stakeholders' preferences into consideration. In order to assess whether fire safety intentions are met in a project, adequate methods must be specified to investigate the consequences from potential fires.

According to Bliven (2014:95), today's fire service evolves on the maintenance strategy and compliance. Budget cutbacks have taken a toll on the fire service nationwide, regardless of the size of the affected jurisdiction, sometimes resulting in reductions in staff, service, equipment purchasing, wages, benefits and so forth. Most of the cutbacks are from the results of state and city budget shortfalls and to make these constraints work without sacrificing service delivery needs innovative managerial input where possible. The effect depends on the service area's geographical size and demographics, current staff/operating levels and run volume, among other factors.

Due to an incomplete maintenance schedule and repair schedule as well as the deterioration of fire protection systems in the AFB, the Department of Public Works in Limpopo Province has taken an initiative in budgeting R35 million in order to address the dilapidation of the fire protection systems.

All these fire protection systems are categorised under the Pressure Equipment Regulations of the Occupational Health and Safety Act (OHSA No.85 of 1993) and must also comply with sections A and T of SANS 10400. The success of the evaluating maintenance and implementation programme will ensure that all the fire protection systems within the AFB will operate/function optimal and that the AFB complies with regulatory standards stipulated in the National Building Regulations and National Fire Protection Association (NFPA) standards as well as OHSA No.85 of 1993.

Leavitt (2013:30) states that, in failing to maintain the fire protection systems can damage a company's brand management, business reputation and asset protection. The fire protection systems are governed by the NFPA codes but many building owners have specific requirements that they want to undertake, based on their own specific risks. Leavitt (2013) also stressed the need to view maintenance in terms of incident prevention rather than merely conducting maintenance to comply with codes and standards.

Hui (2006:14) defines fire safety strategy as a plan on how to use one or a combination of fire protection measures to achieve predetermined fire safety objectives. There could be one or more fire safety objectives in a single project. Typical fire safety objectives include, but are not limited to, the following:

- Building occupants' safety
- Property and contents protection
- Business continuity
- Adjacent property protection
- Protection of fire fighters
- Averting a catastrophic loss
- Environmental protection

After an unequivocal decision between the researcher and the client (AFB and Public Works) with regard to maintenance strategy, the researcher was given a node to assess the importance of evaluating the maintenance strategy within the AFB. The assessment has been approved by the AFB Fire Department operations and local authority as an appropriate solution allowing for the service to be rendered.

1.3 OBJECTIVES OF STUDY

The objectives of this study are classified into two objectives, namely primary and secondary objectives.

1.3.1 Primary objective

The main primary objective of this research was to evaluate the maintenance strategy of the fire protection systems in an Air Force Base (AFB) situated in the Limpopo Province.

1.3.2 Secondary objectives

The secondary objective of this study was to understand the impact of maintenance on the fire protection systems with a particular reference to the AFB maintenance strategy. The secondary objectives among others included the following:

- To stress the importance that maintenance strategies have on fire protection systems.
- To identify barriers in the maintenance strategies of an AFB in maintaining their fire protection systems.
- To examine the effect that a planned implementation maintenance program (PIMP) has on the fire protection systems of an AFB.
- To gain more insight into maintenance strategy through conducting a literature review.
- To derive conclusion from empirical study and provide recommendations on how to execute planned implementation maintenance program (PIMP).

The evaluation of the preparedness of the AFB together with Department of Public Works (DPW) to institute a maintenance strategy in order to supplement integration with other operational departments can result into continued process improvement at the AFB. This could ensure a culture and process of continuous improvement which could lead to long-term operational excellence.

The secondary objective of the study was to ensure that the maintenance and implementation program takes the lead and this will ensure that the Operations Department and the maintenance schedules process, including all technical players will be more effective. Consequently, the lessons learnt at the AFB in Limpopo, as a result of the study, will be recommended for possible implementation at all air force bases in South Africa.

1.4 SCOPE OF STUDY

The scope of the research take into account literature study which comprised investigating the operational challenges at the AFB, evaluating the fire protection systems maintenance program and employees' involvement in maintenance operations.

1.4.1 Field of study

The study evaluated the maintenance strategy of the fire protection systems at the AFB and focused on maintenance as key a word. The study was performed in the Limpopo Province.

1.4.2 Geographical demarcation

The research embraced a literature study which covered investigating the effects of the current maintenance strategies in government institution. The study was carried out on the employees working at the AFB as well as the Department of Public works to examine their perceptions towards maintenance importance strategies. The employees were divided into three groups, i.e. maintenance, technical and operation units, based in their reporting structure at the AFB.

According to the Department of Government Communication (2016: 427), the Limpopo Province is one of the poorest provinces of South Africa. It covers approximately 125 754 km^2, which represents merely 10.3% of the South African surface area. Limpopo has a population of about 5.7 million people. The province is divided into five municipal districts, namely Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg district (Department of Government Communication, 2016: 427). The geographical footprint of Limpopo is presented in the map below.

Figure 1.1: Represent the map of Limpopo Province

Source: http://www.customdigitalmaps.com

1.5 RESEARCH METHODOLOGY

The population is the entire collection of individuals being considered for a study (McBurney, 2010:412). The employees (include the utility men, technicians and fire brigade personnel) are all in the Maintenance Department while the operators (fire fighters) are in the Operations Department. The problem identified at this site had prompted the author to use only this as a case and not any other site.

Keller (2010:119) implies that, when choosing the unit analysis, it is essential to consider the unit of generalisation as the conclusions and interferences drawn as a result of the analysis may be accurate only at the level of the unit analysis.

1.5.1 Literature study and aim of study

This study aimed to evaluate the importance of maintenance strategy of fire protection systems as core maintenance implementation programme at AFB. It sought to demonstrate how maintenance strategy influences organisational performance at the AFB.

Interviews functioned as a source of information and were followed by discussions with management members of the Department of Public Works. Other sources of information pertaining to this study were as follows:

- Total productive maintenance manuals
- Maintenance Engineering manuals
- Maintenance Management and Engineering manuals
- Maintenance Performance Measurement journals

The literature was supplemented by academic journals and published articles from qualitative approaches in business studies, Google scholar searches and other databases, for example Business Source Premier and Emerald Library.

1.5.2 Empirical study

This section includes a description of the specific techniques to be employed, the specific measurement instruments (interviews and observations) to be used and the activities initiated in conducting the research which is in the form of qualitative research.

1.5.2.1 Research design

This study adopted a qualitative method to assess the effects of maintenance strategies of fire protection systems in the AFB.

1.5.2.2 Study population and sampling method

Purposive sampling is one technique often employed in qualitative investigation. With a purposive non-random sample, the number of people interviewed is less important than the criteria used to select them. The characteristics of individuals are used as the basis of selection, most often chosen to reflect the diversity and breadth of the sample population (Bell *et al.*, 2015:186).

Purposive sampling can be used with a number of techniques in data gathering (Baruch, 2011:59). Bell *et al.* (2015:186) further state that a study will adopt purposive sampling since the inherent bias of the method contributes to its efficiency, and the method stays robust even when tested against random probability. Choosing the purposive sampling method is fundamental to the quality of data gathered. The researcher chooses the participants on grounds of their knowledge pertaining to the phenomenon being evaluated.

The targeted study population was limited to an AFB operating in Limpopo Province as well as the Provincial Department of Public Works. The researcher intended to employ semi-structured interviews with five to eight participants with efficient background knowledge pertaining to this study.

1.5.2.3 Data collection

The researcher started the study with a visit to all the various units and departments in the AFB, and also interacted with a number of staff at the Public Works Department. With this, the researcher got to know members of the AFB to better understand the institution and its structures. The objectives of the study were made known to the respondents and they were also assured that their information would be treated with the utmost confidentiality. Assurances from a researcher to respondents of confidentiality of information being sought made the interviewees more relaxed and open in their responses.

Semi-structured questions were used to obtain the views of AFB employees. This was more appropriate because the effects of maintenance negligence were felt by the technical, maintenance and operations team within the base. In the study, interviews were carried out with operations and maintenance representatives. The main goal was to get feedback from the employees and to examine their perceptions towards the fire protection maintenance so that it could assist with the evaluation of the importance of maintenance strategy.

1.5.2.4 Data analysis

The data was collected through hardcopy with semi-structured questions. Data collected was analysed and transcribed word for word as per respondents' replies. Data from semi-structured questions was transformed into useful accomplishment like frequency tables, and these tables were used to draw up conclusions and to make recommendations concerning the importance of fire protection maintenance strategy within AFB in Limpopo.

1.6 LIMITATIONS OF STUDY

The study only focused on the evaluation of the maintenance strategy for fire protection systems and did not incorporate the other systems such as water and waste or security. The research study used a qualitative approach, i.e. to utilise observations and interviews and it did not take quantitative data into account. Furthermore, some other limitations of the research study comprised the following:

- The study was limited to Limpopo Province only.
- Only AFB employees (maintenance and operational respondents) as well as DPW employees were interviewed.

1.7 DIVISION OF CHAPTERS

The main components and focal point of this research is set out in Table 1.1 below. The table represents the sequence of this particular study. The main part of the study was categorised into four chapters, which are summarised as follows:

Table 1.1: Represents the Chapters' layout of the study.

CHAPTER	ELEMENT
Chapter 1	• Introduction • Problem statement • Objective of study • Scope of study • Research methodology • Limitation of study • Division of chapters
Chapter 2	• Literature review on fire protection maintenance strategy.
Chapter 3	• Semi-structured interviews • Data collection • Data analysis
Chapter 4	• Summary, results, conclusion and recommendations.

Chapter 1 - **The problem statement, purpose of the study**

Due to an incomplete maintenance schedule and repair schedule as well as the deterioration of fire detection and protection systems in the AFB, the Department of Public Works in Limpopo Province has taken an initiative by budgeting millions of rands in order to address the dilapidation of the fire protection systems.

Chapter 2 - **A review of the literature applicable to this study**

The theoretical study was based on the operations and maintenance strategy. The primary sources of information for the research was the AFB, Google scholar, maintenance engineering manuals, books, journals and personal work experience on design, maintenance and operations management disciplines.

Chapter 3 - **Empirical research: Data analysis, findings and discussion**

The empirical study was based on the interviewing of employees in the Operations Department.

Chapter 4 - Summary, results, conclusions and recommendations

Recommendations include the systems approach to address the operational and maintenance challenges within the AFB. Finally, a critical evaluation of the primary and secondary objectives set for the study, is confirmed. The findings obtained in the study will be used to provide a basis for future research suggestions within AFB.

1.8 SUMMARY

Chapter 1 provided an introduction to the study. It outlined the problem which the researcher had intended to research and investigate. It also provided the necessary feedback of the study. The next chapter provides the literature review of the study, and lays the foundation for the empirical study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This dissertation pursued to assess the benefit of fire protection systems within an Air Force Base (AFB). This chapter elaborate the intention and interpretation within the field of fire protection systems and maintenance strategy, within the context of the Air Force Base. The fire protection systems aspects evolve defining fire protection systems, international standards for fire protections systems, South African standards for fire protection systems, the importance of fire protection systems in business management, fire protection systems' in AFB in South Africa and challenges experienced in fire protection systems in South Africa.

From maintenance perspective, the maintenance strategy aspects involved in this chapter are the theory of maintenance strategy, defining maintenance strategy, international views/importance of maintenance strategy, South African views/importance of maintenance strategy, maintenance strategy of an airport AFB sector, importance of maintenance strategy in business strategy and function maintenance strategy in business strategy.

2.2 OVERVIEW OF FIRE PROTECTION SYSTEMS

2.2.1 Defining fire protection systems

Oregon (2014: 26) defined fire protection system as an approved device, equipment and systems or amalgamation of technique utilised to sense a fire, activate an alarm and products of a fire or any combination thereof. Koffel (2016:33) denotes that balanced fire protection comprises of sprinklers, automatic fire detection and fire-resistance-rated construction. Some critics may not promote the concept of one of everything but rather support existing passive fire protection feature requirements due to the fact that the active fire protection feature is not 100% reliable.

Burns (2014:16) refers to fire protection systems as measures taken to prevent fires from becoming destructive, an attempt to reduce the impact of uncontrolled fire and saving the lives, infrastructure and property. Fire protection systems involves the fulfilment and execution of safety planning implementations, evacuation drills and education on fire, research, investigation, building construction, safe operations procedures, training of mitigating systems as well as testing of mitigating systems.

Burns (2014) also describes the three basic fundamentals of fire protection systems, namely:

- Study of fire – means the ability to learn the causes of fire, fire extinguishing techniques, detection system and extinguishing equipment as well as their uses, and building regulations.
- Active fire protection – refers to manual or automatic fire detection, which is the use of fire alarms, smoke alarms and firefighting.
- Passive fire protection – means the design of building and infrastructures which uses fire resistance material in construction, allocation of isolating fire, fire walls, fire doors, training of firefighters, fire signage, and evacuation of building in case of fire events.

In support of the above-mentioned, Hui (2013:15) defines fire protection systems as measures that may be employed to safeguard the exposed. This exposed is divided into two, namely:

a) Potential measures for “move the exposed” strategy:

- Fire detection system: a device designed to detect the presence of a fire signature and to initiate action.
- Fire alarm system: a system or portion of a combination system consisting of components and circuits arranged to monitor and annunciate the status of fire alarm or supervisory signal to initiate devices and the appropriate response to those signals.
- Fire-resistant elements: an element of building of material or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.
- Fire suppression system: controls and extinguishes fires without human intervention. Examples of automatic systems include fire sprinkler system, gaseous fire suppression and condensed aerosol fire suppression.
- Smoke management system: a system installed to resist the passage of smoke. The device is operated automatically, controlled by a smoke detection system and where required, is capable of being positioned from a fire command centre.
- Fire emergency management systems: protect the escape route, set up emergency control organisation and implement emergency procedures.
- Emergency lighting and exit signs.
- Intercommunication system: for communication between occupants and fire wardens or emergency services personnel.

b) Potential measures for “defend in place” strategy:

- Fire-resistant elements: an element of building material or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.
- Fire suppression system: controls and extinguished fires without human intervention. Examples of automatic systems include fire sprinkler system, gaseous fire suppression and condensed aerosol fire suppression.
- Smoke management system: a system installed to resist the passage of smoke. The device is operated automatically, controlled by a smoke detection system and where required, is capable of being positioned from a fire command centre.
- Emergency lighting: a battery-backed lighting device that switches on automatically when a building experiences a power outage. Emergency lights are standard in new commercial and high occupancy residential buildings.
- Intercommunication system: for communication between occupants and fire wardens or emergency services personnel.

Notwithstanding the manner in which authors have defined the fire protection systems as mentioned above, for the purpose of this research study and in the researcher's own understanding, the fire protection system means any system that is divided into two categories, namely: passive and active fire protection systems. These two terminologies are defined as follows:

Passive fire protection refers to the installation of firewalls and fire rated floor assemblies to form fire compartments intended to limit the spread of fire, high temperatures and smoke whereas active fire protection means manual and automatic detection and suppression of fires, such as Carbon dioxide (CO2) gas fire suppression systems and fire alarm systems, fire detection systems, telemetry equipment (electronic system), portable fire extinguishers and gas suppression systems, such as FM 200 fire suppression installation.

2.2.2 International standards for fire protection systems

Roach (2014:5) implies that fire protection in buildings as well as their residents comprises of different aspects and components. International Building Code’s (IBC) view components and unification of both passive and active fire protection to strengthen each other and to protect each other in case of failure of any one element. Once a fire has begun, its impact is swayed by the selection of combustible material and construction of the building, which impact the heat released and the path of the fire along the surfaces.

In IBC section 907 (National Fire Alarm) and Signalling Code address fire alarms (NFPA 72), it is stipulated that active fire protection in the form of fire alarms tends to activate first in order to give occupants the opportunity to evacuate safely and notify fire-fighters/responders first. Fire alarms need to be installed into the building classified for the occupational use which is suitable for the purpose of accommodating people. Building analysis elements and hazards will determine whether the best fire protection can be attained by ionisation/photo-electric smoke detectors, an air aspirating very early smoke detection equipment, or by heat and flame detectors, or optical detection methods.

In IBC Section 903 and NFPA 13: Standard for the installation of Sprinkler Systems, automatic fire sprinkler systems are addressed, and it is the most common form of active fire control and suppression system. Wet pipe sprinkler systems are the simplest and fastest method of fire control. Pipes filled with water are ready to immediately spray water upon the activation of one individual sprinkler nozzle, which activates due to increased temperature.

From a passive fire protection perspective, Roach (2014:7) has highlighted alternative methods of fire protection and further states that, in the IBC and the International Fire Code Section (IFC) 904, there are several listed alternate methods of fire protection. These include high-pressure water mist systems (fog) and clean agent gaseous suppression systems such as 3M Novec, 1230 Fire Protection Fluid and DuPont FM-200 Waterless Fire Suppression Systems, which act as coolants. The old Halon gas systems has been ceased in most areas of the world due to its effect on ozone layerv. The IFC Section 904 and NFPA Standards 16, 17, 2001 and 2010 address these alternate systems.

In buildings of a certain height or use with house stairwells and certain horizontal exits, standpipes are installed and serves as a system of piping while fire hose valves that serves as vertical sources of water for fire-fighting, and similarly to fire hydrants in the street. Fire responders can fill and supply standpipes with water (wet). If the standpipes are filled with water, then the operational pressure can be manual or automatically supplied by fire responders, usually by a fire pump. The IBC Section 905 and NFPA 14: Standard for the Installation of Standpipe and Hose Systems addresses the minimum required features necessary for standpipes.

The IBC Section 906 and NFPA 10: Standard for Portable Fire Extinguishers dictates the type and placement of handheld fire extinguishers for occupant use, depending on the hazards present in the building. Table 2.1 below represents all the important NFPA fire protection systems maintenance standards, namely:

Table: 2.1 Represents fire protection systems maintenance standards

System	Standards
Portable fire extinguishers	NFPA 10
Carbon dioxide fire extinguishing system	NFPA 12
Halon 1301 fire extinguishing system	NFPA 12 A
Dry chemical extinguishing systems	NFPA 17
Wet chemical extinguishing systems	NFPA 17 A
Water based fire protection systems	NFPA 25
Fire alarm system	NFPA 72
Water mist system	NFPA 750
Clean agent extinguishing systems	NFPA 2001

Source: Oregon Fire Code (2014:75)

Oregon (2014:76) states that, where a required fire protection is out of service, the Fire Department and the fire maintenance code official must be notified immediately and where required by the fire code official, the building must either be evacuated or an approved fire watch must be provided for all occupants left unprotected by the shutdown/maintenance, until the fire protection system has been returned to service. Oregon (2014) continues by explaining that records of all inspections, tests and maintenance required by referenced standards must be maintained on the premises for a minimum period of three years and must be copied to the fire code official upon request.

From a maintenance/shut-down perspective of fire protection systems, it is a norm in an AFB to perform the potential deviation analysis (PDA) prior to the shutdown of the fire protection systems. The Fire Department, together with Maintenance Department should have to plan accordingly and notify the fire brigade and chief prior to the approval of the shutdown, where all the contingency plans and standbys are clearly discussed during PDA meetings.

2.2.3 South African standards for fire protection systems

The SANS 10400 T (2011:46) states that the fire-fighting equipment and fire protection systems installations in a building must be maintained at all times so that they should be readily available for their purpose. The arrangement of the firefighting equipment and fire protection systems must be clearly visible or indicated by means of visible symbolic signage which conform to the requirements of South African National Standard as contemplated in SANS 1186-1.

Regulatory rules in SANS 10400 T (2011:46) further explain that firefighting hose reels installed in any building of two or more storeys in height or in a single-storey building of more than 250 m^2 in floor area, at a rate of one hose reel for every 500 m^2. This is provided that such hose reels shall not be required in any building categorised as H4 (detached dwelling house) or in any residential unit in an occupancy categorised as H3 (domestic residence), where each unit is equipped with unconnected admittance to ground level. This hose reel installed in such building must conform to the requirements of SANS 543, and must be fitted in conformity to SANS 10105-1 and SANS 10400-W as well as maintained in conformity to the requirements of SANS 1475-2.

Fire hydrants must be provided at a rate of not less than one per 1 000 m^2 of total floor area and not fewer than one per storey located in the firemen's lift lobby in such building or occupancy, or emergency stairway where no firemen's lift is provided, as the case might be and must be distributed in such a manner that the fire hose is installed. Fire hydrants must comply with the requirements set in the SANS 1128-1.

Only competent personnel are permitted to designed, installed and maintained automatic sprinkler fire-fighting system in compliance to SANS 306-4, SANS 10287, or SANS 14520-1, as appropriate and the automatic sprinkler fire-fighting system must be provided in any building that is greater than 30m in height, except where such building is exclusively of an occupancy categorised as H3 (domestic residence) where the division size is not greater than 500m^2 and as well as basement storey which surpass 500m^2 in floor area.

A building that contains occupancy must be equipped with portable fire extinguishers, and this portable fire extinguishers must not be obstructed by any foreign material, and must be approved by the local fire authority. Portable fire extinguishers installed in a building must conform to the requirements of SANS 1910. These portable fire extinguishers must also be installed, maintained and serviced by competent persons in conformity to SANS 1475-1 and SANS 10105-1. Table 2.2 below presents the fire protection systems maintenance standards for South-Africa, namely:

Table: 2.2 Represents fire protection systems maintenance standards

System	Standards
Portable fire extinguishers	SANS 10105-1
Carbon dioxide fire extinguishing system	SANS 1475-1 and SANS 10105-1
Halon 1301 fire extinguishing system	SANS 14520 / 246 / 322 / 306
Dry chemical extinguishing systems	SANS 1825, SANS 10460, SANS 6406
Wet chemical extinguishing systems	SANS 14520 / 246 / 322 / 306
Water based fire protection systems	SANS 306-4, SANS 10287, or SANS 14520-1
Fire alarm system	SANS 10139

Source: SANS 10400 T (2011), formulated by the researcher

The SANS 10400 T (2011:46) stipulates that the fire detection systems are utilised to explain any type of automatic sensor network and related control, and also indicating equipment. These sensors are detecting heat, smoke, gaseous combustion products and radiation. Usually, the control and indicating equipment operates a fire alarm system, and it may conduct other signalling or control functions as well. An automatic sprinkler systems can also be utilised to operate a fire alarm system.

The standard further explains that the factors which need to be taken into account when evaluating what standard of fire alarm, automatic fire detection or voice alarm or communication system is to be provided, will differ from each set of premises to the other. Therefore, the suitable and proper standard need to be considered on a case by case basis. Any fire-fighting equipment, installations and fire protection systems in any building must be so installed and maintained as per the standards stipulated above and must be readily available for their purposes at all times.

2.2.4 Importance of fire protection systems' in business management

Smith (2013:33) highlighted that for fire protection systems' to be effective, it is preferable for the management of fire safety to be under the control of a single person of sufficient seniority within the management structure so that there is little or no risk of issues becoming neglected through

communication problems. The standard of management of fire safety is likely to be poor if the role is undefined or unknown. It is also essential that, for the management of fire safety to be effective, the nominated person must be empowered to command sufficient resources to maintain the various fire safety systems, to enforce requirements, initiate testing, maintenance or repair and where necessary command staff.

Smith (2013) continues by stating that these selected persons responsible for routine administration of fire protection system within a building can and should play a major part in ensuring the continued safety and protection of the building and its occupants. Smith highlighted the following overview of the typical fire protection systems' management responsibilities which clearly shows the wide-ranging area of management of fire protection systems and how important it is for the continued effective operation of any fire safety and/or fire protection strategy:

- Ensuring an awareness of and maintaining a high standard of housekeeping.
- Being aware of all of the fire safety features provided and their purpose.
- Being aware of any particular risks on the premises. For example, issues relating to hot work or unusual construction materials such as sandwich panels.
- Being aware of responsibilities towards disabled people.
- Ensuring that all necessary and appropriate communication systems are in place to deal with any fire incident.

Whatever basic life safety strategy is established, those responsible for the management of fire protection systems in buildings have an important role and their tasks in planning for an evacuation include (Smith, 2013):

- developing and maintaining emergency plans, including evacuation plans, victim help and emergency accommodation plans;
- planning for bad weather, including evacuation into hostile weather conditions; and
- plans for the mitigation of potential environmental impacts of fire, for example water run-off.

Siemens (2015:4-6) specifies that safe data centres are the indispensable backbone of today's highly engineered society. They are processing an ever-increasing quantity of videos, voice and data throughout a global network of several billion devices. Applications such as social media, cloud computing, online banking and e-healthcare solutions impact our life every day. In today's world, no one can afford not to be connected. Failure of the internal data centre or of the vital data centre which serves the general public, poses a significant problem within a short time.

Therefore, the most important objective in a data centre is maximum availability (99.995% per year). It is thus understood that data centres have to be designed, implemented and operated in such a way that a high level of availability can be guaranteed, even in case of a fire. High availability can only be achieved if all relevant influencing factors are planned, implemented and put into effect in the company in a coordinated and consistent way.

For maximum protection, a comprehensive fire protection system is needed to ensure business continuity, personal safety and damage mitigation in case of fire. The cornerstones of such a system are a fire detection system that guarantees earliest and most reliable fire detection in a highly ventilated area and that activates the alarming devices, the relevant fire safety controls and appropriate response measures.

2.2.5 The fire protection systems in an Air Force Base in South Africa

Bind (2007:30) states that the forestry plantations around Mbombela (formerly known as Nelspruit) and in the Barberton valley are high risk areas when it comes to fire sensitive areas. Recent fires in the area enabled ground and air firefighters support, but were becoming overwhelmed, and of which extra support was needed. In the afternoon, two Oryx and one A-109 got an airborne from the AFB Hoedspruit to help out where required.

South African Air Force described the Oryx as a multi-role helicopter. Its main uses in the South African Air Force are: medium to heavy transport and communications flights, task force rapid deployment operations, firefighting and search & rescue missions. It can carry up to 20 fully equipped troops, or 6 wounded on stretchers with 4 attendants, or 3,000 kg freight carried in the cabin, or 4,500 kg freight on an external sling (Martin, 2016:64).

On the arrival at the Mbombela airfield Fire Department head office, the briefing was held and each team was assigned to its fire. Normally, a team consists of a spotter aircraft which evaluate the fire from higher level, and decide on which part of the fire he/she should drop water. Rest of the team, comprises of one or many helicopters equipped with Bambi buckets. These Bambi buckets are made out of a thick plastic canvas type, which is fire resistant material that could hold up to 2000 litres of water.

Wingrin (2017:1) asserted that January 2017 was a challenging month for the South African Air Force (SAAF) Cape-based 22 Squadron as they had been called into battle for numerous mountain fires. The first week of 2016 saw fires raging around Somerset West and Grabouw,

causing damage of over R50 million with seven houses and other dwellings gutted. On 6 January 2017, winds swept fires closer to the historic Lourensford Estate wine farm.

Jonker (2017:2) states that each fire is different and that they operate in a very dynamic environment. Generally, a Landing Zone (LZ) is identified and a fuel bowser is sent from AFB Ysterplaat to provide fuel on site. Each helicopter will deploy with two Bambi buckets. The aircraft lands at the LZ, the buckets are fitted (often with rotors turning) and they then head straight out to fight the fire. Each crew operates a six-hour shift, which includes refuelling and other breaks.

The Western Provincial Local Government, Environmental Affairs and Development Planning Minister (Anton Bredell) agrees that the SAAF is performing a sterling job. “We are grateful to the SAAF and the Minister of Defence for their assistance. The Oryx helicopters are much larger and able to deliver a bigger payload compared to the helicopters we usually rely on. We know the SAAF assistance will make a huge difference.”

Mrs Helen Zille (Premier of the Western Cape, South Africa) commended those Western Cape residents and all the firefighters, professionals from all five District Municipalities, Local Municipalities and City of Cape Town, the staff from Cape Nature, SANPARKS and the Working-on-Fire Program (State of Provincial Address, 2017). Zille continued by acknowledging the efforts of members of the Fire Protection Associations, Volunteer Wildfire Services and private contractor teams. Pilots from the South African Air Force and the private sector also contributed greatly, as did the South African Defence Force Joint Operations Centre, and the National Disaster Management Centre.

2.2.6 Challenges experienced with fire protection systems in South Africa

Strydom and Savage (2016:83) state that the mountainous areas of KwaZulu-Natal, Mpumalanga and the Western Cape Province have the highest frequency of fire. South-western areas of South Africa (winter-rainfall regions) encountered higher fire incidents throughout the summer seasons while other parts of the country occurs in winter seasons. Strydom and Savage (2016) further explain that certain areas of the country that encountered bimodal rainfall months, did not indicate clearly the fire months due to the complexity of wet and dry seasons. The effect of weather changes in South African fire occurrence disclose that increased air temperatures and occurrence of La Niña has got an effect on fire activities.

Fire will always remain a nature and essential occurrence in an environmental routines. However, due to an increase brought on through anthropogenic activities, fires are having a negative

influence on the environment systems, on society and the economy. The likelihood of an accident fulfilling the requirements to be classified as a disaster is increasing as a result of increased population densities and increased settlement in high-risk area (Strydom & Savage, 2016).

Fire disasters are of great concern in South Africa and one can conclude that these disasters are going to increase. A large percentage of South Africa's population is located in rural areas, where they are often housed in close quarters, which allows fires to spread rapidly through housing structures. These rural areas are also generally situated in fire-prone regions of the country, making them vulnerable to fires. The South African *National Veld and Forest Fire Act of 1998(Act 101 of 1998)* specifies the prevention of wildfires through the implementation of a National Fire Danger Rating System under the responsibility of the Department of Water Affairs and Forestry.

The National Fire Danger Rating System is currently operational and is being used by the South African Weather Service and other interested parties to mitigate wildfire outbreaks. Under this specific Act, fire protection systems are considered the responsibility of the landowner and lack of regional coordination is visible. While regional coordination is lacking, a number of regional fire prevention or protection agencies has been established. These agencies comprise of mostly private landowners and agro-forestry managers working as umbrella for fire protection associations. The *National Veld and Forest Fire Act of 1998* promotes the formation of these regional fire protection associations and requires all landowners to be members of local fire protection associations but coordination between different fire protection associations is minimal.

2.3 MAINTENANCE STRATEGY

Alsyouf (2011:70) asserts that the maintenance strategy is a combination of approach and policies which depends on numerous factors, namely:

- nature of the plant,
- maintenance goals
- equipment to be maintained,
- product or process focus.

Alsyouf (2011:72) further states that researching, performing of many inspection, as well as repairs and replacement decisions are required in the maintenance strategy. The maintenance strategy describes events that triggers the category of maintenance schedule. The main perturb is all about constructing the facility's favourable maintenance action, and also the best life-plan

for each unit of the facility which should be done in conjunction with operation and other affected functions.

If maintenance strategy well defined, and it is known to all employees and managerial members, then new and existing problems will be resolved. If the maintenance strategy is not in place, then measurable time will be attained from developing and defining a maintenance strategy, communicating it and lastly focusing on the tactical choices for how to achieve it. Tactics are the actual activities needed to implement the strategy, which concern the management of processes, people and physical asset infrastructure (Campbell & Reyes-Picknell, 2006).

Salonen (2011:78) conducted a research where the business companies' overview on the maintenance strategy was explored. Six Organisations were involved in the research, and four of the companies did not have maintenance strategy, nor did they use measures relevant for maintenance control. Salonen (2011:86) also presented the second case study where stakeholder involvement in one company was tested. In conclusion from the study, was that stakeholder involvement might lead to a unknown view on the Maintenance Department's expected deliveries to the Production Department, which might contribute to higher cooperation between these two departments. Table 2.3 below represents different maintenance strategies that can be adopted by any industry or organisation.

Table 2.3: Represents different maintenance strategies

Corrective	Preventive		
Run-to-fail	Predetermined	Predictive	
Maintenance approaches			
Fix when it breaks	Scheduled maintenance	Condition based maintenance diagnostics	Condition based maintenance prognostics
No scheduled maintenance	Maintenance based on a fixed time schedule	Maintenance based on current condition	Maintenance based on forecasting of remaining equipment life
	Intolerable failure effect and possibility of preventing the failure effect	Maintenance scheduled based on evidence of needs	Maintenance need is projected as probable within mission time
	Based on the useful life of the component forecasted during design and updated through experience	Continuous collection of condition monitoring data	Forecasting of remaining equipment life based on actual stress loading
	Failure mechanism is time based, age or usage	Gradual degradation from the onset of failure	Gradual degradation from the onset of failure

Source: (extracted from Turki *et al*., 2014:17)

A maintenance strategy is categorised into three various kinds or techniques, namely: preventive, corrective and predictive (Prajapati *et al.,* 2012:392). According to Razak *et al.* (2012), echoes the opinion that the accomplishment of the maintenance purpose is through the application of maintenance methods or techniques for a machine or equipment.

These maintenance strategies are described as follows:

a) Corrective maintenance –Sharma *et al.* (2011) explain this maintenance strategy as reactive, failure-driven and unscheduled maintenance techniques where repairs of the apparatus are conducted after failure or fault has prevailed. Sharma *et al.* also refers to this strategy as breakdown based, failure based, run to failure and unplanned maintenance strategy.

b) Predictive maintenance – According to Srivastava and Mondal (2013:13) predictive maintenance, the operational specifications of the apparatus are monitored and equated to programmed operational standards and requirements. This strategy is recognised as condition based maintenance.

c) Preventive maintenance – This refers to proactive or planned maintenance technique. Srivastava and Mondal (2013:13) that under this preventive implies maintenance strategy, the machines/apparatus are repaired and refurbished as per planned intervals and periodical intervals which are programmed and organised in order to keep the machine in good operating condition and to prevent failure or fault of machine. Salonen and Bengtsson (2011) argue that the maintenance expenses due to preventive maintenance strategy are normally less than or almost identical expenses to that of corrective maintenance strategy.

2.3.1 Defining maintenance strategy concepts and definitions

According to Salonen and Bengtsson (2011:337) various authors interpret maintenance correlated terms exchangeable and distinctly. It is usual in the maintenance management literature to pinpoint expressions such as maintenance concepts and maintenance strategies in an effort to describe maintenance management terms. Gebauer *et al.* (2008:941) refers to total productive maintenance (TPM) and reliability centred maintenance (RCM) as maintenance strategies while Salonen and Bengtsson (2011:338) view total productive maintenance and reliability centred maintenance as maintenance terminologies.

Although the process in which various writers uses distinct maintenance concepts, for the purpose of this study the above mentioned terminology and terms such as *maintenance strategy* and *maintenance concept* are defined as follows:

a) **Maintenance strategy.** According to Lind and Muyingo (2012:18) maintenance strategy is defined as a long-term plan which involve maintenance management principles and a course of action for fulfilling favourable or effective maintenance. The different element of an optimal maintenance strategy is the usage of more than one maintenance technique or method for a single piece of apparatus or machinery, taking into account the criticality and financial costs implicated through failure of such equipment.

b) **Maintenance concepts**. According to Lind and Muyingo (2012:18) maintenance concept is defined as *an* integration of maintenance method and techniques, i.e., corrective, preventive and predictive maintenance. Furthermore the holistic structure which integrate these maintenance techniques is also known as maintenance concepts. According to Salonen (2011:26) maintenance concepts are broaden to reinforce/strengthen the effectiveness of maintenance process as well as to realm maintenance activities in a manufacturing organisation. Naughton *et al.* (2013:290), view maintenance concepts differ from each machine to the other, and Reliability centred maintenance (RCM) being a typical example of a maintenance concept.

Notwithstanding the manner in which authors have defined the maintenance strategies concepts as mentioned above, for the purpose of this research study, in the author's own understanding, maintenance strategies means the maintenance classifications and approaches that are divided into three categories, namely corrective, predictive and preventive. These three terminologies are defined as follows:

- **Corrective maintenance strategy** means a maintenance task performed to identify, isolate and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.
- **Predictive maintenance strategy** means techniques that are designed to help determine the condition of in-service equipment in order to predict when maintenance should be performed.
- **Preventative/ preventive maintenance strategy** is a maintenance strategy that is regularly performed on a piece of equipment to lessen the likelihood of it failing. Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.

2.3.2 International views on the importance of maintenance strategy

Amit *et al.* (2014:175) attest that maintenance is becoming a critical functional area in most types of organisations and systems including construction, manufacturing, transportation, etc. It is becoming a major function that effects and is being affected by many other functional areas such

as production, quality, inventory, marketing and human resources. Maintenance is one of those policies which production industries, with continuous arrangements, are using to increase production and to decrease costs and also to stay in the circle of global competition.

Amit *et al.* (2014) further continue by stating that there is an increasing trend among manufacturing organisations to recognise the maintenance of assets and machines as an essential part of the operations function, while realising that an effective maintenance strategy can contribute significantly to the production activities. The globalisation and the fluctuation of the markets challenge all industries to be effective in designing their products, efficient in their manufacturing process, reliable in delivering their products and to pursue customer satisfaction during their products usage lifecycle phase.

Chandrahas and Mahapatra (2015:256) acknowledge that, in last few decades, research has been done all over the world on maintenance strategy selections. The research work is about the selection of a maintenance strategy in a plant which is still in construction phase. Possible alternatives are considered preventive, condition based, corrective and opportunistic maintenance.

Baglee *et al.* (2015:3) implies that effective use of leading edge information and communication technologies (ICT) is seen as important and possibly critical to the future competitiveness of the European Industry. In particular, manufacturing organisations are frequently characterised by high staff turnover, a lack of knowledge and training and a lack of appropriate asset management strategies. This has resulted in poor manufacturing efficiency and large amounts of waste. The implementation of a structured maintenance strategy has made the development of ICT including software and hardware systems possible.

According to Malgorzata (2016:49), many organisations are pursuing to earn competitive advantage (CA) with regards to the following variables, namely: cost, quality, service and on-time deliveries. The effect of maintenance on the said or abovementioned variables has urged an increased attention to the study of maintenance strategy as an essential stance of continuous production improvement. Maintenance strategy means a form of guidance and essential tool to the maintenance department in order to attain quality, efficiency and effectiveness in performing its mission and vision responsibilities.

Industries are aiming to gain more CA with regards to cost effective, quality, service and on-time deliveries. The effect of maintenance on the said or mentioned variables has urged an increased attention to maintenance as an underlying part of a continuous production improvement.

European standards acknowledge maintenance strategy as well as all the activities of the maintenance management that determine the maintenance intentions, priorities and responsibilities as well as execute them by means of maintenance planning, maintenance control, overseeing and other several approaches improving (Malgorzata, 2016:52).

2.3.3 South African views on the importance of maintenance strategy

While the importance of the provision of infrastructure to support socio-economic growth has to date been well-recognised within Government, the potential of infrastructure maintenance as a powerful tool of economic growth and service delivery needs to come more to the fore. Infrastructure maintenance strategy must be regarded as a strategic tool to promote improved service delivery, to unlock funding to extend infrastructure to historically disadvantaged communities and to support the nation's economy. Maintenance of existing infrastructure should not be seen as of secondary importance to the apparently more attractive prospect of new infrastructure (Cidb, 2007:5).

According to Wall (2008:68), the National Infrastructure Maintenance Strategy was approved by cabinet in 2006. This strategy sets overarching policies for sector based initiatives and describes the framework for a coordinated programme or actions. Simultaneous infrastructure investment and maintenance that will result from this strategy will not only improve infrastructure performance and underpin services sustainability, but will also contribute significantly towards national and local economic growth and will add long-term jobs.

According to Sunjka and Murphy (2014:59), South Africa is progressively becoming an important zonal/state focal point for maintenance of aircraft operators flying in sub-Saharan Africa. South Africa is known to be a home for more than 70% of aviation activities in the Southern African Development Community (SADC) area, and its share of the area’s aircraft has shown an expansion from 68% to 80% in an interval of 1997 to 2007 (IATA, 2011). However, South African aircraft maintenance organisations (AMOs), are faced with an increasingly competition from other countries such as Middle East, Far East and within Africa.

In the event of global competition increasing, it is in the trading attraction of South African aircraft maintenance organisations to improve on their existing aircraft maintenance infrastructure in order to champion and subjugate a larger share of the growth in an African horizon and global aircraft maintenance organisation market. In response to growing competitive rivalry, aircraft maintenance organisations in Europe has established the need of lean fundamental proposition

from management level to the shop floor in a coordinated effort in order to remain competitive in a changing environmental marketplace.

Simoes *et al.* (2011: 283) state that there is general consensus on the part of different authors, that in the asset-intensive manufacturing plants, maintenance is usually the highest cost in the operational allocation. Various scholars pretended that in manufacturing plants, maintenance strategy spending is a percentage of manufacturing operational expenses and that these differ from plant to plant, for instance. The following is a logic behind their purport percentages:

- Razak et al. (2012:25) : 15 % - 40 %
- Zaim et al. (2012:17) : 15 % – 70 %
- Visser and Kotzé (2010)**South African** manufacturing industries : 20% - 50%

Adamu *et al.* (2016:4) assert that maintenance management strategies have evolves from a single technical operational function to a multi-functional operation that include key management units such as strategic and operations administrations of an organisation. Accordingly, strategic management plays an essential role in the strategic maintenance methods.

The Department of Public Works (2010:2) highlighted that its vision is that infrastructure is adequately maintained and operated, resulting in sustained service delivery, growth and employment creation, thus contributing to the goals of Accelerated and Shared Growth Initiative for South Africa (ASGISA) and the Expanded Public Works Programme (EPWP). This will be achieved by improved infrastructure asset management planning, budgeting and implementation**.** The Department of Public Works (2010) asserts that the following are four steps of the National Infrastructure Maintenance Strategy, of which the implementation will lead to the achievement of this vision:

- Strengthening the regulatory framework governing planning and budgeting for infrastructure maintenance.
- Assisting institutions with non-financial resources.
- Developing the maintenance industry.
- Strengthening monitoring, evaluation and reporting and feeding this into a process of continuous improvement**.**

2.3.4 Maintenance strategy of the Air Force Base sector

The South African National Defence Force (SANDF) is tasked with a large number of responsibilities, such as border protection, anti-piracy patrols, disaster relief and peacekeeping. However, large portions of its defence equipment are either old, obsolete or in short supply, which greatly affects the SANDF's ability to meet its mandate. Reports emerged that the majority of the South African Air Force's (SAAF's) C-130 Hercules transports are grounded due to maintenance problems (Martin, 2016: 64). Maintenance is one of many issues facing the SAAF and with the budget being tight, this is not going to get better any time soon (Martin, 2016:64).

Martin (2016) further continues by stating that the SAAF's maintenance strategy, repair and overhaul capabilities were hit hard by the 2013 cancellation of the Denel Aero Manpower Group (AMG) maintenance contract. This saw hundreds of skilled technicians being retrenched, as the contract was declared irregular by the Auditor General. Of the 530 technicians employed under the contract, 140 were retained to train their replacements but the last were laid off in April 2017, forcing the SAAF to outsource a lot of their air force base maintenance work.

The biggest threat facing the SAAF is not just a lack of maintenance and serviceable airframes, but a lack of funding in general. The department of Treasury allocated the Air Defence component of the South African National Defence Force R6.883 billion for the 2016/17 financial year, which is R284 million less than the previous financial cycle (Martin, 2016).

According to Astra (2009:6), the top management of the South African Air Force Base set objectives to implement the Total Quality Management (TQM) philosophy supported by European Foundation for Quality Management Model (EFQM). The two standards were complimented by the Major General since they were used in conjunction with their maintenance strategy which were benefitting the AFB.

Dotzla (2010:13) highlighted that each maintenance process has got its own distinctive control and process technique. One specific particular maintenance strategy can be in control of a given maintenance process while an integration of strategies is more typical. Dotzla further classified maintenance strategies as reactive maintenance, preventive maintenance and predictive maintenance as well as reliability centred maintenance.

2.3.5 Importance of maintenance strategy in business strategy

Baglee and Knowles (2010:276) state that recently there has been an increase in paying much attention to the importance of maintenance inside the business fields/section, and this occurs as

a result of increasing pressure upon organisation in order to improve equipment availability and performance. According to Chan *et al.* (2005:333) it is increasingly becoming more inconvenient to disregard maintenance as an organisations. Nowadays organisations are considering maintenance as a fundamental section or department of their business. However, current trends has demonstrated that in general, many manufacturing processes are not functioning as intended, insofar as cost effectiveness in terms of their operation and support is concerned.

Most organisations are now changing their obsolete maintenance strategies with proactive new strategies such as preventative and predictive maintenance as well as total productive maintenance (Baglee & Knowles, 2010:279). Furthermore, Baglee and Knowles continue in stating that, presently maintenance executions have allowed companies to strategically direct their resources to the maintenance tasks that are regarded as critical to the effectiveness and efficient operating of their equipment.

For an example, the South African Air Force (SAAF) is now considering the maintenance strategy of its bases very crucial. Currently the R35m budget allocated to Hoedspruit Air Force Base in the Limpopo Province proves the commitment from the SAAF. The budget will be pumped into the preventative maintenance strategy that is going to enhance the operational system of the fire protection systems as discussed in detail in Chapter 1 of this study.

Baglee and Knowles (2010:281) state that the introduction of total productive maintenance (TPM) within the manufacturing organisation, a number of organisations have declared improvements in machinery availability, reliability and a reduction in maintenance expenses. They also explained the advantage of total productive maintenance (TPM) as an increased product quality, equipment availability and a reduction in operational expenses. Accordingly, production processes now need to be improved in line with current trends of conducting business with minimum unforeseen disturbances.

Ben-Daya *et al.* (2009: 66) state that measuring the maintenance production performance is critical for any production and operational organisation, consequently, a commonly measure used by companies is the maintenance strategy performance for measuring the maintenance productivity. Publications indicated that performance measurement has captured the imagination and involvement of researchers and management from the companies since the nineteenths (Kumar et al., 2014).

According to Ben-Daya *et al.* (2009:88), operational assessment is a means to gauge the implementation of strategies and policies of the management of the organisation, which are the

characteristics of maintenance performance measurement. Maintenance performance measurement permits organisations to comprehend the worthiness generated by maintenance, to re-evaluate and revise their maintenance policies and approaches, to justify investment in new trends and methods, to revise resource allocations and to understand the effects of maintenance on other functions and stakeholders as well as on health and safety.

Kumar et al. (2014:194) stipulated that an essential aspect of maintenance performance measurement is the formulation of maintenance performance indicators, linking maintenance strategies with overall organisational strategy. Notwithstanding the overwhelming advantage gained through effective performance measurement and management and the fact that organisations are using integrated balanced performance management systems tend to outperform their counterparts. Simoes *et al.* (2011:123) imply that only one–third of the companies with good maintenance management policies leaned to realise the full gains of their maintenance management initiatives.

Alsyouf (2011) elaborates that the necessity for maintenance management to obtain appropriate formal educational training, which incorporates the various aspects of their organisational duties, is becoming more important, as maintenance managers are being called upon to combine and direct the maintenance efforts to meet organisational strategic goals efficiently and effectively.

To support the above-mentioned statements in line with this study, the AFB has appointed its high official ranking as maintenance officer for their Maintenance Department, for example the Major (HJ Van Staden) who is in charge of the Hoedspruit Air Force Base Maintenance Department (refer to Appendix 1, letter of study approval from the AFB). The Maintenance Department is linked with the Operational Department where the fire brigade is in charge and always in liaison with the maintenance sections regarding any fire protection systems.

2.3.6 Functions of maintenance strategy in business strategy

Muchiri and Pintelon (2008:3520) have summarised the maintenance objectives in five categories, namely:

- Ensures that the plant functional, that is availability, reliability and product quality.
- Ensures that the plant achieves its design life span
- Ensures that the plant and environmental is always safe
- Ensures cost effectiveness in maintenance
- Ensures effective use of resources such as energy and raw materials.

Muchiri and Pintelon (2008) continue by stating that, once the maintenance objectives are outlined, maintenance strategy formulation is necessary to help decide which type of maintenance needs to be done, when to do it and how often it can be done. It is a norm and the attentiveness of asset management to know the relationship between the input and the outcome of the maintenance strategy with regards to total contribution to business strategic intentions (Chattopadhyay, 2007:241).

Chattopadhyay (2007) further asserts that the maintenance role would emphasise the maintenance execution that should be exercised by the employees within the organisation. The formal success of the output can be raised by involving the most proactive maintenance application in the maintenance role and by continuing to practice it on the work floor. This leads toward to the essential of the identification of an effective maintenance role for any applied productivity improvement strategy and for its further existence.

Muchiri *et al.* (2008:3523) state that once the maintenance intentions and strategies have been instituted, the prosperity of the maintenance role is lies on the maintenance work management. Consequently, another point of view of looking at the maintenance performance is not only to maintain but also to strengthen the systems or the plant operational system as a result of turnaround planning.

Sawang (2011:23) has initiated a framework for defining the key performance indicator for managing the maintenance function based on physical asset management needs and asset reliability operations. Key performance indicators assist an organisation to define and measure progress toward organisational objectives and quantifiable measurements to determine the continuous improvement in conducting an innovation and implementing activity that is critical to the prosperous of a business entity.

Adamu *et al.* (2016:6) state that strategic management refers to a system that needs the input of top executive managers' examinations of the environment in which the company operates before the formulation of a strategy and control of the strategy as well as the plan for implementation. Strategic management is owned and controlled by executive management, and its main role with regards to maintenance management is the designing of maintenance policies that guide maintenance managers in preparing schedules and selection of maintenance strategy.

Adamu further continues in stating that strategic maintenance management is a world class maintenance management approach utilised by many organisations in order to optimise the valuable assets such as built infrastructures. The maintenance process is considered as cost

efficient which enables focus on resource management for best return on investment, and always avoids intrusive maintenance. Maintenance process also adapts performance evaluation techniques which produces results that assist in strategic planning in order to improve maintenance strategies.

2.4 SUMMARY

This chapter sufficed to emphasise the theoretical parts and outlook of fire protection systems and maintenance strategy in the environment of an Air Force Base. Consistently with the intentions of the research, fire protection systems' theoretical exposure were: defining fire protection systems, international standards for fire protections systems, South African standards for fire protection systems, the importance of fire protection systems in business management, fire protection systems in AFB in South Africa and challenges of fire protection systems in South Africa.

Maintenance theoretical aspects deliberated on were: maintenance strategy, defining maintenance strategy, international views/importance of maintenance strategy, South African views/importance of maintenance strategy, the maintenance strategy of an airport AFB sector, the importance of maintenance strategy in business strategy, and function maintenance strategy in business strategy.

The following chapter details and reinforces on the widening the study methodology embraced for this research and also presents the results and a discussion of the empirical study. The following chapter will also examines at the theoretical frameworks and models as well as the best applications in the maintenance strategy of fire protection field.

CHAPTER 3

RESULTS AND DISCUSSION OF THE EMPIRICAL STUDY

3.1 INTRODUCTION

This chapter act as clarification of the study methodology employed during the implementation of the research, designated: *Evaluating the Fire Protection Systems' Maintenance Strategy of an Air Force Base in the Limpopo Province*. Furthermore, the purpose of this chapter is to present, discuss and interpret the results obtained from the empirical study.

The empirical study was conducted by means of one-on-one interviews with semi-structured questions to get the opinions of Air Force Base (AFB) employees in the Limpopo Province. A template sample of the semi-structured interview questions is presented in Appendix A and B.

This chapter present an awareness into the approaches and procedures that were followed to determine the following, namely: sampling method and size, study population, semi-structured questions interview formulation, data collection, data analysis, and demographic formulation of the sample group, presentation and explanation of the researched results.

3.1.1 Aim and objectives of the study

The main objective of this research study was to assess the fire protection systems' maintenance strategy of an Air Force Base in the Limpopo Province and to understand the impact of maintenance on the fire protection systems with particular reference to the AFB maintenance strategy. Additionally, the study sorked toward providing recommendations on how to optimise and improve the fire protection systems. The objectives of this research were broken down into five secondary objectives, namely:

- to stress the importance that maintenance strategies have on fire protection systems;
- to identify barriers in the maintenance strategies of an AFB in maintaining their fire protection systems;
- to examine the effect that a planned implementation maintenance program (PIMP) has on the fire protection systems of an AFB;
- to achieve more insight into maintenance strategy through conducting a literature review; and
- to draw a conclusion from the empirical study and provide recommendations on how to execute a planned implementation maintenance program (PIMP).

3.2 RESEARCH METHODS

This section provides a detailed overview of the different study strategies and procedures that were followed during the gathering of relevant information to best satisfy the research study objectives. Except the study strategies, the various selections made by the researcher and how the data was collected are explained below. The chapters' goal is to create the possibility for the reader to critically analyse and review the logical process and selections made for this study. Lastly, the reliability and validity of this research complete the research method part.

3.2.1 Research design

Exploratory, descriptive and causal (explanatory) researches are the three main classes of research design (Ghauri & Grønhaug, 2010:56). This study focused on exploratory research. Ghauri & Grønhaug (2010) states that, when the research problem statement is incorrectly understood, a more or less exploratory research design will be sufficient. This study suits the criteria mentioned above, and accordingly a qualitative, exploratory research approach was chosen.

After considering the verbal data dimension varying from structured to unstructured questionnaires, an open-ended, semi-structured approach was the choice of selection, using just a few key open questions. Open questioning has an advantage of allowing the Interviewer a privilege and extemporaneity of responses and allows the interviewer an opportunity to scrutinise further. Consequently, Oppenheim (2000) explain that open questions are time-consuming to analyse, and cost an interviewer a lot time to conduct it and also demand more effort from the respondents.

For this qualitative study, approved by the Air Force Base in Limpopo's Major, H.J van Staden (refer to Appendix C), semi-structured in-depth interviews were conducted. The interview questions were formulated by the author to attain the best results in order to analyse and answer the stated study objectives. The semi-structured questionnaire used in this study is listed in Appendix A.

3.2.2 Construction of a semi-structured interview

Ghauri and Grønhaug (2010: 58), considered interviews as the best data gathering approach for research projects. In this research, the semi-structured interview method was used. Saunders *et al.* (2009:320) stated that semi-structured technique can be explained as a method where the topics are covered and the sample size, respondents to be interviewed and questions to be asked

are determined prior. With open-ended questions, the interviewees can be more specific and provide accurate responses.

Furthermore, during an interview, follow up questions could come out and the interviewer could ask for additional elaboration of attitudes and responses. The reason for using the interview approach to gather data is that the interview questionnaires are open and basically all the answers differ. Furthermore, the direct contact with the AFB and the face-to-face conversations provide more information in the end. In the opinion of the researcher, a survey or questionnaire would provide less information. Usually, the response rate is always less than five percent hence the reason to carry out the interviews face to face and not via e-mails is very important.

Specialists of the AFB with positions in the field of maintenance and operations were chosen for the interviews to get access to the highest possible knowledge. The five interviews were conducted in meeting rooms of the AFB and all of them were recorded. The interviews consisted of 10 questions and were approximately 10-20 minutes long (refer to Appendix A for details). The researcher would have prized to conduct more interviews to gain access to even more information but realised that there would be repetition. Refer to Appendix A and B for detailed semi-structured interview questions and AFB interviewees.

3.2.3 Study population and sampling

Purposive sampling is the technique employed in this qualitative research study. With a purposive non-random sample, the number of people interviewed is less important than the criteria used to select them. The characteristics of individuals are used as the basis of selection, most often chosen to reflect the diversity and breadth of the sample population (Bell *et al.*, 2015:186).

A sample of two Operations employees and three Maintenance Department employees (sample total of five) was selected for the empirical study, since these two various departments' workers will affect prosperous execution of maintenance strategy. All the interviewees were purposively selected from the workers list of these two departments.

3.2.4 Data collection

There are two types of data sources which are equally important for any research study, namely primary and secondary data. According to Spens and Kovacs (2006), primary data is requested from study respondents whilst secondary data is requested from sources which area is already in the existence, and these sources are journals and publications. Leedy and Ormrod (2005) states

that it is of essential importance for the study to have enough data for analysis and interpretation, as this ensures that correct conclusions are designed from the study.

For the intentions and motives of this study, the tool utilised for primary data gathering was the semi-structured questionnaire interviews conducted one-on-one with AFB Maintenance and Operations Departments' employees at the work place. After a rigorous five months of data gathering with a good/high response rate, the structured questions interviews were carried out successfully.

The semi-structured questions were extracted after an in-depth literature study. The interviews were successfully conducted with all respondents who are currently working at the Maintenance and Operations Department of the AFB, which means five respondents participated in the interview. The interviews lasted approximately 2.5 hours. All interviews were recorded and transcribed and their accuracy was verified by going through the questions and answers with respondents. Figure 3.1 below indicates the data gathering approaches exhibited and provides an overview of what type of primary and secondary sources exist.

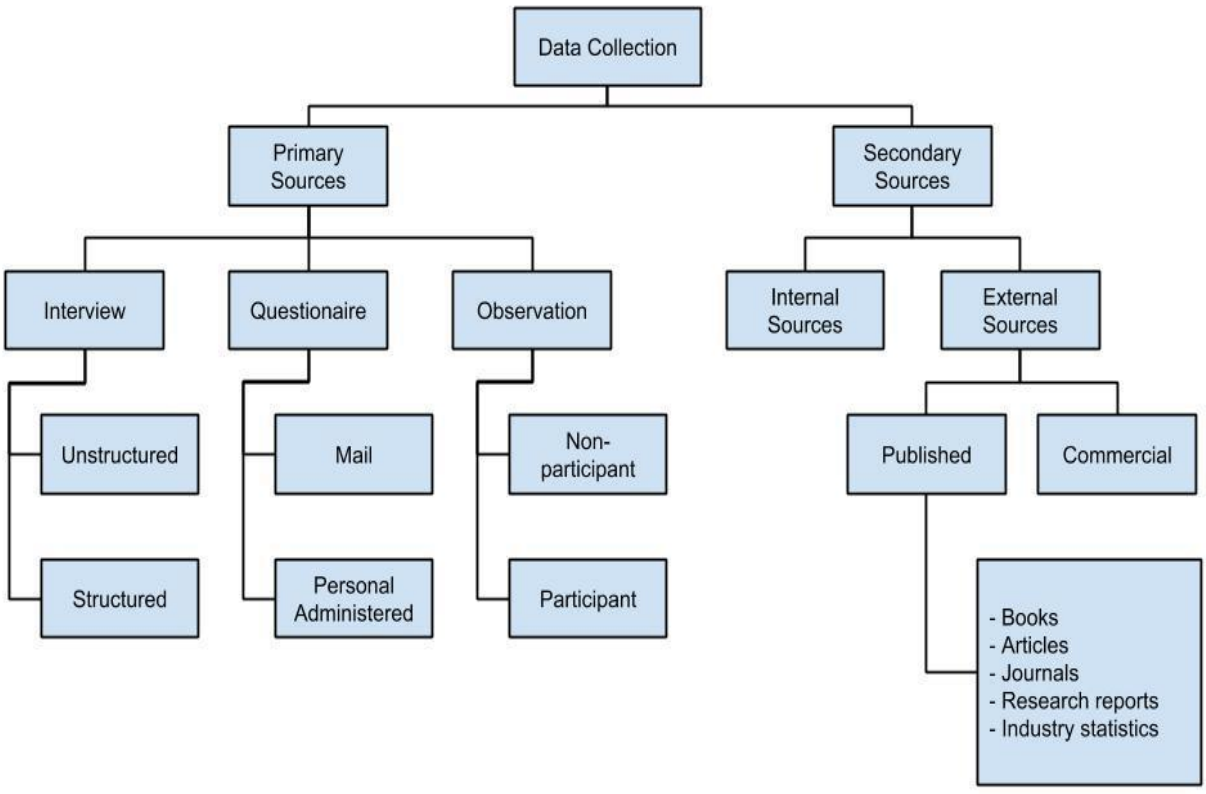

Figure 3.1: Data collection method (Ghauri & Grønhaug, 2010: 63)

To obtain the target goal of fulfilling the study objectives, this study used both primary and secondary sources as contemplated in figure 3.1 above. To prove and compare the findings of the gained information through interviews, the secondary sources were used.

3.2.5 Statistical analysis of data

According to Piercy (2011:1), in a semi-structured interview, the researcher asks a series of open-ended questions, with accompanying queries that probe for more detailed and contextual data. Respondents' answers provide rich, in-depth information that helps us to understand the unique and shared aspects of lives and meanings attributed to lived experiences. With these data, the five-step method of data analysis developed by McCracken for long interviews was used.

The analysis of the data was conducted without using statistical analysis tools. The following steps were used to analyse the qualitative data:

Step 1 – Describes respondents according to their qualifications and experience concerning the study.

Step 2 – Lists semi-structured questions with reference to the literature.

Step 3 – Transcribes respondent's reply to each question word for word.

Step 4 – Interprets their responses and strengthens it with reference to literature resources.

Step 5 – Highlights all responses in one paragraph after every question has been transcribed.

3.3 DEMOGRAPHIC INFORMATION OF RESPONDENTS

The target population of this research study comprises of people who are currently employed at Air Force Base specialising in maintenance and fire protection services, located/situated in Limpopo. This group equates to a total of five employees. These employees are from all hierarchical levels and their routine works/jobs are directly or indirectly affected by the maintenance and operational duties of fire protection systems. The target population included section managers, supervisors, technicians, maintenance artisans and Fire Department operators.

3.3.1 Gender classification of respondents

General information 1 – Gender. The purpose of this question was to determine the gender of the respondents. Table 3.1 below represents the gender distribution of the specific population.

Table: 3.1 Represents Gender distribution of respondents

Gender	Frequency	Percentage
Female	0	0%
Male	5	100%
Total	**5**	**100%**

From the data presented in Table 3.1 above, it becomes clear that no females (0%) participated in this study, compared to five males (100%). From the Air Force perspective, it is understandable that few or no females are presented in this department/section due to the nature of the operations.

3.3.2 Racial group classification of respondents

General information 2 - Race classification. The motive of this question was to determine and differentiate between the different participants' race group. Table 3.2 provides the different races presented by the population groups.

Table 3.2: Represents race distribution of respondents

Race	Frequency	Percentage
Black	1	20%
White	3	60%
Coloured	1	20%
Indian	0	0%
Total	**5**	**100%**

Result analysis in Table 3.2 above demonstrates that 60% of fire protection systems maintenance participated in this study was white. The rest of the population was presented by 20% black and 20% coloured participants.

3.4 DATA ANALYSIS

Appropriately, the data analysis process is the ultimate phase of the research study process. The intention of data analysis is to ensure that categorical information is summed up into mathematical number of which the researcher can use to draw up conclusion and objective of findings concerning the research problem (Biggam, 2008:656). The primary data for this research study is gathered through applying a semi-structured interview questionnaire, is qualitative. The data for this research study was analysed and transcribed word for word by respondents' replies.

The data was collected through a hardcopy with semi-structured questions. Data collected was analysed and transcribed word for word as per respondents' replies. Data from semi-structured questions for the interview was transformed into useful outputs such as frequency tables and these tables were used to draw up conclusions and to make recommendations concerning the importance of fire protection maintenance strategy within AFB in Limpopo.

3.5. PRESENTATION AND DISCUSSION OF RESULTS

According to Wilkinson *et al*. (2010) states that in order to develop detailed understanding of the beginnings, motives, successes and concerns regarding the fire engineering as a discipline, conducting and analysing semi-structured interviews questionnaire of key individuals from the past and present-day stakeholder groups is of importance. The stakeholder groups interviewed included the following:

- **End users**: Those who either maintain or operate the fire protection systems.
- **Specialist:** Those who have been trained and understand the fire protections systems, i.e. subject matter experts.

Five experts were interviewed one-on-one through semi-structured questions. The semi-structured questions were formulated to understand the respondents' views on their expertise, the motivations for using fire engineering and their perceptions of the role of other stakeholders. The technique utilised for selecting the respondents and the interview questions design is described in details in 3.2.2 above and the full questions are listed in Appendix A and B. The following technique was used to report on qualitative data without using statistical tools:

3.5.1 Interviewee educational and experience background

Question 1 – Educational background and experience, the motive of this question was to discover the educational and experience background of the respondent pertaining to the fire

protection systems within the AFB. As fire engineering is young and new discipline in South Africa, it is unlikely that the AFB employees within fire engineering (maintenance and operation department) have received formal education in the topic prior to practicing of fire engineering field. As suspected, majority of the respondents were appointed at their role in fire protection maintenance from a background in another discipline such as electrical and mechanical.

The two most popular routes to fire protection maintenance or fire engineering out of the interviewed people are by diploma qualifications in Electrical or Mechanical Engineering. This is because majority of the respondents undertook their higher education and training at a time before dedicated fire protection maintenance qualifications were offered. Table 3.3 below represents the academic distribution of respondents:

Table 3.3: Represents academic distribution of respondents

Academic qualification	**Frequency**	**Percentage**
Matric	0	0%
Certificate	0	0%
Diploma	5	100%
University degree	0	0%
Post graduate degree	0	0%
Total	**5**	**100%**

All five respondents have a diploma, representing 100% of the total respondents. Having a diploma makes them qualified and trained in the requirements of fire protection system maintenance services.

3.5.2 Analysis of semi-structured questions interview

This section deals with the analysis of the results which were gained through the experts' interviews. If possible, a connection is made between the relevant theory and the results. The combination of the expert interview results and the research questions brings out the answers to the research questions. The following are interview questions developed for the respondent/participants:

- **Question 1** - Please provide a brief explanation of your educational background and work experience within AFB
- **Question 2** - What is your experience/knowledge pertaining to fire protection system maintenance?
- **Question 3** - In your opinion, what is the importance of fire protection system maintenance as an engineering discipline?
- **Question 4** - Please describe your training in consideration to undertake your role in respect of your interface with fire protection system maintenance?
- **Question 5** - How has fire protection system maintenance or its impact on AFB changed during your career? Motivate.
- **Question 6** - How do you envisage fire protection system maintenance changing in the future, from your perspective?
- **Question 7** - What is your perception of the role of the stakeholders in fire protection system maintenance?
- **Question 8** - What are the main problems/barriers experienced by you in maintaining the fire protection system at the AFB Limpopo?
- **Question 9** - Any innovative proposals to address the issues in question 8?
- **Question 10** - General remarks.

3.5.3 Transcribing word for word by respondent's reply

This section provides the findings which were gained through the expert interviews. The findings are explicit for the AFB because just users from this industry were interviewed. Therefore, the findings and afterwards the analysis, are focusing just on the AFB and are not generalised. With a scope of ten questions, information was collected and transcribed. They serve as a basis for the analysis in the next chapter.

Appendix B below gives an overview of the respondents in this study.

INTERVIEWEES INFORMATION

Respondent	Name	Role	Department
Respondent 1	Harry Van Staden	Major	Maintenance
Respondent 2	Moabi K. J	Fire Chief/ Brigade	Operation
Respondent 3	Frans van der Merwe	Electro-Mechanical Engineering Head	Maintenance
Respondent 4	Steve Albert	Fire Protection systems Specialist	Maintenance and Operation
Respondent 5	Ruan Bronkhorst	Fire Protection systems Specialist	Maintenance and Operation

Question 1: Please provide a brief explanation of your educational background and work experience in the AFB

Question 1 served as a start to get all respondents into the topic. **Respondent 1** was appointed as a maintenance facilities manager, started in 1986 as an apprentice in air craft maintenance. In 1989, **Respondents 1** qualified as a fully-fledged air craft maintenance artisan. **Respondent 1** continued to study until he obtained a National Diploma in Air Craft Maintenance in 2005. In summary, 31 years' experience described the ranks of **Respondents 1** within the AFB in Limpopo. Respondent 1 is very knowledgeable in the maintenance/mechanical engineering field of an air craft.

Respondent 2 was appointed as a Fire Chief/Brigade, joined the AFB in 1992 and went through rigorous training in the Air Force Base until he achieved the required qualification to occupy this position. A National Diploma in Fire Technology is the highest qualification obtained by **Respondent 2**. **Respondent 2's** main experience is in the fire operational section where they are dealing with fire statutory requirements such as complying with the SANS 10400.

Respondent 3's experience is based on electro-mechanical engineering and general and specialised knowledge in fire protection system maintenance and other engineering disciplines. **Respondent 3** joined the Air Force Base in 2000 and also holds a Diploma in Mechanical Engineering.

Respondent 4 holds a National Diploma in Electrical Engineering, worked in the AFB from 1982 until 1993 and later became a specialist contractor within the base. **Respondent 4** specialises in the Fire Protection Maintenance and Operational systems. **Respondent 4** has more than 35 years' experience which highlights the depth of Respondent 4 as subject matter expert in the field of Fire maintenance systems.

Respondent 5 specialises in the Fire Protection Maintenance and Operational systems. **Respondent 5** has more than 6 years' experience which highlights the depth of **Respondent 5** as a subject matter expert in the field of fire maintenance systems. He also holds a National Diploma in Mechanical Engineering.

Question 2: What is your experience/knowledge pertaining to fire protection system maintenance?

The second question dealt with the interviewees' background pertaining to the fire protection system maintenance.

Respondent 1 alluded that the fire protection systems maintenance was conducted through the outside contractors and these contractors kept the systems in good condition for many years. **Respondent 1** stated that he felt that he was not fully equipped with the necessary knowledge pertaining to fire protection system maintenance at the AFB.

Respondent 2 sees the importance and essence of keeping the fire protection systems in good condition and this will help fire fighters in case of fire events. The fire fighters will be able to come and further extinguish the fire manually since the fire protection system will not be able to cover the larger space/portion of the affected area. **Respondent 2** further stated that it is important to maintain the fire protection systems since they will be able to protect property from being damaged during the fire events.

Respondent 3 stated that he was involved in fire protection systems maintenance since 2009 and he is also involved in day-to-day activities regarding the fire protection system. Another responsibility in his work is to liaise with fire consultants and service providers.

Respondent 4 has been installing and maintaining fire protection systems since 1993 until date. As a subject matter expert, he also advises the Air Force Base of the new systems in the market as well as trainings pertaining to fire safety engineering.

Respondent 5 has been installing and maintaining fire protection systems from 2009 up until date and is very knowledgeable.

Question 3: In your opinion, what is the importance of fire protection system maintenance as an engineering discipline?

The third question involved the drivers of fire protection system maintenance.

Respondent 1 sees fire protection system maintenance as an important discipline because one can save property from incurring fire prior to a major fire hazard. The lives of the people are also protected.

Respondents 2's opinion with regard to question 3 was that serviceability and effectiveness are to do with rapid accessibility firefighting or extinguishing agent.

Respondent 3 alluded that fire protection system maintenance is very important because it involves the aviation safety and is the area of their expertise as well as the Air Force Base as a whole.

Respondent 4 has been involved in the fire protection system maintenance for many years and also signed off service level agreements with the AFB in order to keep the base in good condition. **Respondent 4** also became the advisor in terms of the importance of fire protection system maintenance as an engineering discipline for many governmental institutions and departments.

Respondents 5, being a subject matter expert, always try to knock door-to-door in order to encourage the AFBs to look after their fire protection systems maintenance.

Question 4: Please describe your training in consideration to undertake your role in respect of your interface with fire protection system maintenance?

The fourth question asked the interviewees about their fire protection system maintenance skills and knowledge, access to relevant and appropriate tools and information and access to competent colleagues.

Respondent 1 has not done much training in the fire protection systems maintenance, but only attended basic firefighting courses.

Respondent 2 was very equipped with fire protection system maintenance. Most of the knowledge was acquired through the refresher courses within the AFB and also interacting with civilian fire brigades in terms of getting acquainted with modernised fire protection methodology.

Respondent 3, being an electro-mechanical expert, received fire protection system training from external experts which will be conducted through the continuation of training on the job as well as training manuals for references.

Respondent 4, as an accredited installer and maintainer, trains the AFB employees with regard to fire protection system maintenance.

Respondent 5 also conducts training for fire suppression systems for the AFB employees as well as taking them through on-the-job training.

Question 5: How has fire protection system maintenance or its impact on AFB changed during your career? Motivate.

The respondents were asked about their perception of how the discipline of fire protection system maintenance, or its impact, has changed during their career.

Respondent 1 has confidence in the current fire protection system maintenance within the AFB and that it will last longer if maintained regularly. He will also rely on the system in future.

Respondent 2 stated that the AFB had experienced and witnessed the burning of a generator that was protected by an unmaintained fire protection system few years ago and this had been an eye opener for the AFB to take a quick resolution to start looking at its property.

Respondent 3 implied that, for the past three years, fire protection systems maintenance has picked up because they did not have maintenance schedules in place. As for now, they are satisfied that this fire protection system maintenance is effective.

Respondent 4 is fairly involved in the current and future development in terms of fire protection system maintenance and always advises the AFB with regard to the new technology in the market.

Respondent 5 also shared the same input as **Respondent 4**.

Question 6: How do you envisage fire protection system maintenance changing in the future, from your perspective?

The respondents were asked how they envisaged that the practice might change in the future. Some correlated issues popped up.

Respondent 1 sees a continuation of fire protection systems' maintenance since one fire suppression system called Halon fire suppression system was recently decommissioned and changed due to an effect on ozone layer, which was not environmentally friendly.

Respondent 2 implied that technology always changes and also gave an example that in the old days we use to have big extinguishers that were manually operated but now it's all about automatic fire protection systems which are maintained on site.

Respondent 3 stated that fire protecting system maintenance changes due to new fire protection system installation, bearing in mind that few cables are now used as compared to previous installation.

Respondent 4, as an expert, always brings less fire protection system maintenance, in other words minimum maintenance. Most of the things can be done remotely instead of moving around and conducting visual inspections.

Respondent 5 is looking forward to the future because the AFB has got much obsolete equipment that need to be changed due to the unavailability of spares within the country.

Question 7: What is your perception of the role of other stakeholders in fire protection system maintenance?

The most important section of this knowledge elicitation exercise involved asking the respondents about their perception of the roles of the stakeholders' involvement in fire protection maintenance.

Respondent 1 stated that it took the Department of Public Works (DPW) a while to engage into the fire protection system maintenance but since the appointment of the fire protection systems maintenance, things are now going smooth. **Respondent 1** further stated that the stakeholders at DPW should consider continuity rather than short-term plans.

Respondent 2: since the government project are done on a tendering process or basis, the interaction between the AFB and DPW is very crucial to align the requirements of fire protection system maintenance.

Respondent 3 appreciates the involvement of DPW as a stakeholder within the AFB and also mentioned the service level agreement between the AFB and the maintenance contractor.

Respondent 4 mentioned the benefits of stakeholder's involvement where fire protection systems maintenance service level agreement has been signed. As for the AFB, **Respondent 4** alluded that the DPW should engage into the continual process of maintaining the fire protection systems since millions of rands are spent time and again when the systems are not taken care of.

Respondent 5 is very concerned about the stakeholders not dealing with the issues of old equipment that are also difficult to purchase in the market.

Question 8: What are the main problems/barriers experienced by you in maintaining the fire protection system at the AFB Limpopo?

Respondent 1 alluded that, sometimes the DPW prioritises other projects and forgets about the fire protection system maintenance within the AFB. For example, fire extinguishers are left for two to three years without being maintained and this negligence will one day lead to a serious problem in the AFB.

Respondent 2, as Respondent 1, assorted that fire extinguishers are left for two to three years without being maintained and gets frustrated as a responsible fire chief.

Respondent 3 implied that since the fire protection systems within the AFB are electronically operated, the stakeholders should appoint the contractor which is familiar with the fire protection systems maintenance.

Respondent 4, as experienced employee, is facing many challenges after installation and commissioning of fire protection systems. Once the fire protection system is up and running, the stakeholder seems not to spend money on a maintenance system.

Respondent 5 sees the stakeholder as a main obstacle since the stakeholder is having cash to finance the project.

Question 9: Any innovative proposals to address the issues in question 8?

Respondent 1 proposed that the stakeholder should give the AFB a budget so that the base can decide on its own priorities and this will create job opportunities.

Respondent 2 feels that the DPW should appoint one contractor to perform maintenance of the fire protection system in order to avoid confusion.

Respondent 3 proposed a service level agreement between DPW and fire protection system maintenance specialised contractors.

Respondent 4 and 5 stipulated that service level agreement between DPW and the fire protection system maintenance contractor is very important.

Question 10: General remarks

Respondent 1 implied that it is worthwhile to conduct such exercise in the base because this initiative will not lead to further degradation of the fire protection system and this will save the Air Force Base a lot of money.

Respondent 2 implied that technology is changing and is pleading with the DPW and AFB to consider latest designed fire protection systems that are available in the market. **Respondent 2** further asserted that the training of fire fighters within the AFB is of high importance.

Respondent 3 alluded that the fire protection system is working and that it is only wild animal that are tempering with the system.

Respondent 4 sees the importance of continual maintenance of the fire protection system and also feels that the AFB and DPW must work together so that they can familiarise themselves with the need and requirements of fire protection systems.

Respondent 5 believes that the AFB should start to replace the obsolete fire protection system with modernised technology bit by bit.

3.6 RESPONDENTS' RESPONSES INTERPRETATION

Five subject matter experts were questioned and their responses were received via an electronic recording. The semi-structured interview questions were formulated to understand the respondents' views on their expertise, the motivations for using fire protection system maintenance and their perceptions of the role of other stakeholders. The technique utilised for selecting the interviewees and the questions design was fully explained in 3.2.2 and the full questions are listed in Appendix B. The following responses, issues and trends were identified.

3.6.1 Interviewees educational background and work experience in the AFB

As fire protection system maintenance or fire engineering is a relatively new discipline in South Africa or the African continent as a whole, it is unlikely that the AFB employees acquired formal education in fire engineering prior to practicing the profession. As questionable, the majority of respondents got appointed at their role in fire protection maintenance from another field such electrical and mechanical engineering. The two most popular paths to fire protection maintenance system out of the people interviewed, are by Diploma qualifications in Electrical and Mechanical Engineering discipline. The reason behind this, is due to many of the respondents approach their higher learning, education and training at a time before dedicated fire engineering qualifications were introduced in South Africa and we are also facing real challenges in South Africa.

3.6.2 Respondents experience/knowledge pertaining fire protection system maintenance

Many respondents explained their experience with fire protection maintenance systems as ambidextrous/versatility. For instance, one out of five also play an active role in training in the discipline by participating in code and SANS 10400 T, guidance authoring activities or holding seminars fundamentally practical in the discipline. This confirms the proposition that, since well the discipline is still new in South Africa, the number of key players are relatively small and each of these individuals is involved in a wide variety of activities. This is good as it assists to quickly move the discipline forward.

3.6.3 Opinion in fire protection system maintenance an engineering discipline

When asked what they thought about the importance of fire protection system maintenance as a profession, the overwhelming opinion of the respondents was the ability to mention safety and property protection. This is a very positive opinion and is shared by stakeholders, putting forward that AFB demand has been a driver for fire protection maintenance systems.

3.6.4 Competency in taking respective role with regards to fire protection systems maintenance

Another question asked to the interviewees was about their fire protection system maintenance competency, access to relevant information and access to competent fellow employees. The huge majority of participants reckoned themselves to be equipped enough, sufficiently equipped or at least felt competent to take responsibility to their daily routine works. For the purpose of this study, being adequately equipped means having the basics of a relevant educational background

which is electrical or mechanical engineering. Several participants identified gaps in some of these constituents, including educational qualifications.

It was brought into attention that, whilst fire engineering is still a new engineering field in South Africa, the training utensils and models are also not detailed. Some participants acknowledged that they did not necessarily obtain relevant qualifications directly.

Many interviewees added that successful fire protection systems maintenance requires teamwork where support from employer, colleagues and the stakeholder, sometimes externally stakeholder (Department of Public Works), is essential.

3.6.5 Development of fire protection system maintenance

The participants were asked about their perception of how the profession of fire protection system maintenance, or its impact, had changed during their careers. They were also asked how it was anticipated the discipline might change in the near future. Some interrelated issues were mentioned. It was widely accepted that the discipline is maturing, today the profession is emerging as a recognised and separate professional fire engineering profession. Participants agreed that fire engineering is becoming familiar and known as well as accepted in South Africa.

3.6.6 Future developments

Other views regarding how fire protection system maintenance may develop in the future included an overwhelming thought that fire protection system maintenance would become more embraced, more sophisticated and would be utilised more. This was stated by respondents from all relevant departments within the AFB. With regards how the discipline might develop, AFB employees suggested that fire protection system maintenance would develop to reflect modern approaches/techniques of construction as well environmental and sustainability issues, for example, the decommissioned Halon fire suppression systems and replaced by FM 200 fire suppression systems.

3.6.7 Perception of stakeholders' role

The most arguable part of this knowledge elicitation exercise involved asking the participants about their insight of the roles of the stakeholders such as DPW involved in fire protection system maintenance. An analysis of the answers clearly demonstrate that participants had more negative comments than positive comments, when describing their counterpart professionals in the industry.

The criticism of AFB (end-users) within the fire protection system maintenance process can be summarised that there was a lack of engagement when the budget is planned which results in them falling short of their responsibilities during operation.

3.6.8 Problems or barriers experienced by respondents

Another pressing question asked to interviewees was with regard to the barriers they were experiencing in respect of maintenance of fire protection system. An analyses of the responses indicated that there was a bit of ignorance from DPW and this frustrated them in terms of providing funds for maintenance plan schedules. There was no teamwork between end-user and the stakeholders, for example, the end user was not consulted in terms of drawing the maintenance budget.

3.6.9 Innovative proposals

When asked what they thought about the innovative proposals to address fire protection system maintenance barriers, most interviewees highlighted that the stakeholder should sign a fire protection system maintenance service level agreement with the relevant specialised fire protection contractors. This will also minimise the cost in terms of high budget when the systems are left for years unattended.

3.6.10 General remarks

When asked for general remarks, the interviewees stipulated that nowadays, the fire protection system maintenance evolves on the modernised technology. The obsolete equipment should be replaced and this will minimise maintenance costs within the AFB.

3.7 ETHICAL TREATMENT OF RESEARCH PARTICIPANTS

Ethics is of absolute significance in the research study, especially when data must be collected from the research respondents. According to Cooper and Schindler (2003:57) the ethical consideration in research design ensures that the rights of the research participants are all times protected and safeguarded. Leedy and Ormrod (2005:373) emphasise the fact that ethical considerations such as assurance of anonymity, confidentiality, voluntarism and disclosure protection must be taken into account in the formulation, design and administration of the measuring tool.

This is achieved by affixing the informed consent form as part of the questionnaire (Cooper & Schindler 2003). The informed consent basically act as to describe to the participants that their participation is voluntary and it also reassures them about confidentiality. According to Walliman (2011: 43), there are two aspects of ethical issues in research:

- the individual values of the researcher relating to honesty and frankness and personal integrity; and
- the researcher's treatment of other people involved in the research, relating to informed consent, confidentiality, anonymity and courtesy.

Permission to conduct this study was ethically approved by the research ethics committee of the North-West University (WorkWell) under the protocol reference Number: ***EMSPBS16/11/25-01/18.*** The sample of the ethical clearance is appended in APPENDIX D.

3.8 SUMMARY

The outcome and discussion of the empirical study are formally disclosed in Chapter 4. The research was of a qualitative nature, as the study incorporated the semi-structured interview questions. The interview questions utilised to perform the empirical research comprises of ten questions. The data collecting process, response to the transcribed questionnaire and biographical profile of the participants were also discussed. The semi-structured interview questions were conducted face-to-face to the population group.

The population group incorporated AFB employees in the Limpopo Province. The whole population group comprises of five fire protection system maintenance experts and were all interviewed and utilised in this research. The information gathered from the respondents was recorded/captured and transcribed. The empirical results were analysed as set out in the context of the research objectives and the problem statement.

The semi-structured interview questions were all transcribed to discover the internal consistency and reliability among items in the measuring tool since there was no statistical analysis tool used. The interviewees' responses were interpreted collectively as per question asked.

The following chapter's conclusion was drawn from the results that are already contemplated in chapter 3, and recommendations are made on how to strengthen the fire protection system maintenance in Limpopo Province.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

4.1 INTRODUCTION

The motives of this last final stage on the *Evaluating the Fire Protection Systems' Maintenance Strategy of an Air Force Base in the Limpopo Province* is to complete and finish the empirical research as examined in Chapter 3 and to propose empirical recommendations to strengthen Fire Protection Systems Maintenance strategy, with the objective of enhancing the perceived success of the Air Force Base in Limpopo. Consequently, the study was able to deliver a more comprehensive basis for assessing and enhancing the Fire Protection Systems' Maintenance Strategy of an Air Force Base instead of just focusing on single aspect.

This chapter comprises of four segments. The first element focuses on the conclusion extracted from the empirical research in Chapter 3, the second section, namely, recommendations based on the findings. In the third section, a critical assessment of the primary and secondary objectives is discussed. The last phase of segment/section makes proposition for future research.

4.2 CONCLUSION

The conclusion extracted is based on the empirical study performed in the previous chapters. The conclusion consists of the biographical information of participants and is summarised as follows:

4.2.1 Achievement of research objectives

The author is pleased that all the goals and intentions of this research were attained, and this was fulfilled by performing a conscientious analysis and elucidation of literature and information received from the transcribed questions acknowledgement. An analysis on how each objective was attained is discussed below:

The first objective was to stress the importance which a maintenance strategy has on fire protection systems. Campbell and Reyes-Picknell (2010: 66) state that, if there is a proper and defined maintenance strategy that is understood by all employees and management members, then the latest problems rather than the old recurrent problems will be resolved. When maintenance strategy is not in place, measurable time will be attained from developing and defining a maintenance strategy, communicating it and lastly focusing on the tactical choices on

how to achieve it. Tactics are the actual activities needed to implement the strategy, which concern the management of processes, people and the physical asset infrastructure.

The gathered data results revealed that the fire protection system maintenance strategy at Limpopo Air Force Base (AFB) is viewed as an essential information. There was a strong concurrence among the participants that the fire protection system maintenance strategy is an important function which contributes positively to AFB's operational effectiveness. The SANS 10400 T (2011:46) states that any firefighting apparatus, installations and fire protection systems in any building must always be installed and maintained as to be readily available when needed. The disposition of such firefighting equipment must at all times not be obstructed or must be indicated by symbolic signage which must always be visible and conform to the requirements stated in SANS 1186-1.

The second objective was to identify barriers in maintenance strategies of an AFB in maintaining their fire protection systems. The results revealed perceived short-comings of the fire protection system maintenance strategy at Limpopo Air Force Base (AFB) which are as follows: the reactive maintenance approach by the stakeholder, an absence of the predictive maintenance, ineffective maintenance scheduling and the budget provided for the fire protection system maintenance being always low.

Furthermore, unemployment of the maintenance planner in the maintenance departmental structure contributes as a challenge. These shortcomings render the maintenance strategy and function ineffective. Wireman (2004:103) reports that an empirical research conducted in US air force bases, accomplished that only one-third of air force bases hire a maintenance planner. According to Wireman (2004:106) the barring of the maintenance planner in the maintenance companies organogram is a major hindrance to effective maintenance planning and scheduling.

The third objective was to examine the effect that the Planned Implementation Maintenance Program (PIMP) has on the fire protection systems of an AFB. The empirical confirmation demonstrated that the successfulness level of the PIMP at Limpopo AFB is viewed to be very low, recommending that the maintenance strategy is inefficient. Non-replication of the best practices pertinent to the effective maintenance system, such as absence of a maintenance strategy and policy, non-tracking of the maintenance costs and failure to conduct maintenance audits renders AFB's maintenance function inefficient. From the researcher's point of view, it is understandable that the AFB should be able to control its in-house budget for the fire protection system maintenance, unlike relying on the stakeholder (Department of Public Works) who tends to take a bit longer to fund the maintenance schedules.

The fourth objective was to gain more insight into the maintenance strategy through conducting a literature review. The motives of the literature review was to gather all relevant data and concepts that apply to this study of the fire protection systems maintenance strategy of an Air Force Base in the Limpopo Province. It covered twelve primary topics, namely defining fire protection systems, an overview of fire protection systems, international and South African standards for fire protection systems, the importance of fire protection systems' in business management, the fire protection systems in an Air Force Base in South Africa, challenges experienced with fire protection systems' in South Africa, defining maintenance strategy concepts, international and South African views on the importance of maintenance strategy, the maintenance strategy of the Air Force Base sector, the importance of maintenance strategy in business strategy and the functions of maintenance strategy in business strategy. Each subject/topic has played an important role in developing an extensive foundation from which to fully survey and assess the fire protection systems maintenance strategy of an Air Force Base.

The fifth objective was to draw a conclusion from empirical research, and provide recommendations on how to execute a Planned Implementation Maintenance Program (PIMP). The research results asserted that the majority of the AFB workers are of the view that the AFB's operational performance departments can be improved by the implementation of a fire protection system maintenance strategy, and this was confirmed by empirical literature review studies for maintenance strategy. Furthermore, there was an agreement from AFB workers (Maintenance and Operation departments' employees) on the potential hindrance of the maintenance strategy implementation, and this was occurring due to poor communication by stakeholders, lack of determination and restricted resources.

Furthermore, the outcome of the research also established that the AFB's maintenance function is liable towards both a cost centre opinion and a first-generation maintenance perspective, equivalent to a reactive maintenance technique. These directions negatively affect the successfulness of the AFB's maintenance function and also contribute to the negative perception with regards maintenance. Fire protection systems maintenance strategy is perceived by majority workers as a remedy for maintenance inefficient as well as a positive contributor to the operational performance areas. In consideration of all the aspects, the maintenance function at the AFB is ineffective. Fire protection system maintenance strategy implementation will be of the solution in order to improve maintenance effectiveness and operational performance.

4.2.2 Demographic information

- **Gender:** Five participants participated in the survey, all five were males which represent 100% of respondents while no females (0 %) participated in the study. From the Air Force's perspective, it is understandable that few or no females are presented in this department/section due to the nature of the operations.
- **Race:** The largest race group of respondents was white (60%). The rest of the population was presented by 20% black and 20% coloured participants respectively.
- **Highest academic qualification:** All respondents have a diploma, which is a total of five participants that represent 100% of the participants. Having a diploma makes them qualified and trained in the requirements of fire protection system maintenance services.

4.2.3 Data collection

The data gathering was meant to furnish the necessary data in order to develop a inclusive understanding of the status of fire protection systems maintenance, including barriers and problems, benefits and desired changes. Data collection comprised of interviews with knowledgeable AFB employees of the fire engineering field from a different study backgrounds, and who had experiences with the fire protection system maintenance. In total, five respondents were interviewed, and this number proved to be enough in the fact that this a new engineering discipline in South Africa.

Additionally, there was sufficient evidence to support each of the findings in the data analysis portion of the study. In terms of experience, the subject pool met all expectations with an average of approximately 35 years in the fire protection system maintenance career field. The interviews were conducted in one format at the discretion of the interview subject, i.e. a personal interview.

4.2.4 Data analysis

Data analysis was accomplished by interview questionnaires transcription. The question transcribing analysis was utilised to develop an understanding of the current fire protection system maintenance strategy within the AFB and how it needs to change. The interview questionnaire comprised of identifying common themes in the interview information and best practices in maintenance of fire protection systems as identified during the literature review.

4.2.5 Implications of the research study

This research add-up to the present knowledge in the field of fire protection systems maintenance, especially in the reference of the Air Force Bases in South Africa. The outcome of this dissertation divulge that maintenance successfulness of an AFB is extremely affected by the perception of the maintenance function and by noncompliance of maintenance practices, such as maintenance planning and scheduling, usage of reactive maintenance techniques of fire protection systems and inadequate or a lack of resources (e.g. maintenance planner and budget).

4.2.6 Limitations of study

The study respondents consisted of the AFB employees in Limpopo (full-time employees) only, and who are currently working at Maintenance and Operations Departments/sections. The AFBs have different operational duties which differ from each other in capacity operations, for an example aircraft operation and water operation.

4.3 RECOMMENDATIONS BASED ON THE RESEARCH FINDINGS

The main objective of this research study was to evaluate the fire protection systems' maintenance strategy of an Air Force Base in the Limpopo Province. The outcome revealed a gap of AFB's fire protection system maintenance as comparing it with the characteristics of an efficient maintenance strategy. With regards to the preceding, AFB's fire protection system maintenance function is inefficient, and it is against the background that the researcher outlines recommendations of how to improve AFB's fire protection system maintenance effectiveness. The recommendations are further derived from a semi-structured questionnaire analysis and are described as follows:

a) **Educational background.** As fire protection system maintenance or fire engineering is still a new discipline in South Africa or the African continent as a whole, it is unlikely that the AFB employees obtained relevant qualification in the subject prior to practicing the field. The two most popular paths to fire protection system maintenance out of the people interviewed are by Diploma qualifications in Electrical or Mechanical Engineering. The researcher recommends that the AFB should equip its employees with relevant training and qualification, for example there are many accredited institutions that are offering Fire Engineering discipline studies in South Africa such as the Institute Fire Engineers, the Automatic Sprinkler Inspection Bureau and they are also endorsed by Engineering Council of South Africa. This will enhance

the knowledge of employees and they will rely less on consulting external contractors for maintenance of their systems.

b) **Stakeholder's role.** The most pressing part of this knowledge elicitation exercise involved asking the participants about their perception of the roles of the other stakeholders such as DPW involved in fire protection system maintenance. An interpretation of the replies demonstrated clearly that participants had more negative comments than positive comments when narrating their fellow professionals in the organisation.

The condemnation of end users within the fire protection system maintenance process can be summarised as a lack of commitment when the budget is planned and which results in falling short of their responsibilities during operation. Another pressing question was asked to interviewees with regard to the barriers they were experiencing in respect of maintenance of the fire protection system. An analyses of responses indicated that there is a bit of ignorance from DPW and this frustrates the respondents in terms of providing funds for maintenance plan schedules. There is no team work between the end-user and the stakeholders, for example, the end-user is not consulted in terms of drawing the maintenance budget.

The researcher can sum it up by recommending that the two departments, AFB and DPW, should start working together closely in order to strengthen and prioritise the need of the fire protection system maintenance requirements. Furthermore, departments within the AFB as well as stakeholders (DPW) should be encouraged to work together and closer relationships between departments will ensure operational effectiveness within the AFB. Close cooperation and re-alignment in motives between departmental/sectional management will lead to workers relations between departments improve which will lead to effectiveness implementation of a fire protection systems maintenance strategy.

4.4 SUGGESTION FOR FUTURE STUDIES

The purpose of the study was on the evaluation of the maintenance strategy of the fire protection system at the AFB situated in the Limpopo Province. The study could be extended to other Air Force Bases in other provinces in South Africa, where a maintenance function is crucial for operational activities. The study recommend the following for future studies:

- The result of maintenance practices on the successfulness of a fire protection system maintenance strategy in an Air Force Base.
- The implementation of proactive maintenance approaches in AFBs and their strategic benefits.

- Maintenance strategy must be implemented in order to improve maintenance effectiveness and operational performance, at the AFB.

This study also revealed that maintenance strategies support AFB fire protection systems maintenance effectiveness and also positively contribute to the improvement of operational performance areas. This research highlights the importance of maintenance successfulness improvement in the AFB. Furthermore, the research proclaim the potential of maintenance strategies as a solution to improvement of AFB operational performance.

4.5 CRITICAL EVALUATION OF THE STUDY

4.5.1 Evaluation of the study process

This segment evaluated the effective of the research against the research objectives as designed in chapter 1. The primary and secondary objectives were revisited and formulated as follows:

- To stress the importance that maintenance strategies have on fire protection systems. This objective was achieved by the literature review in Chapter 2.
- To identify barriers in maintenance strategies of an AFB in maintaining their fire protection systems. The empirical study resolved this objective in Chapter 3.
- To examine the effect that a Planned Implementation Maintenance Program (PIMP) has on the fire protection systems of an AFB. The empirical study resolved this objective in Chapter 3.
- To gain more insight into a maintenance strategy through conducting a literature review. Chapter 2 has resolved this objective.
- To draw conclusions from the empirical study and provide recommendations on how to execute a Planned Implementation Maintenance Program (PIMP). Chapter 4 resolved this objective by concluding and providing recommendations.

4.5.2 Evaluation of the researcher/author

Due to an exposure that conducting this mini-dissertation had presented, the author was recruited to register as an Associates Member with the Institute of Fire Engineers (United Kingdom) in 2016, as well as a Member with Association of Fire Engineers in South Africa. As an affiliated member, the author should attend the annual general meeting as well as continuous professional development with the following:

- Fire engineering profession
- enforcers
- academics and fire safety community

4.5.3 Key contributions of this study

This study presents the findings from a one-year Master of Business Administration (MBA) research project. As described in Chapter 1, the main objective of this study was to evaluate the maintenance strategy of the fire protection system in an Air Force Base (AFB) situated in the Limpopo Province.

The findings indicated that this objective was achieved by studying a series of previous events and familiarisation with the AFB, as outlined in Chapter 1 and 3.

With regard to a very limited literature and study in this highly specialisation discipline of fire protection system maintenance, this study has establish many meaningful awareness. The main awareness in this study include the following:

- drawing new insights into the experiences and relationships between the different stakeholders in the fire protection system maintenance;
- identification and documentation of a process involving business impact analyses to inform fire safety objective setting;
- involvement in the training of the AFB employees with regard to the new system; and
- how to close out and handover the projects from the government perspective requirements.

4.6 SUMMARY

The study pursue to evaluate the successfulness of the maintenance strategy of a fire protection system at an AFB situated in Limpopo Province. The empirical research done in this study supplemented the theory of maintenance management pertaining to the strategic role of the maintenance duty within the AFB. Empirical evidence furnished by the study findings indicated that the maintenance function is viewed to be a very important management function at an AFB.

The viewed shortcomings of the AFB’s maintenance strategy are: a passive maintenance technique, non-utilisation of the preventive maintenance, inefficient maintenance scheduling and non-availability of a maintenance planner in the Maintenance Department's organogram.

The study also confirmed the positive support towards the implementation of a maintenance strategy as the formula for improvement of maintenance effectiveness. The study recommends that a maintenance strategy must be implemented in order to improve maintenance effectiveness and operational performance at the AFB.

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APPENDIX A: SEMI-STRUCTURED INTERVIEW QUESTIONS

General Information

Date of Interview	
Name of Interviewee	
Gender	
Race	
Department	
Position/Function	

Interview questions for AFB employees

1. Please provide a brief description of your educational background and work experience in the AFB
2. What is your experience/knowledge pertaining to fire protection system maintenance?
3. In your opinion, what is the importance of fire protection system maintenance as an engineering discipline?
4. Please describe your training in consideration to undertake your role in respect of your interface with fire protection system maintenance?
5. How has fire protection system maintenance or its impact on AFB changed during your career? Motivate
6. How do you envisage fire protection system maintenance changing in the future, from your perspective?
7. What is your perception of the role of other stakeholders in fire protection system maintenance?
8. What is the main problems/barriers experience by you in maintain the fire protection system at the AFB Limpopo?
9. Any innovative proposals to address issue in question 8?
10. General remarks:

N.B.: For the purposes of this survey/interview, the stakeholder group which have been identified include end users/operators and department of public works

APPENDIX B: INTERVIEWEES INFORMATION

Respondent	Name	Role	Department
Respondent 1	Harry Van Staden	Major	Maintenance
Respondent 2	Moabi K.J.	Fire Chief/ Brigade	Operation
Respondent 3	Frans van der Merwe	Electro-Mechanical Engineering Head	Maintenance
Respondent 4	Steve Albert	Fire Protection systems Specialist	Maintenance and Operation
Respondent 5	Ruan Bronkhorst	Fire Protection systems Specialist	Maintenance and Operation

APPENDIX C: AFB STUDY APPROVAL

RESTRICTED

sa air force

Department:
Defence
REPUBLIC OF SOUTH AFRICA

Telephone: 015 799 2074
Facsimile: 015 799 2445
Enquiries: Maj H.J. van Staden

Air Force Base Hoedspruit
Private Bag X504
Hoedspruit
1380

23 February 2017

North-West University, Potchefstroom Campus
Sir/Madam

FIRE PROTECTION STUDIES OF MR. U.A. MHELEMBE AT AFB HOEDSPRUIT

1. The studies of Mr Mhelembe on Fire Protection Studies at AFB Hoedspruit from 5 July 2012 to 25 August 2017 have reference.

2. Mr Mhelembe has been working as a Fire Protection Systems' consulting Engineer within the Air Force Base since 5 July 2012. His main duty is evaluating the fire protection systems' maintenance strategy at Air Force Base Hoedspruit in Limpopo Province.

3. The scope of the project covers only the Fire Protection Systems, namely: **Automatic Sprinkler Suppression Systems, Carbon dioxide Suppression System, Fire detection systems, Telemetry Equipment, Portable Fire extinguishers and the decommissioning of Halogenated hydrocarbon (Halon) suppression system.**

4. I approve Mr. U.A. Mhelembe to incorporate this project into his studies in any University in the Republic of South Africa since we are promoting education in the Defence Force. Other than that, the Fire Protection Systems' are not regarded as a secret feature of the Base. We can even further say that Mr. Mhelembe is currently enhancing the current Fire Protection Systems' in terms of evaluating and the implementation of Fire Protection Maintenance strategy. So we wish him good luck in his studies and future endeavours.

Yours sincerely

(H.J. VAN STADEN)
FACILITY MAINTENANCE OFFICER IN CHARGE AFB HOEDSPRUIT: MAJ

APPENDIX D: ETHICAL CLEARANCE AND PERMISSION TO CONDUCT RESEARCH

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOMKAMPUS

Dear participant,

PERMISSION TO CONDUCT RESEARCH

I am currently enrolled as an MBA student at the North-West University (NWU). I intend to collect data for my research study relating to evaluating the Fire Protection Systems' Maintenance Strategy. The title of my proposed dissertation is;

Evaluating the Fire Protection Systems' Maintenance

Strategy of an Air Force Base in the Limpopo Province

I hereby request you to participate in a semi-structured interview on your experiences as Fire Protection Systems' Maintenance and Operation employee at the Air Force Base in Limpopo. Completion of the interview will take approximately 10-20 minutes. Ethical clearance for this study was obtained from the NWU, Research Ethics Committee (WorkWell), and the number for this study is***EMSPBS16/11/25-01/18.***

I pledge to maintain professional and research ethical codes, which implies that;

- You will only be asked to complete a semi-structured interview for the research project.
- Your participation in this research remains voluntary and anonymously, and you may at any time withdraw from this research.
- Your personal information and feedback will at all times be treated as confidential.
- Your participation in this interview will not interfere with your employment.
- Should you be interested in the research findings, the researcher could provide the research findings to you.

I plan to conduct this research study between June - July 2017. Your participation in this research project is greatly appreciated!

_____

Uncel Mhelembe

MBA Candidate – North-West University

Student number: 26600854

Mobile: 082 5989285

Name and surname: _____ **Date:** _____

Signature: _____

APPENDIX E: ETHICAL CLEARANCE CERTIFICATE

NORTH-WEST UNIVERSITY ®
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05 April 2017

26600854
MHELEMBE, UA MR
mhelemu@gmail.com

ETHICAL CLEARANCE

This letter serves to confirm that the research project of **MHELEMBE, UA** has undergone ethical review. The proposal was presented at a Faculty Research Meeting and accepted. The Faculty Research Meeting assigned the project number **EMSPBS16/11/25-01/18**. This acceptance deems the proposed research as being of minimal risk, granted that all requirements of anonymity, confidentiality and informed consent are met. This letter should form part or your dissertation manuscript submitted for examination purposes.

Yours sincerely

Prof CJ Botha

Manager: Research - NWU Potchefstroom Business School

Original details: Wilma Pretorius(12090298) C:\Documents and Settings\Administrator\My Documents\Briewe MBA\2017\

APPENDIX F: LANGUAGE EDITING LETTER/REPORT

DECLARATION

I, C Vorster (ID: 710924 0034 084), Language editor and Translator, and member of the South African Translators' Institute (SATI member number 1003172), herewith declare that I did the language editing of a mini-dissertation written by mr UA Mhelembe from the North-West University (student number: 26600854).

Title of the mini-dissertation: Evaluating the Fire Protection Systems' Maintenance Strategy of an Air Force Base in the Limpopo Province

C Vorster — 27 October 2017

C Vorster — Date