

**INFLUENCES OF HUMAN PERFORMANCE FACTORS ON THE  
IMPLEMENTATION OF SAFETY PROGRAMS IN AIR TRAFFIC CONTROL THE  
CASE OF KENYA CIVIL AVIATION AUTHORITY**

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**A RESESARCH SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS IN PROJECT  
PLANNING AND MANAGEMENT OF THE UNIVERSITY OF NAIROBI**

2016

**DECLARATION**

This research project report is my original work and has not been presented for any academic award in any university.

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Signed ..... Date .....

This research project report has been submitted for examination with my approval as the University Supervisor.

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## **DEDICATION**

This research is dedicated to my beloved mother Patricia Awuor Ngolo, my late father Silvanus Ngolo, and to my beloved wife Ruth Wavua and lovely daughter Ashley Oduor.

## **ACKNOWLEDGEMENT**

I wish to thank all those responsible for my success at writing this research project report.

My sincere appreciation goes to my supervisor Dr. Moses Otieno for supporting and guiding me in writing and putting together of this research project report in a professional manner. I thank the administration of the University of Nairobi particularly to the school of continuing and distance education for granting me the opportunity to study with them. I also thank all the lecturers who prepared me throughout the course schedule and the supporting staff for offering me support thereto. Special appreciation goes to KCAA for giving me flexible time to carry out the research.

Finally, I express my appreciation to all my fellow comrades in the Masters of Project Planning and Management class for their sharing, interaction and critiques that enabled me succeed in writing this research proposal.

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## ABBREVIATION AND ACRONYMS

<b>ATC:</b>	Air Traffic Control
<b>ATCO:</b>	Air Traffic Control Officer
<b>KCAA:</b>	Kenya Civil Aviation Authority
<b>VFR:</b>	Visual Flight Rule
<b>CTR:</b>	Control Zone
<b>APP:</b>	Approach
<b>TWR:</b>	Tower
<b>ACC:</b>	Area Control Centre
<b>IAF:</b>	Initial Approach Fix
<b>ILS:</b>	Instrument Landing System
<b>GND:</b>	Ground Controller
<b>ATS:</b>	Air Traffic Services
<b>DEP:</b>	Departure
<b>SID:</b>	Standard Instrument Departure
<b>FIR:</b>	Flight Information Region
<b>ICAO:</b>	International Civil Aviation Organization
<b>FAA:</b>	Federal Aviation Administration
<b>TCAS:</b>	Traffic Collision Avoidance System
<b>RA:</b>	Resolution Alert
<b>TMA:</b>	Terminal Maneuvering Area
<b>DATCO:</b>	Duty Air Traffic Control Officer

## **ABSTRACT**

This study set out to establish the influence of human performance factors on the implementation of safety programs in air traffic control the case of Kenya Civil Aviation Authority. The research objectives of the study were to investigate the extent to which team work, alertness, communication skills and situation awareness affect the implementation of safety programs in air traffic control in KCAA. The target population of the study was Air Traffic Controllers and incident investigators of the Kenya Civil Aviation Authority (KCAA) in addition to safety oversight stake holders totaling to 210 and based in the 8 KCAA manned airports in Kenya. A sample size of 65 (derived from Yamane formula) from the target population was used to conduct the research. Data was collected using a questionnaire focusing on the research objectives. The questionnaire was constructed using structured and unstructured questions. Descriptive statistics was used as tool of evaluation in the data analysis. The findings were analyzed by mean scores, standard deviation and chi square test then presented using Tables. The study established that the four factors affected the implementation of safety programs in the organization. The study also revealed that the respondents were homogeneous in their perception to the research questions and this led to consistency in response. Findings revealed that situation awareness contributes most to incidents thereby affecting the implementation of safety programs with a mean of 4.862, and chi square test value of 196 at 95% level of significance and 4 degrees of freedom. Alertness followed closely with a mean of 4.738 and a chi square test value of 140.615 at 95% level of significance and 4 degrees of freedom. Team work was found to have a mean of 4.585 and a chi square test value of 110.923 at 95% level of significance and 4 degrees of freedom. The least yet still ranking high was communication skills with mean of 4.597 and chi square test value of 30 at 95% level of significance and 4 degrees of freedom. The study concludes that human performance factors have significant effect on the implementation of safety programs in air traffic control in KCAA. Measures need to be put in place to ensure that controllers boost their situation awareness, alertness, team work and communication skills in order to successfully implement the safety programs in place. It is recommended that more training and sensitization on the human performance factors be done and Technical Guidance Material to focus more on inclusion of these factors in aviation safety related knowledge base.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background to the Study

ICAO is recognized as the organization responsible for facilitating collaboration in the development of international civil aviation Standards and Recommended Practices (SARPs) and ensuring synchronized application of the SARPs to facilitate the progressive growth of civil aviation. Safety programs are essential for the existence of rapid growth of civil aviation. Recognizing the critical importance of this mandate, the 37<sup>th</sup> session of the ICAO assembly (2010) concluded that efforts must be intensified through a review of SARPs concerning human factors and the incorporation of new guidelines that will contribute to improving Operational Safety. It was also observed that although significant efforts have been made in the area of Human Factors, knowledge in the field does not appear to govern the day-to-day practices of most organizations in the industry or the States. It appears that a gap exists between knowledge of Human Factors and its incorporation in day-to-day aviation practices, According to Boeing Company Statistical summary of commercial jet airplane Accident Worldwide Operation (2006), it turned out that of the commercial aircraft accidents for the past 10 years, 55% were caused by pilot error, 17% by aircraft defect, 13% by weather condition, 5% by airport and ATC, 3% by maintenance and 7% by miscellaneous matters. Although ATC accounted for only 5% of commercial aircraft accidents, which is comparatively lower than other factors, it should not be overlooked that the 55% portion for which pilot error accounts, either directly or indirectly involves ATC because the cooperation between a pilot and an air traffic controller composes a significant part of aircraft operation W. C. Moon et al (2011).

It has been estimated that between 60 and 90 percent of major incidents in complex systems such as aviation are caused by human error (Rouse & Rouse, 1983, as cited in Wickens & Hollands, 2000). Human errors are generically defined as all those occasions in which a planned sequence of mental or physical activities fail to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency (Salmon, et al., 2011).

On 7 December 1944, delegates from 52 nations met in the United States of America, formulated and signed the Convention on International Civil Aviation better known as the Chicago Convention. The resulting Convention set forth the principles for the safe, efficient and sustainable growth of civil aviation.

The Convention has since enabled the global civil aviation system to develop safely and systematically by setting global civil aviation regulatory policies and guidelines. It also led to the birth of the International Civil Aviation Organization (ICAO), a United Nations specialized agency with 191 Contracting States (ICAO Doc 7300).

As the number of aircraft and the demand for ATC services increases, so does the workload of the controller. Hopkins (1995) observes that human factors in air traffic control is evolving slowly from a mechanistic to a more socio-technical approach”, focusing more on the dynamics between controller and technology. While fundamental ergonomic issues regarding equipment and workplace design remain important, increasing focus is now being given to the role of human performance (including decision making and problem solving functions), communication, and teamwork. The impact of automation on ATC is also becoming more relevant, as a variety of new technologies are being introduced to help cope with the long term growth of air traffic, with the goal of alleviating stress within already congested airspace.

Despite this mandate, ICAO and Contracting States have struggled to address the challenges experienced in the development of civil aviation in the Africa-Indian Ocean region (AFI Region). Stolzer et al (2008) states that although aviation is among the safest mode of transportation in the world today, accidents still happen and in order to further reduce accidents and improve safety, proactive approaches must be adopted by the aviation community. Choforche (2012) argues that the performance of African aviation industry is still lagging behind those of the rest of the world (Birhanu et al 2012). Nonetheless, demand for air transport has increased steadily over the past years with passenger numbers and freight traffic growing by 45% and 80%, respectively according to African Development Bank Group.

Air transportation plays a vital role in the country’s growth process by accelerating convergence of goods and persons. The contribution of air transport far exceeds that of road transportation sevenfold. Growth in air transport has direct maps into economic growth due to spill over effects through creation of direct and indirect jobs in the industry and other auxiliary sectors such as tourism and other service sectors. Expansion of air transport creates market opportunities for local entrepreneurs by creating regional and global economic centres. Air transport plays a major role in driving sustainable economic and social development worldwide. According to the Global Aviation Safety Plan (GASP 2014-2016) air transport directly and indirectly supports the

employment of 56.6 million, over 2.5 billion passengers and \$5.3 trillion worth of cargo annually.

The global nature of the aviation industry, the complex and dynamic aviation environment requires that aviation regulators, air operators, and service providers cooperate to maintain a safe air transport system (Dannatt, 2006). According to the GSIE rating contained in the ICAO Safety Report (2014) while Africa accounted for the lowest percentage of global traffic volume at only 2%, it had the highest regional accident rate at 10% of the global share. Cognizant of the major challenges that Africa faces related to aviation safety, several programs have been developed and implemented by various aviation stakeholders. One of the 3 notable programs developed by ICAO is the Comprehensive Regional Implementation Plan for Aviation Safety in Africa (AFI Plan) established in January 2008 with the aim to support African States in addressing aviation safety deficiencies.

East African Community is a regional economic community determined to implement regional initiatives in the civil aviation sub-sector to enhance safety. The Community has, with effect from 1<sup>st</sup> June 2007, established a regional safety and security oversight agency as a specialized institution of the Community to oversee civil aviation safety and security in the region. Prior to this establishment the Partner States' civil aviation rules and regulations have been harmonized and are in conformity with Standards and Recommended Practices contained in the Annexes to the Convention on International Civil Aviation. East African Community Civil Aviation Safety and Security Oversight Agency (CASSOA) was established with the support of the AFI Plan as an autonomous self-accounting body of the East African Community following the signing of the Protocol for the Establishment of CASSOA by the three founder Partner States, Kenya, Tanzania and Uganda together with the two new entrants (the Republics of Burundi and Rwanda) , on 18th April 2007 during the 5th Extraordinary Summit of EAC Heads of State held in Kampala, Uganda. Despite all these initiatives however, aviation safety within African States remains elusive or negligible.

Kenya is a signatory to the Chicago Convention on International Civil Aviation Organization, and in accordance to Article 37 of the Convention it is obligated to comply with the ICAO SARPs. The Kenya Civil Aviation Act was enacted on 25th December 2013 and became effective on the same day. The Act established the Kenya Civil Aviation Authority (KCAA) as an autonomous corporate body. It performs two broad key functions; to provide air navigation

services in Kenya's Flight Information Region (FIR) and to regulate the aviation industry in Kenya.

Primary functions of KCAA are regulation and oversight of aviation safety and security, economic regulation of Air Services and development of civil aviation, provision of Air Navigation Services (ANS), and training of aviation personnel.

The KCAA's overall strategy as reflected in its strategic plan for period 2010-2015 is based on its commitment to provide a safe and efficient civil aviation environment that contributes to the achievement of Kenya's developmental objectives, as articulated in the Vision 2030. Since its establishment in 2002 KCAA has continued to implement its mandate despite facing various challenges mainly related to funding and level of autonomy. KCAA is undertaking various projects with the aim of delivering its part in Kenya's Vision 2030 which aims to make Kenya a middle income country by the year 2030. Some of the projects entail a restructuring project comprising aligning organizational structure to its strategy, recruitment, training and retention of competent staff, rightsizing and resourcing the organization appropriately, achieving international safety and security compliance, re-organization of the airspace and modernization of air traffic management systems.

A study carried out by the George Washington University Consortium (2004) indicates that many civil aviation regulatory authorities mandated by national governments to ensure safety and security of air transport operations are not able to sustain effective regulatory activities to match the pace of traffic growth. The ICAO Universal Safety Oversight Audit Programme (USOAP) follow up audit of Kenya conducted in 2013 revealed that the implementation of the Critical Elements (CE) pertaining to establishment of a regulatory system had improved significantly since the comprehensive audit of Kenya in 2008. However, the effective implementation of CEs relating to safety surveillance actions and resolution of safety concerns remained low, 61% and 51% respectively. Amongst others, Kenya had not established a mechanism to ensure the availability of sufficient aviation safety oversight personnel, and the Safety Management System of the aerodrome operator was not fully implemented. In addition, the CE relating to the establishment and effective function of incident and accident investigation remained at 42% low.

Inadequacy of aviation guidance material and oversight capability has the potential to permit unsafe acts and conditions that could hinder identification and resolution of system weaknesses and the attainment of enhanced safety, efficiency and continuity of aviation operations.

According to the Kenya Transport Sector Support Project, the aviation industry in Kenya has recorded major growth over the last 5 years. For instance, in 2004, about 5.5 million passengers were handled at Kenyan airports. This figure rose to 6.9 million in 2009 and to 8.6 million in 2012. In order to keep pace with this growth and increasing importance of the aviation sector in the development of Kenya, KCAA air navigation service and regulatory functions require strengthening.

The primary objective of ATC is ensuring the safe and orderly movement of aircraft through a nation's airspace. To accomplish this, ATC work is divided into three major services, namely; advisory services, flight information service and air traffic control service (U.S. Office of Personnel Management, 1978).

These three primary functional services are divided among the three different air traffic control units– Tower, Approach and en-route control units. These three ATC units control different areas and heights and are in constant communication with each other as they hand aircraft over from one area to the next. This involves efficient coordination and communication between the control areas. ATC manages a number of primary phases, ground operations (which oversee from the apron to the taxiway to the runway), take-off and climb, cross country flights and approach and landing (Wickens, Mavor, & McGee, 1997).

Controllers use navigation facilities and standard procedures to issue instructions and clearances to pilots in order to keep aircraft properly separated. ATC Clearance may include speed, altitude and directional information. ATC staff depends on radar, aircraft position reports as well as a visual view of the runways in order to issue control instructions that provide separations. This assures the orderly movement of aircraft that are departing, landing and approaching for landing. This is done through the conveyance of essential traffic information to pilots regarding clearances and other crucial procedural instructions (U.S. Office of Personnel Management, 1978).

In order to maintain certain separations between aircraft, controllers have to be apt at interacting with pilots, other controllers and a wide range of stimuli as well as making decisions based on



this range of input. Following this, it is apparent that the controller must be able to execute multiple cognitive functions simultaneously (Moon et al., 2011). Depending on the station controllers assume during their shift, they will deal with a wide variation of stimuli and objectives.

Station standing instructions (SSIs) convey a multitude of regulations and procedures that must be adhered to at all times. Included in the SSIs are the duty priorities of an ATCO and the correct phraseology to be used, among other aspects. The Duty Priority states that the ATCO is to give first priority to separating aircraft and issuing safety warnings. Good judgment shall be used in prioritizing all other provisions of service, based on the requirements of the situation at hand, within prescribed regulations and documentation. This provides the scope and primary purpose of ATC.

There are a number of different control areas that controllers may assume during a shift. Controllers in different control facilities rely on different types of stimuli to perform their tasks. For example, controllers in the tower depend on a direct visual of the airport whilst controllers in Radar approach control and en-route environments depend on computer-based, partially automated radar displays (Wickens et al., 1997). This demonstrates the range of cognitive tasks required by controllers in order to complete different tasks successfully. The variety of visual stimuli presented by differing technological displays is coupled with the dynamic nature of the constantly changing images which change according to priorities. During standard operations, controllers must take various contextual complexities into account in order to manage traffic successfully (International Civil Aviation Organization, 2005). Complexities may include dealing with adverse meteorological conditions, congested airspace and malfunctions, all of which are considered in this research. This calls for a number of different types of cognitive functions such as attention, situational awareness and information processing in order to successfully perform the task.

Previous research has found that controllers report and prioritize key goals in the following order; avoiding violation of minimum separation standards, avoiding deviations from standard operating procedures, avoiding any disorder that may result in overload and lastly, making unnecessary requests to the pilot (Seamster, Redding, Cannon, Ryder, & Purcell, 1993). These goals are focused on preventing safety events.

Safety event: It can often be difficult to identify the scope or extent of a safety occurrence as it can be difficult to establish when an occurrence really began (Eurocontrol, 2003). There are two principal safety events that can occur through erroneous Air Traffic Controlling, namely; loss of separation (LoS) and runway incursions (RI). This section explicates these primary safety events, providing a brief description of the safety standards and what is considered an infringement of those standards.

Runway incursion: A runway incursion is defined as “any occurrence at an aerodrome involving the incorrect presences of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft” (International Civil Aviation Organization, 2007). Kenya Civil Aviation Authority (KCAA) Standards and Procedure Manuals state that aerodrome control is responsible for issuing information and instructions in order to prevent collisions between aircraft flying in, taking off, landing and aircraft in the vicinity of the aerodrome traffic zone. The aerodrome is also responsible for aircraft and vehicles, obstructions and other aircraft on the manoeuvring area (CAA Standards & Procedures Manual, 2013). Aerodrome controllers are required to maintain a constant visual watch over the area the aerodrome is responsible for in order to ensure that it remains free of obstructions, vehicles and other obstructions when needed for aircraft movements (CAA Standards & Procedures Manual, 2013).

Loss of separation: A Loss of separations (LoS) involves an infringement of both horizontal and vertical separation minima in controlled airspace (International Civil Aviation Organization, 2013). The KCAA Standards and Procedure Manuals contains the regulations regarding minima for horizontal separation and sets the minimum separation at 5 Nautical Miles (Nm). Vertical separation is infringed upon when the vertical distance between aircraft falls less than the prescribed minima. KCAA Standards & Procedure Manual specifies the standards and regulations regarding vertical separation minima at 1,000 ft up to Flight Level (FL) 290 between all aircraft and 2,000 ft between all aircraft above FL410. A LoS is an event in which either horizontal or vertical separation minima are infringed upon.

Safety and standard rating: There are a number of procedures that are considered compulsory for controllers. These procedures include the practice of read-back, issuing traffic information and using radio telephony (R/T) phraseology. Read-back is defined as a procedure whereby the

receiving station repeats a received message or an appropriate part thereof back to the transmitting station so as to obtain confirmation of correct reception (ICAO Annex 10). Traffic information is issued in a strict format that must be followed and forwarded to aircraft in the airspace and R/T phraseology sets out the phrasing of communications to be used when controlling.

## **1.2 Statement of the Problem**

The safety of Kenyan air transport system is the Kenya Civil Aviation Authority's (KCAA's) guiding and most fundamental Strategic Objective. The unique approach to achieving this objective has been through adoption of International Civil Aviation Organization (ICAO) Standards and Recommended Practices and incorporating them into Kenyan aviation practices. ICAO is committed to developing proactive and risk-based solutions to reduce the global accident rate and the organization calls on the aviation community to recognize the importance of adhering to a globally harmonized approach to improving and monitoring safety programs.

Despite the significant efforts by KCAA to adhere to these safety measures, aircraft incident and accidents continue to be one of aviation safety's greatest challenges in the Kenyan airspace. In 2003, a plane crash in Busia resulted in the death of a cabinet minister and injuries to several other ministers. Investigations revealed that the cause of the accident was a combination of factors including human factors. Other high profile accidents include the 2006 crash of Kenya air force plane in Marabit that resulted in the death of 14 leaders and the 2008 plane crash in Narok resulting in the death of a cabinet minister and assistant minister. The 3 are among the 36 airplane accidents recorded in Kenya in the period between 1995 and 2012.

Since human factors is a major contributor to aviation incidents and accidents, it must be an important focus of any aviation safety strategy. It is by this background that the researcher felt it necessary to do a research on human factors affecting air traffic controllers in the discharge of their duties and bring forth mitigation strategies to these incidents and accidents.

### **1.3 Purpose of the study**

The purpose of this study was to examine the influences of human performance factors on the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority.

### **1.4 Objectives of the study**

The study was based on the following objectives:-

1. To determine how team work influence the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority.
2. To examine how alertness affect the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority
3. To assess the influence of communication skills on the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority
4. To establish the role of situation awareness in the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority

### **1.5 Research questions**

The study sought to answer the following questions:

- i. To what extent does team work influence the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority?
- ii. How does alertness affect the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority?
- iii. What is the influence of communication skills on the implementation safety programs in air traffic control in Kenya Civil Aviation Authority?
- iv. What is the role of situation awareness in the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority?

## **1.6 Research hypothesis**

The study was guided by the following hypothesis to be tested at 95% significance level:

- H1:** There is a relationship between team work and the implementation of safety programs in air traffic control.
- H2:** There is a relationship between alertness and the implementation of safety programs in air traffic control.
- H3:** There is a relationship between communication skills and the implementation of safety programs in air traffic control.
- H4:** There is a relationship between situation awareness and the implementation of safety programs in air traffic control.

## **1.7 Significance of the study**

This study is of immense significance to air traffic controllers in Kenya as it was set to outline human performance factors from the list of the past incident reports, and from the research to be conducted, their relationship and how they have affected the implementation of safety programs in the Kenyan airspace. Recommendations from this study will be used to mitigate or alleviate these human factors thereby improving safety in air traffic control in the Kenyan airspace.

International aviation bodies may use the outcome of the study to identify and establish programs tailored to deal with specific challenges in addressing human performance factors to safety of air traffic control.

To researchers and academicians, the study will be a supply of reference material for future researches on other related topics.

The study covers a very critical area in aviation safety and the recommendations of the research can be used in policy formulation.

## **1.8 Delimitation of the study**

The study was discrete to Kenya Civil Aviation Authority, Air Traffic Control Department. Of the nine human performance factors documented from the list of air traffic control incident analysis reports for the years 2013 and 2014, this study was set to only concentrate on four being team work, communication skills, alertness and situation awareness.

### **1.9 Limitations of the study**

The study faced the following limitations;

- 1 Insufficient resources both monetary and time to enable the researcher carry out a wider study of all the controllers. To mitigate this, the researcher reduced the sample to manageable size by using representatives of respondents from each of the 8 KCAA manned airports.
- 2 The collection of data was hard since ATCOs were adamant to give information as they felt it is a waste of their time. To mitigate this, the researcher proposed that the recommendations would be used for the benefit of the same ATCOs level of discharge of their duties.
- 3 Constraints in availability of relevant literature and materials, this being an under researched field in Kenya. The researcher hence intended to use internet search and aviation documents to search for the relevant literature and to consult with the aviation experts to improve the quality of the outcome.

### **1.10 Basic assumptions of the Study**

It was assumed that the information to be given by the respondents was true, trust worthy and valid in order to make reasonable conclusions that can be used in improving safety in the Kenyan airspace from the recommendations that will be made from this research

It was assumed that the questionnaires sent to the respondents was filled correctly and adequately returned back in good time for the analysis of the data.

It is also assumed that the instrument of the data collection is valid, representative and collected desired information.

### **1.11 Definitions of Significant Terms Used in the Study**

**Human Factors** Refers to human and individual characteristics, which influence behavior at work in a way which can affect safety.

**Air Traffic Control:** Refers to a service provided by ground-based controllers on the ground and through controlled airspace and can provide advisory services to aircraft in non-controlled airspace.

**Team Work:** Organized, collective working methods between established groups of people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission.

**Alertness:** Defined as the ability to maintain concentrated attention over prolonged periods of time

**Communication Skills:** Tailored to the ATC environment is the ability to exchange information, including timeliness, accuracy, clarity and receptiveness.

**Situation Awareness:** Is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.

### **1.12 Organization of the study**

The study was organized into five chapters. Chapter one comprised of background to the study, statement of the problem, and purpose of the study and objectives of the study and research questions. It also included basic assumptions of the study, limitations, delimitation and definition of significant terms and organization of the study. Chapter two deals with literature review related to the study thematically as per the study objectives, the theoretical frame work, conceptual framework as well as summary of literature review. Chapter three present the research methodology. It describes the research design, sampling techniques and sample size, research instruments validity and instrument reliability, data collection procedures, data analysis techniques and used in the study. Chapter four will contains data analysis, presentation and interpretations. The findings will also be discussed. Chapter five will contain the summary of the findings, discussions, conclusions and recommendations for action based on the study findings.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter contains an empirical review of pertinent literature on 4 factors of the 9 which were identified from the list of 22 incident reports for the years 2013-2014. These factors were: workload, planning, team work, communication skills, situation awareness, procedure adherence, alertness and attention, and their influence on performance in Air Traffic Control. This review will help in anchoring the study on the theoretical framework and in identification of gaps in the empirical studies from which the conceptual framework was formulated.

#### **2.2 Influence of team work on the implementation of safety programs in Air Traffic Control.**

Air traffic control work in the Kenyan air space is highly distributed and time-critical. Presently there are 196 licensed ATCOS in Kenya spread across 8 manned aerodromes who work in tandem to provide ATC services in the Nairobi (FIR). ATC is done from several different locations, aerodrome control from the tower, Terminal Maneuvering Area (TMA) control from the approach, and en route control from the Area Control Center. About eight hundred aircraft take off and land in Kenyan airports each day, and about two hundred other aircraft overfly through Kenyan airspace. Within and between these 'control rooms', ATCOS are working together to make the complex activity of air traffic control work safe and efficient. Team work is commonly referred to as the organized, collective working methods between an established group of people (Bailey & Thompson, 2000; Erdem & Ozen, 2003; Rasmussen & Jeppesen, 2006). The related concept of team work can be described as a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission (Salas, 1995).

Team work is a critical component in ATC, and "the work of the Individual controller is very much dependent on other controllers, reflected in communicating and coordination with other operational staff such as flight crews" (Woldring, 1999,). Rognin & Blanquart (2001) suggest that interactions occur between different individuals or teams within the phase of a flight. One



form of team work occurs between the duty controllers (DATCO) and coordinating controller, who are responsible for different tasks on the same controlled airspace. The coordinator facilitates the DATCO by coordinating aircraft and providing information when required. The shared physical workspace and control tools facilitate teamwork between controllers responsible for adjacent controlled airspace. When necessary, controllers in adjacent controlled airspaces will explicitly discuss and agree the coordination of aircraft between their control jurisdiction, for example, by confirming the flight level which the aircraft should exit or enter another. An additional, but relatively less investigated form of coordination occurs during shift-change between controllers, known as a hand-over. The outgoing controller must provide a comprehensive briefing of the current situation, control strategies and any upcoming issues to the incoming controller. Standard operating procedures define the information that should be included in a handover in an attempt to reduce omissions that may lead to human error. Each controller will take responsibility to facilitate the handover (Durso et al., 2007). In addition, the incoming controller will often scan multiple sources of information to gain a mental picture prior to taking over watch. When it is safe to do so, a verbal briefing of the situation will take place. The briefing time varies depending on the traffic situation, although it has been recommended that the ATCO taking over watch should report on duty 30 minutes prior to taking over watch. Coordination between various sub-teams is therefore pervasive in the ATC domain and critical to successful completion of a flight.

Coordination has been repeatedly found to influence human performance in the literature (Erdem&Ozen, 2003; Glaser et al., 1999; Rasmussen & Jeppesen, 2006). Specifically within the ATC domain, Malakis, Kontogiannis, and Kirwan (2010b) suggest "coordination appears to be associated with air traffic control performance" (p628) and provide several examples of coordination problems that have been implicated in several high profile aviation accidents (Malakis et al., 2010b). Seamster et al. (1993) conducted an ATC simulation study to investigate the elements of effective coordination and associations with performance. Scenarios depicting operational problems that could occur whilst controlling aircraft were presented to pairs of controllers, representing the executive and coordinating controllers. Controllers were asked to collaborate to solve the issue as they would normally. Scenarios varied by traffic load. High traffic loads could prevent verbal communications at selected points due to the volume and frequency of communications. Findings showed that the controller pairs who engaged in specific

team processes such as situational enquiries, maintaining awareness through monitoring and statements of intent maintained effective coordination and a high level of performance and were most efficient at controlling high volumes of traffic. Controllers who had highest performance also engaged in preplanning, and selection of control strategies during the lower taskloads before higher volumes of traffic. Without engaging in these mechanisms, or the effective application of team strategies, performance was not maintained to a high level suggesting the importance of effective coordination to maintain efficient and safe performance. Analyses of Incident reports also support an association between coordination and performance. The selected working definition describes coordination as 'collective and mutual interaction with humans in the system for performance'. The definition is designed to incorporate the multiple forms of interaction within the ATC system, from interaction between controllers on the same controlled airspace to larger distributed teamwork, for example, between controller and supervisors or pilots. Performance may be enhanced with specific effective teamwork elements. Conversely, inadequate coordination has been associated with performance declines and human errors.

### **2.3 Influence of Situation Awareness on the implementation of safety programs in Air Traffic Control.**

The ability of controllers to maintain an up-to-date mental model of a dynamic and complex traffic situation depends on their ability to integrate information about many aircraft into an internal structure (Mica Endsley 2000). This internalization allows relationships between aircraft to be understood (e.g., which aircraft are traffic for each other, relative speeds, bearings, and ascent or descent rates). This becomes a much more difficult job as the predictability of the aircraft decreases under self-separation conditions. More limited attention and working memory will be required to process each aircraft, leaving the controller with higher workload, poorer SA, or both. SA means (at least partly) knowing about current aircraft positions and flight plans and predicting future states so as to detect possible conflicts. Therefore, in operational terms, SA means having an understanding of the current state and dynamics of a system and being able to anticipate future change and developments. A general definition of SA is that it is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future Endsley, M. R. (1998).

Immanent in Endsley's (1988) commonly cited definition is the assumption that situation awareness (SA) is categorized into three distinct levels. Level 1 SA begins with a situation assessment, and incorporates attending to and perceiving the surrounding environment and the techniques needed to complete this such as visual scanning. Level 2 involves understanding of the current surroundings/situation. Finally, level 3 includes the prediction of the situation or surroundings in the near future (Endsley, 1995). SA is dynamic and the repetition of the process continuously updates understanding of the environment (Parasuraman et al, 2008). SA can also describe the product of the process. SA as a product is defined as "the knowledge that results when attention is allocated to a zone of interest" (Fracker, 1988, p102). The process of developing and maintaining SA, and the resulting SA product may have a bi-directional relationship. Sarter and Woods (1991) suggest that situation assessments result in perception which informs the SA product. This mental representation subsequently primes the individual to attend to specific information in the environment. A distinction can be made between the concepts of individual SA and team SA. Team SA refers to a shared or distributed awareness or mental representation of the environment between team members (Salas et al., 1995). Nevertheless, as this research focuses on individuals' human performance, only individual SA will be reviewed in this section and for the remainder of the research.

Within ATC, ATCOs must continually assess dynamic information sources to develop a mental representation of aircraft in 3D space and projected future aircraft locations. Simultaneously, other relevant information such as speed, destination, and size are assessed and integrated into the representation. Controllers call this 'the picture' (Endsley & Rodgers, 1994). Whitfield (1979) investigated the concept of 'the picture' through verbal data from controllers. Results suggested that controllers reported the picture to be a geographical representation. Whitfield (1979) concluded that the picture supplies information to the controller, from which to plan and project situations. Both static (e.g. knowledge about airspace structure) and dynamic (e.g. aircraft information) data were represented in the picture. Both controllers (Mogford, 1997) and researchers (Endsley & Rodgers, 1994) have stated that the picture is essential for effective air traffic control.

SA has therefore been deemed to be essential for the controller to choose appropriate action (Rognin & Blanquart, 2001). It is Important to note that although SA supports selection of an appropriate response, additional processes mediate this relationship. Inadequate or complete loss

of SA may negatively influence performance. 'Losing the picture' is a colloquial term for the controllers' temporary loss of the 3-dimensional mental representation. This loss makes it hard to control traffic safely. Simulation studies have reported findings of a relationship between SA and controller performance.

Data from incident report analyses have also documented associations between Inadequate SA and performance decline or performance-related incidents (Rodgers & Nye, 1993). Rodgers and Nye (1993) conducted an analysis of ATCO operational errors. SA was reported to be a key contributor, with 57% directly attributed to problems involving the radar display. Findings therefore suggest that inadequate SA may be negatively associated with ATCO performance. It was speculated that different levels of SA may lead to different errors and severities of consequences; further research may investigate this hypothesis in a controlled, experimental environment. Controllers may lose part of the picture, such as a single aircraft, which is negatively associated with performance. Kirwan (2011) reports an investigation into a series of similar ATCO-related loss of separation incidents. After a full investigation, Kirwan (2011) suggested that the incidents were occurring through a form of mental filtration, via 'layered situation awareness'. This concept relates to the demands on the controller; to facilitate performance, controllers may selectively focus on particular aircraft of immediate importance. Therefore, other aircraft not demanding action may become filtered out (Kirwan, 2011). Although this is an adaptive strategy to manage task demands, the strategy itself resulted in a partial loss of SA.

Other hypotheses suggest the decline of SA may result from higher workloads placing competing demands on spatial working memory, required for level 3 SA (Wickens et al., 1997). However, causes for inadequate SA are likely to be different depending on the level of SA that is affected. Separate levels of SA and associations with human performance and error should therefore receive further attention in the literature. The working definition of SA "maintenance of a coherent mental picture for current and future events based on continuous extraction of environmental information, which includes controller performance" was adapted from the ATC-specific Skybrary definition. This definition acknowledges the three levels of SA as defined by Endsley (1998), as well as the continuous and cyclical SA process. The inclusion of a mental picture recognizes SA as a product as well as a process, and the importance of this mental picture in the controllers' performance. As controllers colloquially refer to SA as 'the picture' this

definitions also incorporates natural language of an ATC environment. In conclusion, SA has been repeatedly shown to be essential for the work of the ATCO. Both systems and task factors can contribute to the operator's ability to achieve SA (Endsley, 1995a), with a dominant research finding of a negative relationship between taskload or workload and SA. Adequate SA can support performance, whereas both simulation studies and incident report analyses have revealed that inadequate, or loss of SA, can result in declines in performance and safety-related consequences.

## **2.5. Influence of employee communication skills on the implementation of safety programs in Air Traffic Control.**

Most research on Air Traffic Control communications has focused less on the interpersonal component of communications than on its content and form (Wickens et al., 1997). Therefore, this review will examine the communications components and its application to the ATC domain. Communication may be defined as the transfer of meaningful information from one person to another (Hogg & Vaughan, 2002) and involves both the production and the reception of messages, although communication is independent from the concepts of speech and language (Hogg & Vaughan, 2002; Huttunen et al. 2011). The basic model of communication requires a sender; a message or information; a receiver; and a channel of communication (Hogg & Vaughan, 2002). Isaac & Ruitenberg (1999) suggests that communication starts when a sender encodes an idea or message. The message is sent through one or more channels that are either verbal or non-verbal. Different channels have different processing implications for the receiver. The receiver must attend to and decode the message, drawing on long term memory to apply meaning to the symbolized message. Receivers differ in personal characteristics such as experience, culture and expectations which may influence the decoding and interpretation of the message. A distinction is made between separate forms of communication, including verbal and nonverbal (Isaac & Ruitenberg, 1999). Verbal forms of communication include speech and written communications (Hogg & Vaughan, 2002), as well as para-verbal signs accompanying speech. Huttunen et al. (2011) suggest that speech prosody elements such as pitch, tone and rhythm have an important role in communicating, supporting and contributing to the message, and the interpretation of the message by the receiver. Although it is beyond the scope of this review to examine each one in detail, it should be noted that each element of communication can

influence the likelihood of receipt and of correct interpretation by the receiver, and therefore the efficiency of the communication.

The foundation of ATC is Task-related communication (Huttunen et al., 2011) and is critical to the control task. Communications occur between aircraft pilots and ATCOS at different stages of a flight (Rognin & Blanquart, 2001). Verbal communications and para-verbal signs (see Huttunen et al., 2011) are the primary means of communication between ATCOs and aircraft pilots (although communications through written data link is contemporarily also used in specific Circumstances) to issue instructions and provide information (Wickens et al., 1997). In addition, communications between controllers in adjacent controlled airspaces are critical to the ATC task in order to coordinate aircraft movements between departure and destination aerodrome. Task-related communications between the DATCO and coordinating controller on the same controlled airspace also support the control task. When possible, verbal communications are also used for explicit discussion. However, due to the proximity of the two controllers, non-verbal communication such as gestures can be utilized effectively to send information (Rognin & Blanquart, 2001). To facilitate safe and efficient communication between various aviation professionals, task-related communications are regulated by a set of established communication standards. "The need for clear and unambiguous communication between pilots and ATCOS is vital in assisting the safe and expeditious operation of aircraft" (EUROCONTROL, ICAO Phraseology reference guide). English is used as the standardized language. In addition a standardized phraseology is used in all communications which has been designed for maximal clarity and to protect against ambiguity. Research findings have indicated that regulation and standardization of communication supports efficient communications (Kanki et al., 1991; McKinney et al., 2004; Rognin & Blanquart, 2001). Communications may influence performance both positively and negatively. Effective communication supports individuals in developing a shared awareness of the situation or system, supports teamwork and therefore results in a maintenance or increase of performance (Rognin & Blanquart, 2001; Kanki et al., 1991). A large body of work exists exploring the qualities of effective communications, such as Increased planning statements, structure and predictability (Kankl et al., 1991). Errors of communication have been repeatedly found to influence performance negatively, occasionally with severe consequences. Findings generally suggest that verbal and written communication errors have been a critical contributor to risk in a variety of industries (Gibson, Megaw, Young,

& Lowe, 2006,). General figures suggest 40% - 80% of incidents in safety-critical domains may result from communication errors (Sexton & Helmreich, 1999; Tajima, 2004). A number of taxonomies exist for classifying communication errors (e.g. Corradini & Cacciari, 2002; Skantze, 2005). Gibson et al. (2006) suggest that failures of communication may be defined by three primary criteria: the adequacy of the transfer of communication goals, deviations from accepted or regulated grammar, and errors of commission or omission when compared to contextual objectives or requirements. The factor of communication not only influences overall performance, but communication error may be therefore classified as a measure of performance. Incident report analyses have reported a relationship between errors of communication as a contributor to performance related incidents and performance decline (Isaac & Ruitenber, 1999; Rantanen, Mc Carley, & Xu, 2009). Communication errors within the controller-pilot read back-hear back closed loop are deduced to be contributors to aircraft breaches of separation minima. Cardosi et al (1998) conclude that Implementation of supports to reduce the number of communication errors between pilot and controller should be a priority. Several types of miscommunication are documented in literature from the aviation domain. Miscommunications can include ambiguity through word choices or distortions of meaning (Isaac & Ruitenber, 1999). This is more likely if standard phraseology is not used. Slips are also frequent forms of miscommunication, which result in verbally communicating information that was not intended (e.g. saying flight level 340 instead of 240). Of course, if this is not detected in the read back, the pilot may then follow the instruction. Miscommunications can result from a number of physical and psychological causes or contributing factors. Physically, the intelligibility of speech may be affected by the physical systems (Isaac & Ruitenber, 1999) such as the radiotelephony system blocking calls or distorting communications. Headphones may also create distortion to verbal messages potentially resulting in mis-hearing, as can a high level of ambient noise in the operations room. One of the more frequently reported psychological contributors to communication errors or miscommunication is the expectation bias. Expectation bias is thought to result from top-down information processing, as opposed to the more intensive bottom-up processing. Expectation about what the receiver is going to hear may override direct perception (Shorrock, 2007), potentially contributing to non-identification of errors in hear backs. The frequency and potential severity of consequences of communications errors have resulted in crew resource management for pilots and team resource management for controllers including training

for standardized and effective communications (Leonard et al., 2004). These initiatives have been shown to positively influence communications and resulting team performance (Leonard et al., 2004).

A working definition of communications tailored to the ATC environment is 'the exchange of information, including timeliness, accuracy, clarity and receptiveness'. Elements found to influence the effective transfer of information are explicitly acknowledged, although the definition is broad enough to encompass the many and distributed forms of communication which occur in ATC operations. In conclusion, communications are essential within ATC and the wider aviation domain. Separate forms of communications including verbal, para-verbal speech features, written and non-verbal are essential for the safe and efficient flow of traffic, through Communication between controllers and pilots as well as between teams of controllers. Communication errors and miscommunications have been associated with performance decline and performance-related incidents. Training programs are in place for aviation professionals that raise awareness of communication Issues and the potential consequences of communication errors.

## **2.6. Influence of alertness on the implementation of safety programs in Air Traffic Control.**

Alertness, also termed sustained concentration, is defined as the ability to maintain concentrated attention over prolonged periods of time (Warm, J. et al 2008). During this time, the person attempts to detect the appearance of a particular target stimulus. The individual watches for a signal stimulus that may occur at an unknown time (Sternberg, Robert, 2009). When the activity needs to be continued for a long period of time uninterrupted, the ability to be continuously alert for the period of the occurrence of unpredictable but critical events risk being compromised. Mackworth (1985) provided an early definition of alertness: "a state of readiness to detect and respond to certain small changes occurring at random time intervals in the environment" Recent findings indicate that maintaining vigilance under low taskload considerably requires a high mental workload. Hopkin (1988) noted that the emphasis in air traffic control research on high taskload and stress has led to a comparatively neglect of low taskload and boredom. If continuously being alert is boring but very demanding and if boredom itself is a stressor (Thackray, 1981), then the neglect of these factors becomes doubly serious. It therefore follows



that both low and high levels of taskload (for instance number of aircraft) can lead to substandard performance.

Being vigilant for critical events such as loss of separation, altitude deviations, VFR pop-ups, incorrect pilot read-backs, runway incursion, track deviations and other important events when on duty is an important component of air traffic control. However despite the importance of controller vigilance during operations in air traffic control, there are comparatively few studies of vigilance during simulated air traffic control.

The impact of vigilance on attention has been explored to a limited extent in the literature. Attention may be defined as the cognitive act of orienting and perceiving specific items in the environment (Eysenck, 2001). Vigilance and attention are argued to be independent constructs, although significantly related, as attention is required for vigilance tasks. Deaton and Parasuraman (1993) have hypothesized that vigilance would deplete cognitive resources, resulting in decreased attention. As attention resources are depleted, the vigilance decrement may occur, as suggested by the attention resource theory (Wickens, 1984). However, limited empirical research has investigated this hypothesis, and future research is needed to address this potential interaction. Further research is also needed to explore the bi-directional interactions between vigilance and other human factors. With increased knowledge of factor interactions and subsequent impacts on human performance, the potential to predict when human error is likely to occur is achievable (Hollenbeck et al., 1995). This would have significant implications for safety critical industries which depend on human operators monitoring automated systems.

## **2.7 Theoretical Framework of Aviation Safety Programs**

This section presents theories that were reviewed during this study. The safety models include the SHEL Model of human factors and Swiss Cheese Model.

### **2.7.1 The SHEL Model of human factors in Aviation Safety**

The SHEL Model is defined as the relationship of human factors and the aviation environment (Reinhart, 1996). This concept originated from the SHEL Model by Edwards in 1972, whereby the name was derived from the initials of its components (Software, Hardware, Environment, and Live-ware). In 1975, Hawkins developed the concept into the SHEL Model with an introduction of another Live-ware into the original concept, SHEL Model (Hawkins, 1987). The most different point between Edwards's SHEL Model (1972) and Hawkins's SHELL Model (1975) is that Hawkins urged for the necessity of another Live-ware (the person) and illustrated the interactions between the central Live-ware and each of other four systems (Hawkins, 1987).

It was generally noted that most of the air accidents and incidents are related to human factors, whereas the technical failures in aircraft maintenance today has enormously reduced with a number of advanced equipment inventions (Hawkins, 1987). Moreover, in the perception of human factors, every individual, either in the operation or the supporting part of aviation, has individual strengths and limitations. Thus, many states in the world strive to secure the safety by continuous training subject to the interactions of each of SHEL components (Hawkins, 1987).

The main elements in the model can be is the hardware which entails various equipment, tools, aircraft, workspace, buildings and other physical resources short of human elements in aviation; the software comprises non-physical resources such as organizational policies, rules and regulations, procedures, manuals and documents. The next element is the environment which entails in addition to containing factors which influence where people are working such as climate, temperature, vibration and noise, also contains socio-political and economic factors. The live-ware includes factors like teamwork, communication, alertness, situation awareness, leadership and norms. The central live-ware can be defined as human elements such as knowledge, attitudes, cultures and stress. This live-ware is regarded as the core of the SHEL Model and other components match with the live-ware as the central figure (Hawkins, 1987).

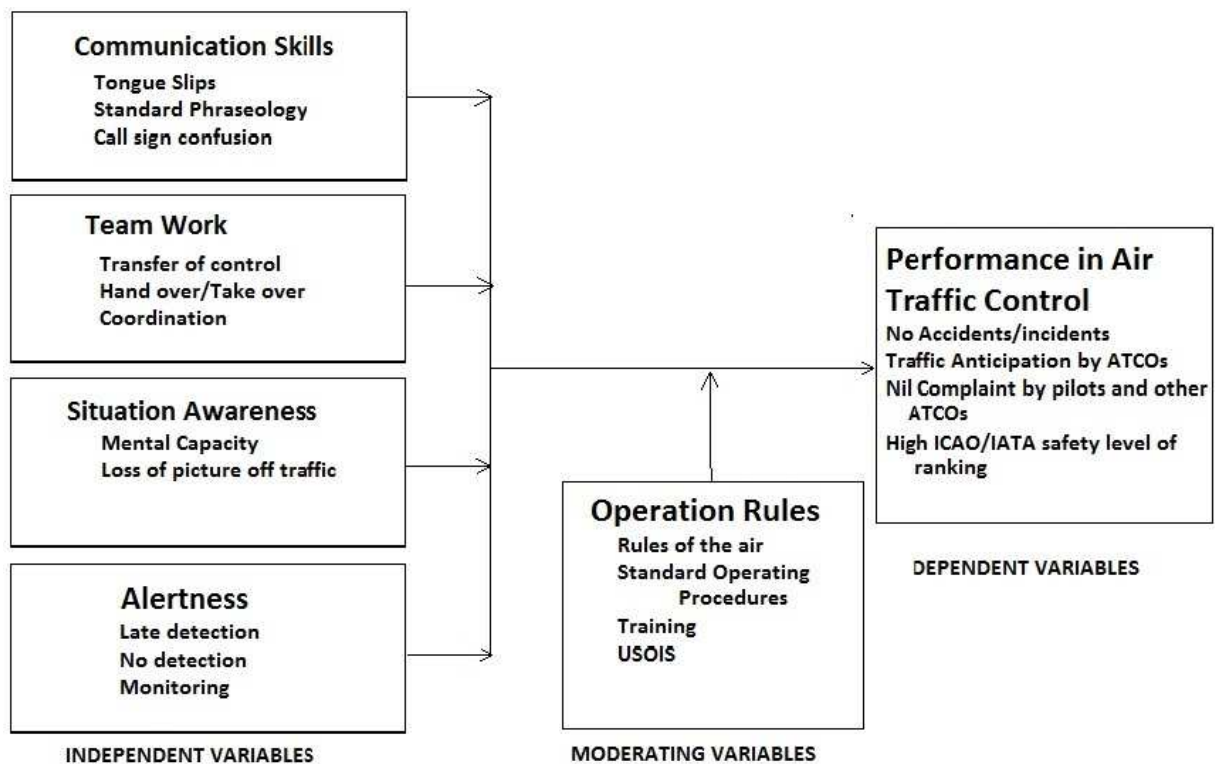
### **2.7.2 Swiss Cheese Model on Aviation Safety**

Industry-wide acceptance of the concept of the organizational accident was made possible by a simple, yet graphically powerful model developed by Professor James Reason, which provided a means for understanding how aviation operates successfully or drifts into failure (Wiegmann & Shappell 2003). According to the Swiss cheese model, accidents require the coming together of a number of enabling factors, each one necessary, but in itself not sufficient to breach system defenses. Complex systems such as aviation are extremely well-defended by layers of defenses in-depth, single-point failures are rarely consequential in the aviation system (Reason).

Equipment failures or operational errors rarely become breaches in safety defenses, but rather the triggers. Breaches in safety defenses are a delayed consequence of decisions made at the highest levels of the system, which remain dormant until their effects or damaging potential are activated by specific sets of operational circumstances. Under such specific circumstances, human failures or active failures at the operational level act as triggers of latent conditions conducive to facilitating a breach of the system's inherent safety defenses. In the concept advanced by the Reason model, all accidents include a combination of both active and latent conditions.

The Swiss cheese model of accident causation associates human system defenses to a series of slices of randomly-holed Swiss cheese arranged vertically and parallels to each other with gaps in-between each slice. Reason hypothesizes that most accidents can be traced to one or more of four levels of failure: organizational influences, unsafe supervision, preconditions for unsafe acts, and the unsafe acts themselves. In the Swiss cheese model, an organization's defenses against failure are modelled as a series of barriers, represented as slices of the cheese. The holes in the cheese slices represent individual weaknesses in individual parts of the system, and are continually varying in size and position in all slices. The system as a whole produces failures when holes in all of the slices momentarily align, permitting a trajectory of accident opportunity so that a hazard passes through holes in all of the defenses, leading to an accident.

**Figure 2.1 Conceptual framework**



## 2.9 Knowledge Gap

The study sought to establish the influences of human performance factors on the implementation of safety programs in air traffic control in Kenya Civil Aviation Authority. In current control environments human performance factors do occur in isolation or as a multiple thereby negatively affecting the successful implementation of safety programs in KCAA. The residual threats for incidents frequently result from the interaction these factors and their cumulative impact on performance.

However, relationships and interactions between these human performance factors and implementation of safety programs has received scant attention in the literature in Kenya. This has limited the study of performance in safety in air traffic control to a reactive, retrospective analysis of likely causes of incidents and accidents as opposed to proactive strategies for prevention of their occurrences. The study sought to research on four parameters namely: team work, communication skills, alertness and situation awareness with a view of establishing their influences on implementation of safety programs in air traffic control in KCAA.

### **2.3 Summary of Literature Review**

The literature presented summarizes research relating the four human factors (team work, communication skills, alertness and situation awareness) to performance. The review supported that each human factor had been reported to influence human performance, and specifically, human performance within an ATC setting. This information contributes background Information to the thesis and to the project aim of identifying a set of factors that have been found to influence controller performance. This section of the review has contributed to the current research by providing background information regarding previous findings, and provided initial information for later hypothesis generation of the relationships between factors. The review concludes with a suggestion that, in order to progress in the area of human performance, and human error prediction, it is necessary to focus future work on exploring the relationships between human factors, and the combined, subsequent association on human performance and error, in applied settings. This may serve to reduce the current controversies in this field, and lead to further understanding and progression in the area of human performance.

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1 Introduction**

The purpose of this chapter is to give an overview of the research methodology intended to be used in carrying out the research. It involves a blueprint for the collection, measurement and analysis of data. Among the areas covered include; the research design to be used, the target population to be studied, the sample size and sampling procedure to be applied, data collection methods, data collection instruments to be used and data collection procedures. Further, it examines the validity and reliability of the instruments to be used in data collection as well as data analysis and presentation procedures.

#### **3.2 Research Design**

Research design refers to how the researcher put a research study together to answer a set of questions. The research design is based on a strategic combination of methods to be applied to address the objectives of the thesis. Both quantitative and qualitative analysis research designs will be incorporated. Data specific to ATC environment (incident reports, questionnaire of air traffic control professionals) is to be used to gain a representation of human performance factors occurring in the field. This study will apply descriptive survey design. Descriptive research design is a scientific method which involves observing and describing the behavior of a subject without influencing it in any way (Shuttleworth 2008). Descriptive research design will be appropriate in this study since it can demonstrate the existence of human performance factors in ATC domain in KCAA and can challenge accepted assumptions about the way things are and can provoke action. This design is considered as most appropriate as well for purposes of determination of relationship between the variables.

#### **3.3 Target Population**

Quinlan (2011) defines target population as all individuals, items or units relevant to the study. This study comprises ATCOs and incident investigators. These populations were selected to capture perspectives from individuals with different experiences. ATCOs are familiar with factors that influence their performance whilst incident investigators have experience in the

factors that most frequently contribute to incidents. There are 196 Air Traffic Controllers in Kenya spread across 8 KCAA manned aerodromes, 4 accident investigators a manager in Air Traffic Services, a Director in Safety Standards Regulations and a Safety management systems coordinator from each of the KCAA manned aerodromes.

**Table 3.1 Target Population Distribution**

<b>Designation</b>	<b>Contact Person</b>	<b>Location</b>	<b>Number</b>
Air Traffic Controllers	Kenya Air Traffic Controllers	KCAA HQ	196
MATS	MATS	KCAA HQ	1
DASSR	DASSR	KCAA HQ	1
SMS Coordinators	SMS representatives	8 KCAA manned airports	4
Accident investigators	Accident investigators	KCAA HQ	8
<b>Total</b>			<b>210</b>

### 3.4 Sample Size and Sampling Procedure

Under this section, the method used to determine the sample size from the target population and from which data collected was presented. Further this section describes the sampling techniques used in selecting individuals to be included as the subjects of the study sample.

#### 3.4.1 Sample Size

A sample in research study is a group on which information is gathered (Frankel 2000). The whole idea of sampling is that by selecting some of the elements of a population we can draw conclusion about the entire population (Cooper 2006). The sample for this study comprised of 65 ATCOs and incident investigators to represent the general fraternity of Kenyan ATCOs. The study sample size has been calculated using Yamane formula (1996), which can be calculated at 3%, 5%, 7% and 10% precision (e) levels. Confidence level used is 95% with degree of variability (p) equivalent to 50% (0.5)

$$n = \frac{N}{1 + Ne^2}$$

n=sample size, N=study population (210), e=margin error of 10%, n= 63.2258 ≈ 63

Therefore the sample size was 65 which is 30% of the target population.

**Table 3.2 Sample size**

Designation	Number	Sample size
Air Traffic Controllers	196	55
MATS	1	1
DASSR	1	1
SMS Coordinators	8	4
Accident investigators	4	2
<b>Total</b>	<b>210</b>	<b>63</b>

### **3.4.2 Sampling procedure**

Multiple sampling techniques are intended to be used for this research, among them including chain referral sampling, snow ball sampling and cluster sampling. Chain-referral sampling and snow ball sampling will be used to generate a high number of responses, although this form of non-probability sampling may lead to sampling bias (Stangor, 2004) a larger sample may control for this potential bias by being more representative.

### **3.5 Data Collection Instruments**

Carroll (2011) defines data collection instruments as the tools able to measure the variables in the research questions. Limitations to the data mean that it is necessary to confirm and extend the findings with data specific to ATC setting to achieve the research aims. The researcher intends to use incident report analyses and standard questionnaires designed to fit a certain inquiry from the ATCOs.

#### **3.5.1 Incident Report Analysis**

The researcher conducted an analysis of KCAA incident reports for the years 2013 and 2014 to extend the findings from the literature review analysis. A quantitative frequency analysis identified single factors, factor dyads and factor triads that were most frequently recorded to contribute to ATCO performance-related incidents. Findings confirmed the factors identified in the literature analysis. However, the relative frequencies of consideration of factors differed between literature analysis and incident report analysis. Therefore, a questionnaire study is to be conducted to support the previous findings.



### **3.5.2 Survey-questionnaire of ATCOs**

A survey questionnaire was administered to all the respondents as sample from the target population of ATCOs. The questionnaire contains both closed and open ended questions so as to engage the respondents to give in-depth information where necessary. This instrument is considered to be relatively time friendly and cost effective for the purpose of this study.

A review of findings from the two methodologies provided a set of factors which most frequently and negatively influence ATCO performance. The data generated regarding factor relationships will contribute to hypothesis generation for future studies.

## **3.6 Validity and reliability of data collection instruments**

This section demonstrates how the validity and reliability of the data collection instruments will be satisfied by the study.

### **3.6.1 Validity of the research instrument**

Content validity of a measuring instrument is the extent to which it provides adequate coverage of the investigative questions guiding the study (Reichardt and Cook, 1997). The researcher finds it necessary to test the content validity of the research instruments to ascertain whether all the areas that are critical for this study will be included in the research instrument. The questionnaire will be pilot tested to some selected ATCO group among the sample population, with the outcome being used to improve it by ensuring the data obtained is sufficient to the subjects. Orodho (2004)

### **3.6.2 Reliability of research instrument**

Phelan (2005) defines reliability as the degree to which an assessment tool produces stable and consistent results. It is defined as a characteristic of an instrument that reflects the degree to which the instrument provokes consistent responses. The questionnaire will be pilot tested to some selected ATCOS among the sample group with the outcome being used to improve it by ensuring the data obtained is sufficient to the subjects.

### 3.7 Data Collection

#### 3.7.1 Incident Reports

The researcher intends to begin by obtaining relevant incident reports from the Manager of Air Traffic Control Service KCAA. This procedure will allow for selection of only those incident reports relevant to the aims of the study. The following information from each report will be captured in a spreadsheet:

1. Report identifier
2. Risk category
3. Percentage of incidents

**Table 3.3 Contributing Factors**

Factor	Report Identifier	Risk Category	Percentage of incidents
Team work			
Situation Awareness			
Communication Skills			
Alertness			

#### 3.7.2 Questionnaire

The questionnaire consists of items separated into two sections. Section 1 aimed to investigate the frequency of the co-occurrence of single factors in performance related loss of separation incidents and controller performance decrements. Participants are required to indicate the frequency with which that single factors influenced controller performance.

The second section of the questionnaire aimed to investigate the impact of each factor, when combined with another factor, on performance.

Once the questionnaire was developed, two controllers and one incident investigator in addition to two human factors professionals (SMS coordinator), reviewed and approved the questionnaire prior to distribution.

### **3.8 Data Analysis Technique**

Orodho (2002) defines data analysis as the examination of what has been collected in a survey or experiment and making deductions and inferences from this data thorough organizing the data, breaking it into manageable units, synthesizing it as well as searching for patterns.

After the questionnaires were returned, the raw data collected will be cleaned, edited, coded and tabulated in line with the study objectives. The quantitative data collected using the closed ended items of the questionnaire will be assigned ordinal values and analyzed using statistics of percentages, median and standard deviation. The organized data will then be used in testing of hypotheses of the study. Chi square test of the hypotheses will be done on the data. Chi square test will be used since the result is expected to be non-parametric and would give a much more holistic association of the human performance variables with performance.

### **3.9 Ethical Issues**

Munyoki, (2014), argues that Ethics in research should be viewed as integral part of the research planning and implementation, not viewed as an afterthought or a burden. With this in mind, the research work was guided by strict adherence to research ethics which did not allow the researcher to engage in deception or invasion of privacy. Among standard ethics include.

1. The respondents 'right not to respond to the questions was clarified from the onset and consent sought from the word go.
2. The anonymity of the respondents was assured and confidentiality guaranteed as an integral part of the research.
3. Seeking relevant authorization in the university, the state and KCAA before conducting any research.
4. The researcher will maintain humility and conduct the research with utmost honesty avoiding distortions and misleading data manipulation.

### 3.10 Operation of the variables

<b>Objective</b>	<b>Variables</b>	<b>Indicators</b>	<b>Proposed tool of analysis</b>
To investigate the extent to which team work influence the safety of air traffic control in KCAA	Departure and arrival estimates passed to other units	Knowledge of relevant traffic to concerned ATC units	Descriptive statistics
To examine how alertness affect the level of safety of air traffic control in KCAA	Number of aircraft conflicts	Radar vectors given to aircraft Alteration of aircraft direction	Descriptive statistics
To assess the influence of communication skills on safety of air traffic control in KCAA	Effectiveness of communication (Read backs and hear backs)	Use of Standard Communication Procedures and R/T Phraseology	Descriptive statistics
To establish the role of situation awareness in safety of air traffic control in KCAA	Knowledge of aircraft position	Anticipation of incoming traffic	Descriptive statistics

## CHAPTER FOUR

### DATA ANALYSIS, PRESENTATION AND INTERPRETATION

#### 4.1 Introduction

Results from the experiment study are presented in order of the research questions and associated hypotheses. A discussion of findings is presented at the end of each results section to facilitate interpretation of the results in relation to the research questions.

#### 4.2 Questionnaire Response Rate

Questionnaire response rate indicates the percentages of the questionnaires that were filled and returned by the respondents. The returned questionnaires were the ones analyzed. Table 4.1 shows the response rate from the sample size.

**Table 4.1 Questionnaire Response Rate**

Designation	Sample Size	Return Rate
Air Traffic Controllers	61	61
Accident/Incident investigators	4	4
<b>Total</b>	<b>65</b>	<b>65</b>

All the respondents targeted completed and returned the questionnaires which constituted a response rate of 100%. This response rate is excellent and representative of the target population as noted by Mugenda and Mugenda (2003) who posits that a response rate above 70% is excellent while a rate of 60% is good and 50% is adequate for analysis and reporting.

#### 4.3 Demographic Characteristics of the Respondents

As part of their demographic information, the study sought to establish the background information of respondents. This included age, gender, level of education, station (geographical location) and years of work experience.

##### 4.3.1 Distribution of Respondents by Age

The respondents were distributed by their age groups as shown in table 4.2 below.

**Table 4.2 Distribution of Respondents**

Age (years)	Frequency	Valid Percent	Cumulative Percent
<b>20-30</b>	5	8	8
<b>31-40</b>	50	76	84
<b>41 and above</b>	10	16	100.0
<b>Total</b>	<b>65</b>	<b>100</b>	

As shown in table 4.3 above, majority of the respondents were the youth. It therefore implies that air traffic control engages youth as the majority while a few of the persons engaged are middle aged mainly in the senior and managerial positions.

#### **4.3.2 Distribution of Respondents by Geographical Location**

The study sought to find out the geographical location of respondents. This was important as the project was carried out across the 8 KCAA manned airports (stations)

**Table 4.3 Distribution of Respondents by Geographical location (station)**

Location	Frequency	Valid Percent	Cumulative Percent
JKIA	20	29	29
MIA	15	23	52
WILSON	15	23	75
KIA	3	5	80
ELD	3	5	85
WAJIR	3	5	90
LOKI	3	5	95
MLD	3	5	100
<b>Total</b>	<b>65</b>	<b>100</b>	<b>100</b>

As shown in table 4.2 above, majority of the respondents; 29% were from JKIA, while only 5% from MLD, LOKI WAJIR ELD AND KIA. This is in line with the magnitude of responsibility of JKIA controllers who are responsible for provision of ACC, APP AND TWR services. MIA, ELD LOKI AND WAJIR controllers provide APP and TWR services while WILSON, MLD and KIA controllers only provide TWR services.

### 4.3.3 Distribution of respondents accordance to gender

**Table 4.4 Distribution of Respondents by gender**

Gender	Frequency	Valid Percent	Cumulative Percent
<b>Male</b>	50	77%	77%
<b>Female</b>	15	23%	100%

The information above shows that majority of the respondents interviewed were males 50(77%) while the number of the females interviewed were only 15(23%) of the respondents. This shows that most of the KCAA air traffic controllers were males.

### 4.3.4 Distribution of respondents accordance to level of education

**Table 4.5 Distribution of Respondents by level of education**

Age (years)	Frequency	Valid Percent	Cumulative Percent
<b>Secondary</b>	0	0%	0%
<b>Tertiary college</b>	12	18%	18%
<b>University</b>	53	82%	100.0%
<b>Total</b>	<b>65</b>	<b>100</b>	

The above analysis shows that most of the respondents interviewed were educated up to university level 53(82%) while those educated up to tertiary college level followed at 12(18%) of the respondents. This shows that most of the respondents interviewed had a higher level of education so as to understand how the factors in question would influence the implementation of safety programs in KCAA.

## 4.4 Influences of teamwork on the implementation of safety programs in air traffic control in KCAA

The first objective was to determine the influence of team work on the implementation of safety programs in air traffic control in KCAA.

**Table 4.6 Teamwork and implementation of safety programs**

Rating on effect of team work	Frequency	Percent
Very often	45	69%
Often	16	24%
Sometimes	2	3%
Rarely	1	2%
Very rarely	1	2%
Total	65	100%

Majority of the respondents were of the opinion that team work has very often affected their ability to provide a safe service 44(69%). 15(24%) of the respondents were of the opinion that team work has often affected their ability to provide a safe service. 2(3%) were of the opinion that team work has sometimes affected their ability to provide a safe service. Only 1(2%) of the respondents were of the opinion that team work has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that team work affects the implementation of safety programs in air traffic control. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.585 and standard deviation 0.762.

Using chi square testing to test the hypothesis;

H<sub>1</sub> There is a relationship between team work and the implementation of safety programs in air traffic control.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Likert scale	1	2	3	4	5
Observed (O)	1	1	2	16	45
Expected (E)	13	13	13	13	13

$\chi^2=110.923 > \chi^2_{\alpha 0.05} =9.488$  at 4 degrees of freedom and 95% level of significance

We accept the alternative hypothesis in that there is a relationship between team work and the implementation of safety programs in air traffic control in KCAA.



#### 4.5 Influences of communication skills on the implementation of safety programs in air traffic control in KCAA

The second objective was to determine the influence of alertness on the implementation of safety programs in air traffic control in KCAA.

**Table 4.7 Communication skills and implementation of safety programs**

Rating on effect of communication skills	Frequency	Percent
Very often	20	30%
Often	17	26%
Sometimes	23	36%
Rarely	4	6%
Very rarely	1	2%
Total	65	100%

Majority of the respondents were of the opinion that communication skills have sometimes affected their ability to provide a safe service 23(36%). 20 (30%) of the respondents were of the opinion that communication skills have very often affected their ability to provide a safe service. 17(26%) were of the opinion that communication skills have often affected their ability to provide a safe service. Only 4(6%) and 1 (2%) of the respondents were of the opinion communication skills have rarely and very rarely in each case affected their ability to provide a safe service. From the above information, more people agreed that communication skills affected their ability to provide a safe service. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.597 and standard deviation 0.569.

Using chi square testing to test the hypothesis;

H<sub>2</sub> There is a relationship between communication skills and the implementation of safety programs in air traffic control.

$$x^2 = \sum \frac{(O-E)^2}{E}$$

Likert scale	1	2	3	4	5
Observed (O)	1	4	23	17	20
Expected (E)	13	13	13	13	13

$\chi^2=30 > \chi^2_{\alpha 0.05} =9.488$  at 4 degrees of freedom and 95% level of significance

We accept the alternative hypothesis in that there is a relationship between communication skills and the implementation of safety programs in air traffic control in KCAA.

#### 4.6 Influence of situation awareness on the implementation of safety programs in air traffic control in KCAA

The third objective was to determine the influence of situation awareness on the implementation of safety programs in air traffic control in KCAA.

**Table 4.8 Situation awareness and implementation of safety programs**

Rating on effect of team work and situation awareness	Frequency	Percent
Very often	58	89%
Often	5	8%
Sometimes	2	3%
Rarely	0	0%
Very rarely	0	0%
Total	65	100%

Most of the respondents were of the opinion that situation awareness has very often affected their ability to provide a safe service 58(89%). 5 (8%) of the respondents were of the opinion that situation awareness has often affected their ability to provide a safe service, while only 2 (3%) of the respondents were of the opinion situation awareness has ever affected their ability to provide a safe service. From the above information, most people agreed that situation awareness has affected their ability to provide a safe service. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.862 and standard deviation 0.425.

Using chi square testing to test the hypothesis;

H<sub>3</sub> There is a relationship between situation awareness and the implementation of safety programs in air traffic control.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Likert scale	1	2	3	4	5
Observed (O)	0	0	2	5	58
Expected (E)	13	13	13	13	13

$\chi^2_c = 196 > \chi^2_{\alpha 0.05} = 9.488$  at 4 degrees of freedom and 95% level of significance

We accept the alternative hypothesis in that there is a relationship between situation awareness and the implementation of safety programs in air traffic control in KCAA.

#### 4.7 Influences of alertness on the implementation of safety programs in air traffic control in KCAA

The fourth objective was to determine the influence of alertness on the implementation of safety programs in air traffic control in KCAA.

**Table 4.9 Alertness and implementation of safety programs**

Rating on effect of alertness	Frequency	Percent
Very often	50	76%
Often	13	20%
Sometimes	2	3%
Rarely	0	0%
Very rarely	0	0%
Total	65	100%

Majority of the respondents were of the opinion that alertness has very often affected their ability to provide a safe service 50(76%). 13(20%) of the respondents were of the opinion that alertness has often affected their ability to provide a safe service. 2(3%) were of the opinion that alertness has sometimes affected their ability to provide a safe service. None was of the opinion that alertness has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that alertness affects the implementation of safety programs in air traffic control. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.738 and standard deviation 0.505.

Using chi square testing to test the hypothesis;

$H_4$  There is a relationship between alertness and the implementation of safety programs in air traffic control.

$$x^2 = \sum \frac{(O-E)^2}{E}$$

Likert scale	1	2	3	4	5
Observed (O)	0	0	2	13	50
Expected (E)	13	13	13	13	13

$x_c^2=140.615 > x_{\alpha 0.05}^2 =9.488$  at 4 degrees of freedom and 95% level of significance

We accept the alternative hypothesis in that there is a relationship between alertness and the implementation of safety programs in air traffic control in KCAA.

**Table 4.10 Combination of teamwork and alertness**

Rating on effect of team work and alertness	Frequency	Percent
Very often	15	24%
Often	30	46%
Sometimes	10	15%
Rarely	8	12%
Very rarely	2	3%
Total	65	100%

Majority of the respondents were of the opinion that a combination of team work and alertness have often affected their ability to provide a safe service 30(46%). 15(24%) of the respondents were of the opinion that the combination has very often affected their ability to provide a safe service. 10(%) were of the opinion that this combination has sometimes affected their ability to provide a safe service.8(12%) of the respondents were of the opinion that the combination has rarely affected their ability to provide a safe service while 2(3%) were of the opinion that this combination has very rarely affected their ability to provide a safe service. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 3.738 and standard deviation 1.085.

Chi square test values  $x_c^2=34.462 > x_{\alpha 0.05}^2 =9.488$  at 4 degrees of freedom and 95% level of significance signify there is a relationship between a combination of teamwork and alertness and the implementation of safety programs in air traffic control in KCAA.

**Table 4.11 Combination of teamwork and communication skills**

Rating on effect of team work and communication skills	Frequency	Percent
Very often	25	38%
Often	21	32%
Sometimes	12	19%
Rarely	5	8%
Very rarely	2	3%
Total	65	100%

Majority of the respondents were of the opinion that combination of team work and communication skills have very often affected their ability to provide a safe service 25(38%). 21(32%) of the respondents were of the opinion that the combination has often affected their ability to provide a safe service. 12(19%) were of the opinion that the combination has sometimes affected their ability to provide a safe service. Only 5(8%) and 2(3%) respectively of the respondents were of the opinion that the combination has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that combination of team work and communication skills affects the implementation of safety programs in air traffic control. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 3.954 and standard deviation 1.073.

Chi square test values  $\chi_c^2=30.308 > \chi_{\alpha}^2_{0.05} =9.488$  at 4 degrees of freedom and 95% level of significance signify there is a relationship between a combination of teamwork and communication skills and the implementation of safety programs in air traffic control in KCAA.

**Table 4.12 Combination of teamwork and situation awareness**

Rating on effect of team work and situation awareness	Frequency	Percent
Very often	42	65%
Often	13	20%
Sometimes	6	9%
Rarely	4	6%
Very rarely	0	0%
Total	65	100%

Majority of the respondents were of the opinion that combination of team work and situation awareness have very often affected their ability to provide a safe service 42(65%). 13(20%) of the respondents were of the opinion that the combination has often affected their ability to provide a safe service. 6(9%) were of the opinion that the combination has sometimes affected their ability to provide a safe service. Only 4(6%) of the respondents were of the opinion that the combination has rarely affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that combination of team work and situation awareness affects the implementation of safety programs in air traffic control. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.431 and standard deviation 0.799.

Chi square test values  $\chi_c^2=87.692 > \chi_{\alpha}^2_{0.05}=9.488$  at 4 degrees of freedom and 95% level of significance signify there is a relationship between a combination of teamwork and situation awareness and the implementation of safety programs in air traffic control in KCAA.

**Table 4.13 Combination of alertness and communication skills**

Rating on effect of team work and alertness	Frequency	Percent
Very often	15	23%
Often	20	31%
Sometimes	19	29%
Rarely	6	10%
Very rarely	5	7%
Total	65	100%

Majority of the respondents were of the opinion that combination of alertness and communication skills have often affected their ability to provide a safe service 20(31%). 19(29%) of the respondents were of the opinion that the combination has sometimes affected their ability to provide a safe service. 15(23%) were of the opinion that the combination has very often affected their ability to provide a safe service. Only 6(10%) and 5(7%) respectively of the respondents were of the opinion that the combination has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that combination of alertness and communication skills affects the

implementation of safety programs in air traffic control. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 3.523 and standard deviation 1.165.

Chi square test values  $\chi^2_c=15.538 > \chi^2_{\alpha 0.05} =9.488$  at 4 degrees of freedom and 95% level of significance signify there is a relationship between a combination of alertness and communication skills and the implementation of safety programs in air traffic control in KCAA.

**Table 4.14 Combination of communication skills and situation awareness**

Rating on effect of team work and alertness	Frequency	Percent
Very often	17	26%
Often	19	29%
Sometimes	20	31%
Rarely	8	12%
Very rarely	1	2%
Total	65	100%

Majority of the respondents were of the opinion that combination of communication skills and situation awareness have sometimes affected their ability to provide a safe service 20(31%). 19(29%) of the respondents were of the opinion that the combination has often affected their ability to provide a safe service. 17(26%) were of the opinion that the combination has very often affected their ability to provide a safe service. Only 8(12%) and 1(2%) respectively of the respondents were of the opinion that the combination has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that combination of communication skills and situation awareness affects the implementation of safety programs in air traffic control. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 3.662 and standard deviation 1.042.

Chi square test values  $\chi^2_c=20.769 > \chi^2_{\alpha 0.05} =9.488$  at 4 degrees of freedom and 95% level of significance signify there is a relationship between a combination of communication skills and situation awareness and the implementation of safety programs in air traffic control in KCAA.

**Table 4.15 Combination of alertness and situation awareness**

Rating on effect of team work and situation awareness	Frequency	Percent
Very often	31	48%
Often	18	28%
Sometimes	11	16%
Rarely	4	6%
Very rarely	1	2%
Total	65	100%

Majority of the respondents were of the opinion that combination of alertness and situation awareness have very often affected their ability to provide a safe service 31(48%). 18(28%) of the respondents were of the opinion that the combination has often affected their ability to provide a safe service. 11(16%) were of the opinion that the combination has sometimes affected their ability to provide a safe service. Only 4(6%) and 1(2%) respectively of the respondents were of the opinion that the combination has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that alertness and situation awareness affects the implementation of safety programs in air traffic control. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.138 and standard deviation 1.006.

Chi square test values  $\chi_c^2=44.462 > \chi_{\alpha 0.05}^2=9.488$  at 4 degrees of freedom and 95% level of significance signify there is a relationship between a combination of alertness and situation awareness and the implementation of safety programs in air traffic control in KCAA.

**Table 4.16 Summary of Mean, Standard deviation & chi square for the variables**

Factor	Mean	SD	$\chi_c^2$	$\chi_{\alpha 0.05}^2$
Team work	4.585	0.762	110.923	9.488
Communication skills	4.597	0.569	30	9.488
Situation awareness	4.862	0.425	196	9.488
Alertness	4.738	0.505	140.615	9.488
Team work and communication skills	3.954	1.073	30.308	9.488
Team work and situation awareness	4.431	0.799	87.692	9.488
Team work and alertness	3.738	1.085	34.462	9.488
Communication skills and situation awareness	3.662	1.042	20.769	9.488
Communication skills alertness	3.523	1.165	15.538	9.488
Situation awareness and alertness	4.138	1.006	44.462	9.488



The range of means was calculated from 3.52 to 4.8 indicating a general high response to the items. Data were further analyzed with non-parametric statistics, Chi square test which revealed homogeneity of response of the respondents thereby implicating that there is a relationship between the variables and performance.

**CHAPTER FIVE**  
**SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND**  
**RECOMMENDATIONS**

**5.1 Introduction**

This chapter presents a summary of the study findings, conclusions and recommendations. The findings are summarized in line with the objectives of the study which include team work, communication skills, situation awareness and alertness. These independent variables were studied against the dependent variable which is performance in the implementation of safety programs in air traffic control in KCAA.

**5.2 Summary of Findings**

This section presents the findings from the study on the influences of human performance factors on the implementation of safety programs in air traffic control the case of Kenya Civil Aviation Authority. It was established that all the human performance factors influenced the implementation of safety programs in air traffic control in KCAA and that this influence was statistically significant at 95% level of significance and 4 degrees of freedom.

**5.2.1 Findings on influences of teamwork on the implementation of safety programs in air traffic control in KCAA**

The study established that majority of the respondents were of the opinion that team work has very often affected their ability to provide a safe service 44(69%). 15(24%) of the respondents were of the opinion that team work has often affected their ability to provide a safe service. 2(3%) were of the opinion that team work has sometimes affected their ability to provide a safe service. Only 1(2%) of the respondents were of the opinion that team work has rarely and very rarely in each case affected their ability to provide a safe service. Rating of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.585 and standard deviation 0.762.

The study established that there exists a significant relationship between team work and the implementation of safety programs in KCAA with a chi square test value of  $\chi^2_c=110.923 > \chi^2_{\alpha 0.05}=9.488$  at 4 degrees of freedom and 95% level of significance.

### **5.2.2 Findings on influences of communication skills on the implementation of safety programs in air traffic control in KCAA**

The study established that majority of the respondents were of the opinion that communication skills have sometimes affected their ability to provide a safe service 23(36%). 20 (30%) of the respondents were of the opinion that communication skills have very often affected their ability to provide a safe service. 17(26%) were of the opinion that communication skills have often affected their ability to provide a safe service. Only 4(6%) and 1 (2%) of the respondents were of the opinion communication skills have rarely and very rarely in each case affected their ability to provide a safe service. From the above information, more people agreed that communication skills affected their ability to provide a safe service. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.597 and standard deviation 0.569.

The study established that there exists a significant relationship between communication skills and the implementation of safety programs in KCAA with a chi square test value of  $\chi^2_c=30 > \chi^2_{\alpha 0.05}=9.488$  at 4 degrees of freedom and 95% level of significance.

### **5.2.3 Findings on influences of situation awareness on the implementation of safety programs in air traffic control in KCAA**

The study established that Most of the respondents were of the opinion that situation awareness has very often affected their ability to provide a safe service 58(89%). 5 (8%) of the respondents were of the opinion that situation awareness has often affected their ability to provide a safe service, while only 2 (3%) of the respondents were of the opinion situation awareness has ever affected their ability to provide a safe service. From the above information, most people agreed that situation awareness has affected their ability to provide a safe service. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.862 and standard deviation 0.425.

The study established that there exists a significant relationship between situation awareness and the implementation of safety programs in KCAA with a chi square test value of  $\chi^2_c=196 > \chi^2_{\alpha 0.05}=9.488$  at 4 degrees of freedom and 95% level of significance.

#### **5.2.4 Findings on influences of alertness on the implementation of safety programs in air traffic control in KCAA**

The study established that majority of the respondents were of the opinion that alertness has very often affected their ability to provide a safe service 50 (76%). 13(20%) of the respondents were of the opinion that alertness has often affected their ability to provide a safe service. 2(3%) were of the opinion that alertness has sometimes affected their ability to provide a safe service. No one was of the opinion that alertness has rarely and very rarely in each case affected their ability to provide a safe service. From the above information, it is clear according to the opinion of majority that alertness affects the implementation of safety programs in air traffic control. Frequency of occurrence ranked 1-5 (5 being very often) the mean was found to be 4.738 and standard deviation 0.505.

The study established that there exists a significant relationship between situation awareness and the implementation of safety programs in KCAA with a chi square test value of  $\chi^2_c=140.615 > \chi^2_{\alpha 0.05}=9.488$  at 4 degrees of freedom and 95% level of significance.

#### **5.3 Conclusions**

The ever growing air traffic volumes and congestions in the Kenyan airspace and forecasts of continued growth into the next decade put a strain on Kenyan air traffic controllers' capacity. International Air Transport Association, for example predicts an average annual passenger traffic growth rate of 5.0% during the next 20 years. The research presented in this study addresses long standing research gaps within human performance literature in relation to implementation of safety programs in the aviation industry. This research therefore provides a foundation from which to develop an ecologically valid and comprehensive understanding of human performance factors and associated implications for controller performance in the implementation of safety programs.

This research has also achieved the understanding of some of key areas the safety programs needs to focus on during training and safety sensitization.

#### **5.4 Suggestions for Further Research**

On the basis of what has been found out from this study, the researcher recommends that similar studies be conducted with different variables being; stress, age, attitude and fatigue and their influence on implementation of safety programs in air traffic control.

In addition, since the study was done at only the KCAA manned airports, the researcher finds it necessary that other studies be done in the unmanned airports within the Kenyan airspace.

Finally the researcher suggests that similar study be carried out to find out the influences of the same factors in the interaction between pilots and controllers since this forms major part of the whole phase of a flight.

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**APPENDIX I: LETTER OF TRANSMITTAL**

Mr. Erick O. Ngolo,

P. O. Box 93939 – 80115,

Mombasa.

Date .....

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

**RE: DATA COLLECTION**

I am Mr. Erick Oduor Ngolo, a student at the University of Nairobi (UoN), School of Continuing and Distance Education (SCDE) pursuing a Degree of Masters of Arts in Project Planning and Management, registration number: L50/76430/2014.

It is a requirement of the course that I collect data from the field with which a research project report will be prepared for presentation. My research topic is INFLUENCES OF HUMAN PERFORMANCE FACTORS ON SAFETY PROGRAMS IN AIR TRAFFIC CONTROL A CASE OF KENYA CIVIL AVIATION AUTHORITY.

All the data collected is related to the research topic mentioned and it is purely for academic purposes. Information gathered will be treated with utmost confidentiality.

Your cordial cooperation and sincerity will be highly appreciated.

Yours faithfully,

Erick O. Ngolo.

## APPENDIX II: QUESTIONNAIRE

The purpose of this questionnaire is to gather research information on influences of human performance factors on safety programs in air traffic control in KCAA. The questionnaire has five sections. For each section, kindly respond to all items using a tick. Tick only one response per question unless the question requires multiple responses.

### SECTION A: DEMOGRAPHIC INFORMATION

a) Age group

<input type="checkbox"/> 20-30years	<input type="checkbox"/> 31-40 years	<input type="checkbox"/> Above 40 years
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b) Gender

<input type="checkbox"/> male	<input type="checkbox"/> female
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c) Level of education

<input type="checkbox"/> secondary	<input type="checkbox"/> tertiary college	<input type="checkbox"/> university
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a) Please select your current occupation

<input type="checkbox"/> Air Traffic Controller	<input type="checkbox"/> Incident Investigator
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a) Are you currently an air traffic control trainee?

<input type="checkbox"/> yes	<input type="checkbox"/> no
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b) How many years of experience do you have in air traffic control?

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c) In which area(s) have you received training in air traffic control?

<input type="checkbox"/> Tower	<input type="checkbox"/> Approach procedural	<input type="checkbox"/> Approach Radar	<input type="checkbox"/> Area Control	<input type="checkbox"/> Area Radar
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d) In which area do you most frequently work as Air Traffic Controller?

<input type="checkbox"/> Tower	<input type="checkbox"/> Approach procedural	<input type="checkbox"/> Approach Radar	<input type="checkbox"/> Area Control	<input type="checkbox"/> Area Radar
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## DEFINITION OF FACTORS

**Team Work:** Organized, collective coordination between controllers who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission e.g. transfer of responsibility of air traffic control of an aircraft.

**Alertness:** Defined as the ability to maintain concentrated attention over prolonged periods of time.

**Communication:** Tailored to the ATC environment is the exchange of information, including timeliness, accuracy, clarity and receptiveness.

**Situation Awareness:** Is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future e.g. progressive knowledge of position of traffic.

## SECTION B: SINGLE FACTOR

(To be completed by Air Traffic Controllers)

**Kindly select your level of agreement with the below statements by ticking only once in each of the questions?**

Use the scale where 1= very often, 2= often, 3= sometimes, 4= rarely and 5= very rarely

	Statement	1	2	3	4	5
1	In your experience as an air traffic controller, how frequently has team work affected your ability to provide a safe service leading to loss of separation?					
2	In your experience as an air traffic controller, how frequently has alertness affected your ability to provide a safe service leading to loss of separation?					
3	In your experience as an air traffic controller, how frequently has communication skills affected your ability to provide a safe service leading to loss of separation?					

<b>4</b>	In your experience as an air traffic controller, how frequently has situation awareness affected your ability to provide a safe service leading to loss of separation?					
Please use this space to share any comments you may have regarding the questions in this section						
_____						
_____						
_____						
_____						

**SECTION C: FACTORS PAIRS**

(To be completed by Air Traffic Controllers)

**3.1 Kindly select your level of agreement with the below statements by ticking only once in each of the questions?**

Use the scale where 1= very often, 2= often, 3= sometimes, 4= rarely and 5= very rarely

	<b>Statement</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>1</b>	In your experience as an air traffic controller, how frequently has a combination of team work and alertness affected your ability to provide a safe service leading to loss of separation?					
<b>2</b>	In your experience as an air traffic controller, how frequently has a combination of team work and communication skills affected your ability to provide a safe service leading to loss of separation?					

3	In your experience as an air traffic controller, how frequently has a combination of team work and situation awareness affected your ability to provide a safe service leading to loss of separation?					
4	In your experience as an air traffic controller, how frequently has a combination of alertness and communication skills affected your ability to provide a safe service leading to loss of separation?					
5	In your experience as an air traffic controller, how frequently has a combination of alertness and situation awareness affected your ability to provide a safe service leading to loss of separation?					
6	In your experience as an air traffic controller, how frequently has a combination of communication skills and situation awareness affected your ability to provide a safe service leading to loss of separation?					

Please use this space to share any comments you may have regarding the questions in this section

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**SECTION D: SINGLE FACTORS**

(To be completed by incident investigator)

**Kindly select your level of agreement with the below statements by ticking only once in each of the questions?**

Use the scale where 1= very often, 2= often, 3= sometimes, 4= rarely and 5= very rarely

	<b>Statement</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>1</b>	In your experience as incident investigator, how frequently does team work lead to controller-related loss of separation incidents?					
<b>2</b>	In your experience as incident investigator, how frequently does alertness lead to controller-related loss of separation incidents?					
<b>3</b>	In your experience as incident investigator, how frequently does communication skills lead to controller-related loss of separation incidents?					
<b>4</b>	In your experience as incident investigator, how frequently does situation awareness lead to controller-related loss of separation incidents?					
Please use this space to share any comments you may have regarding the questions in this section _____						
_____						
_____						
_____						

**SECTION E: FACTORS PAIRS**

(To be completed by Incident Investigators)

**3.1 Kindly select your level of agreement with the below statements by ticking only once in each of the questions?**

Use the scale where 1= very often, 2= often, 3= sometimes, 4= rarely and 5= very rarely

	<b>Statement</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>1</b>	In your experience as an incident investigator, how frequently does a combination of team work and alertness lead to controller-related loss of separation incidents?					
<b>2</b>	In your experience as an incident investigator, how frequently does a combination of team work and communication skills lead to controller-related loss of separation incidents?					
<b>3</b>	In your experience as an incident investigator, how frequently does a combination of team work and situation awareness lead to controller-related loss of separation incidents?					
<b>4</b>	In your experience as an incident investigator, how frequently does a combination of alertness and communication skills lead to controller-related loss of separation incidents?					
<b>5</b>	In your experience as an incident investigator, how frequently does a combination of alertness and situation awareness lead to controller-related loss of separation incidents?					



6	In your experience as an incident investigator, how frequently does a combination of communication skills and situation awareness lead to controller-related loss of separation incidents?					
<p>Please use this space to share any comments you may have regarding the questions in this section</p> <hr/> <hr/> <hr/> <hr/>						