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CITY UNIVERSITY LONDON

Analysis of Aircraft Accidents and effects on Aviation Industry in Nigeria

Danraka Dayyabu

Supervisor: Dr Bond Steve

External Supervisor: Professor Vasigh Bijan

Thesis submitted to School of Mathematics, Computer Science and Engineering for the award of degree of Master of Philosophy in Air Safety Management at City University London

November 2014

Declaration

I certify that this project is wholly my own work and that all material extracted from other sources is clearly referenced.

It has not been submitted before for any other degree or examination at any other university.

This thesis contains 21, 941 words in total, less Appendices using the Microsoft Word 2010, word count command on Windows 8.

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Danraka Dayyabu Mustapha

November 2014

Certification

This dissertation entitled ***'Analysis of Aircraft Accidents and effects on Aviation Industry in Nigeria',*** by Danraka Dayyabu meets the regulations governing the award of the degree of Master of Philosophy in Air Safety Management, School of Mathematics, Computer Science and Engineering, City University London, and is approved for its contribution to scientific knowledge and literary presentation.

______________________________________ __________________

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Supervisor

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Internal Examiner

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Dr Simon Place
External Examiner

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Dr Douglas Greenwell
Chairman

Dedication

For my loving parents:

In loving memory of my father Late Mallam Mustapha Danraka

Abstract

This study was driven by four specific objectives, which are to examine the state of Nigeria aviation industry towards the IASA-FAA category 1 safety status attained in 2010, evaluate the trend of aircraft accidents/incidents and casualties' in Nigerian airspace between 1983 and 2013, attempt quantifying the role of human error on accidents data using the HFACS framework, and evaluate the effects of aircraft accidents in Nigeria aviation industry. To achieve these, a constructionist perspective was held and multiple approaches were adopted including robust literature review and secondary data analysis to deal with the research questions and hypotheses raised. A total of 194 accident/incident records covering the study period 1983-2013 were utilised for the empirical analysis.

Towards the attainment of the IASA-FAA category 1 safety status, the assessment revealed that intensive infrastructural and policy inputs were made on the Nigeria aviation sector and the attained status promises positive socio-economic value. Empirical analysis of data suggests that while commercial aviation is responsible for more than half of the casualty rate, a significant decline in the number of accidents/incidents in Nigeria airspace was indicated. Human factor involvement in aircraft accidents as generally acclaimed was vindicated in this study. Human casual factor at the category of unsafe acts of the operator was observed in more than 70% of the times, and was significantly higher in commercial aviation operations. Therefore the effects of aircraft accidents on aviation industry in Nigeria most significantly affected the commercial aviation operations like many other countries in the world.

Findings from this study can be a useful guide to improving the overall safety performance of Nigeria's aviation industry.

Recommendations on human capacity development and exploitation of the HFACS framework is indeed necessary to further improve safety status and align Nigeria's aviation operation with international best practices.

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I wish to express my sincere thanks to my supervisor Professor Steve Bond. He took my interest in aviation safety issues and showed me how they were related to aircraft system Safety. He introduced me to the fundamentals of safety management and innovative new ways to think about system safety and human behaviour as related to aircraft accidents and incidents. I thank him for guiding me through my postgraduate work and for providing critical feedback that improved on my research writing skills, initiating me to safety expertise in safety management and equipment and systems safety.

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Finally and significantly to the final submission of this research thesis, is my best regards and thoughtful respect to the Post-graduate Board of City University, London for their judicious understanding and kind encouragement while administering the University Policies. God bless you all.

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Abbreviations

ACT	Audit Consulting Training
AIB	Accident Investigation Bureau
AIPB	Accident Investigation and Prevention Bureau
AOC	Air Operator Certificate
CFIT	Controlled Flight into Terrain
CVR	Cockpit Voice Recorder
FAAN	Federal Airports Authority of Nigeria
FDR	Flight Data Recorder
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
NAMA	Nigeria Airspace Management Agency
NCAA	Nigeria Civil Aviation Authority
NCAT	Nigerian College of Aviation Technology
NEMA	National Emergency Management Agency
NIMET	Nigeria Meteorological Agency
NOTAM	Notice to Airmen

1. Introduction

1.1 Background to the Study

Commercial air travel is one of the safest modes of transport available today due to the prompt attention given to accidents and the remedies put in place to prevent their reoccurrence. Air travel is well thought-out to be safe (Harrera and Vasigh, 2009), because major accidents along with several less severe accidents and incidents happen globally every year, the system is considered to be imperfect. Since aircraft are mostly involved in these occurrences, there are many opportunities for investigators to identify faults and causes that, if not remedied or eliminated, could manifest again and lead to their reoccurrence. Proper interpretation of accidents and/or incidents by investigators must be ensured in order to eliminate these faults. Hence, this will enable the investigators to develop recommendations that are comprehensive enough to cover the various ways in which faults could be triggered and disseminate those lessons so that appropriate remedies may be implemented.

Transportation technologies have largely contributed in globalization recently. This implies that air transportation over the years promoted global trade, foreign investment flows, employment generation, airlines companies revenue generation, revenue for government and movement of people. However, these positive externalities of the aviation industry are also associated with negative externalities such as environmental, social and economic losses. According to Wiegmann & Shappell (2003), air transportation is sadly associated with accidents which lead to tragic losses such as passengers' death, airlines' revenue loss (passengers' compensation and low passengers traffic in the events of aircraft accidents).

According to the Aviation Safety Network (ASN, 2014), global commercial aviation accidents records revealed a notable decline in accidents as well as fatalities and the year 2013 tagged the safest year by far as "… *a total of 29 fatal airliner accidents,* *resulting in a record low 265 fatalities. Consequently, the number of fatalities is significantly lower than the ten-year average of 720 fatalities."*

The contribution of Africa to this trend, that is one in every five fatal accidents as against its 3% contribution to global aircraft departures, implicated the continent as the most dangerous aviation safety environment. This is further buttressed by the less than 50%, on average score of the audits performed by ICAO. In addition to this is the fact that air companies of 14 African countries are in admissible into the E.U and another 3 countries prohibited to fly in the United States of America (ASN, 2014).

There is a conscious concerted effort to reduce aircraft accidents and incidents in the global aviation community. As a result of which the principal aims of the International Civil Aviation Organization (ICAO) Universal Safety Oversight Audit Program (USOAP) and the International Aviation Safety Assessment (IASA) by the Federal Aviation Administration (FAA) programs are drivers to significantly reduce the number of technical hitches related to aviation safety, which includes aviation accidents, incidents, and sustained improvements of safety and operational practices for consumers of air transportation globally.

Usually when an aircraft accident or incident occurs a number of investigative agencies are involved. In Nigeria, the Accident Investigation Bureau (AIB) is the principal agency charged with the responsibility of aircraft accident investigation and reporting (AIB, 2013).In addition to AIB, specifically for accident occurring in Nigeria supporting agencies such as NCAA participate. Also according to Annex 13 (ICAO, 2010), a representative from the country of manufacture of the airplane and/or engine, other relevant agencies and stake holders (operator etc.) participate.

In accordance with Annex 13 (ICAO, 2010):

> *"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not for the purpose of this activity to apportion blame or liability."*

Accordingly, AIB customarily states that:

"…with the participation of the parties, including the NCAA, will seek to identify any areas of safety concerns during the investigation and implement the appropriate actions for correction or improvement."

The Nigeria aviation industry plays a major role in this. However, the attainment of IASA-FAA Category 1 flight safety status in 2010 (US Embassy, 2012; NCAA, 2013) was a remarkable milestone in the development of the Nigeria aviation industry. As a result improved, global affiliations and recognition through the growing engagements with international communities through the aviation industry is observed. However, the extent to which this status will impact positively in aviation activities in Nigeria requires critical assessments to be appreciated.

Certainly, attaining this safety status is not immunity to aircraft accidents or incidents as experienced even in advanced countries, but with this status, highly deleterious occurrences of accidents or incidents are expected to reduce significantly. Again, this remains to be appreciated from critical analysis. There are indications of pockets of non-compliance to the ICAO's Annex 13 requirement of accident and serious incidents reporting (ADREP) to accident investigation agency in Nigeria (AIB) which generally results in incomplete accidents and or incidents records. For example, serious incidences that occurred with two Kabo Air's B747-200 aircraft registration 5N-EEE on 30th January 2002 on take-off at King Abdul Aziz International Airport, Jeddah where one of the tyres busted (AIB, 2002a), and resulted serious damage to the aircraft and 5N-PPP on 5th February 2002 on approach into Maiduguri International Airport, where the aircraft was damaged beyond repairs as a result of that serious incident (AIB, 2002b).

Also, cases of non-adherence to ICAO Aeronautical Information Service Manual (AISM) DOC8126, regarding the issuance and notification of Notices to Airmen (NOTAMS) have been identified to have contributed to runway incursion accidents and incidents in Nigeria. The incidence of a B747-200 aircraft registration ZS-OOS, operated by Hydro Air Cargo which occurred on 29th November 2003 at Murtala Mohammed International Airport, Lagos where the aircraft struck stacks of asphalt after landing on runway 19L, as a result of which the aircraft was damaged beyond repair (AIB, 2003). Also other two events that occurred at Nnamdi Azikiwe International Airport, Abuja involving a B-747 registration N-7585A cargo flight operated by Ethiopian airlines on 23rd April 2012 which the aircraft exceeded high speed exit to the end of the runway (AIB, 2012), and another B-747 registration EK-74789 a cargo flight operated by Saudi Arabian Airlines which occurred on 4th December 2013 in which the aircraft hits ground equipment, veered off the runway and got damaged beyond repairs (AIB, 2013b).

In the foregoing scenarios, for instance, there are at least 14 causal categories out of the 19 Human Factors Analysis and Classification System (HFACS) that were found (Table 6.11 and Appendix A4) to be responsible in all the accident/incident. Thus buttressing the common position of fact that more than 50 to 85% causal factor of aviation accident are due to human error (O'Hare et al., 1994; Wiegmann & Shappell, 2001; Yacavone, 1993).

Studies have shown that aircraft accidents have tremendous adverse impact on the aviation sector of any nation, with severe social development (Brueckner, 2003; Button & Taylor, 2000), environmental (Davidge, 2005) and economic impact (Chance & Stephen, 1987; Mitchell & Maloney, 1989).

1.2 Problem Statement and Justification for the Study

Available literatures presenting empirical analysis relating particularly to aircraft accident/incident in Nigeria are quite scanty when compared to the sizable number of reports from developed countries, although aviation operations in Nigeria commenced over five decades ago. However, a number of studies in Nigeria have considered the historical developments, aircraft and passenger movements in the Nigeria aviation industry (Ladan, 2012, Afolayan et al, 2012) and the impact of deregulation on Nigeria airline services (Adeniyi& Cmilt, 2011). In the context of aircraft accidents/incidents within Nigeria airspace, accident cost estimation was determined (Adebiyi, 2008), and a comparative assessment of two air crashes was presented by Edeaghe, Esosa & Idiodi (2005).

Nevertheless, the foregoing studies were a source of motivation for this study especially the work of Adebiyi (2008), which hitherto was the most comprehensive literature compilation of air accident data in Nigeria, but contains a number of shortcomings that this study attempted to provide further clarifications. Notable short comings are in the number of air accidents/incidents recorded, the appropriate taxonomy and details associated with each accidents/incidents presented. Thus this study also adopted the study frame commencing 1983 as with the study of Adebiyi (2008) for comparability, and up to year 2013 as the most updated at the time of this study.

Consequently, the study period of three decades was expected to provide sufficient data that would enable a broader assessment of accident/incident perspectives within Nigeria airspace. The study period therefore covers the pre-establishment era of specialized agencies such as the AIB in the Nigeria aviation industry and provides the basis of evaluating the impact of their activities following their establishment.

Access to official gazette on accident/incident in Nigeria can be a tough challenge, considering government bureaucracy and perhaps could be a reason why accident data such as in the study of Adebiyi (2008) revealed inconsistencies. This is one specific challenge which this study attempted to overcome by ensuring the veracity of data collected. The advantage of the researcher of this study as an official of AIB was anticipated to mitigate this challenge.

The application of Human Factors Analysis and Classification System (HFACS) in the analysis of air accidents is now being universally adapted to understanding human causal factors in air accidents. Previously human error involvement was thought to be complex, difficult to comprehend and disseminate until the development of the HFACS framework since mid-1990 (Shappell et al., 2006). Its application has been confirmed reliable and universally comparable (Gaur, 2005; Wiegmann & Shappell, 2001a). Therefore, until the attempt of this study, there is not a single literature providing information that quantifies the human causal factors and the analysis of aircraft accidents in Nigeria airspace using the HFACS framework. The result of this study will serve as a reference material for future local and international studies using HFACS to assess human error as causal factors in aircraft accidents in Nigeria airspace.

Key achievement by the Nigeria aviation industry within the study period was the attainment of the IASA-FAA Category 1 safety status in 2010, which may be considered a significant milestone and an upshot reflecting positive developmental strides. Accordingly this was also taken into consideration and forms the pivot of the research questions raised in the analysis of air accident/incident in Nigeria airspace.

1.3 Research Questions

The specific research question that guides this study is: **How has the Nigeria aviation industry fared in the last three decades and in relation to the need to sustain the IASA-FAA Category 1 safety status attained in 2010?**

In addressing the above question, pertinent sub-questions developed were as follows:

- What is the aircraft accident Trend between 1983 and 2013 in Nigerian airspace?
- What is the relationship between the total number of accidents in a year and the number of accidents responsible for casualties?
- What is the relationship between the number of accidents resulting in casualties and the total number of casualties recorded in study period 1983-2013?

- Does human error accounts for up to 70% of causes of accident in Nigeria airspace?

1.4 Objectives of the Study

The main objective of this research is to attempt an implementation of HFACS on aircraft accidents in Nigerian airspace and assess its effects on aviation industry. However, the specific objectives of the study are to:

1. Examine the state of Nigeria aviation industry towards the IASA-FAA category-1 safety status,
2. Evaluate the trend of aircraft accidents/incidents and casualties in Nigerian airspace between 1983 and 2013,
3. Attempt quantifying the role human error contributes to aircraft accidents data (Nigeria) using the HFACS framework, and
4. Evaluate the effects of aircraft accidents on Nigeria aviation industry.

1.5 Hypotheses of the study

From the sub-questions four main negative hypotheses were formulated simply only to support the position of the conventional "null hypothesis" as follows:

Ho_1: There is no significant decline in the number of accidents for the study period 1983 and 2013,

Ho_2: There is no significant relationship between total number of accidents in a year and the numbers of accidents responsible for casualties.

Ho_3: There is no relationship between the number of accidents resulting in casualties and the total number of causalities per year for the study period 1983-2013.

Ho_4: There is no significant difference between the proportions of human error causal factors in the three different types operations if compared.

1.6 Focus and Approach of the Study

This study is focused on aircraft accidents and incidents that occurred within Nigerian airspace between 1983 and 2013. This covers three decades of aviation operations in Nigeria, sufficient to draw inferences on dynamics of issues that have impacted on aviation safety. Thus aircraft accidents and incidents in all forms of civil aviation, commercial, general aviation, and special category were collected as secondary data. Generally, from a constructionist perspective, assessment of aircraft accident is a complex process, with more than just considerations for social-psychological aspects. There are technological and economic aspects, therefore multiple approaches to providing answers to the research questions and hypothesis were engaged in this study. Deductive empirical analyses were adopted in evaluating the magnitude and trend of accidents and casualties and in the attempt to analyse human error involvement using HFACS framework. Together with strong literature review and data assessments discussions of findings in relation to examining both the state of Nigeria aviation industry towards the IASA-FAA category 1 safety status and the effects of aircraft accidents on Nigeria aviation industry within the last decade.

1.7 Structure of the Thesis

This thesis consists of eight chapters. Chapters 2 to 4 are general literature review with analysis and discussions of findings as it were. Chapter 2, *Nigeria Aviation Industry,* consists mainly of literature dealing with the historical developments, administration, air transport facilities and types of operations in Nigeria aviation sector. It is essential to lay foundations of the terrain under study. Presenting its antecedents, this chapter also considered trend analysis of air transport movements which include aircraft, passenger, cargo and mail movements for period of fourteen years (1999-2012) in retrospect.

Chapter 3, *Causes of Aircraft Accidents or Incidents*, relates the technicalities and complexities associated with aircraft accidents and incidents. Focus was on the evolving Human Factors Analysis and Classification System (HFACS) as developed from the Reason's "Swiss Cheese" Model, consequently presenting the conceptual framework of the study.

While Chapter 4, *Aircraft Accident Investigation Report and HFACS* draws from the arguments in chapter 3, that the HFACS framework is predicated on a well-documented final accident investigation report with demonstration using a typical accident investigation report, Chapter 5, *Methods of Data Collection and Analysis,* deals with the methodological aspects of the study. It outlines the sources and integrity of the secondary data collection and its appropriateness for the study. Statistical approach to data analysis, which includes the descriptive and inferential statistics performed were presented.

Chapter 6, *Results of Data Analysis***,** presents the results of the secondary data analysis implemented in this study. The interpretations of the results are also discussed in this chapter, especially in providing answers to some of the research questions and validating research hypothesis formulated.

Chapter 7 *Discussions* argues the implications of results with special focus on the effects of aircraft accidents on the Nigeria aviation industry, while Chapter 8 *Conclusion* summarises the findings of this thesis and makes recommendations based on this findings with prospects of the Nigeria aviation industry.

2. Nigeria Aviation Industry

2.1 Introduction

The Nigeria aviation industry has grown by about twice its operations in the last decade, especially in terms of international recognitions and airport facility upgrades. Between years 2000 and 2013, significant milestone achievements were recorded that can be directly linked to the growing democratic governance sustained for a decade and for the first time in the history of Nigeria.

This chapter focuses on the antecedents of the Nigeria aviation industry, dealing with the historical developments, administration, categories and air transport facilities of aviation operations in Nigeria. It is essential to lay foundations of the terrain under study as it also considered trend analysis of air transport movements which include aircraft, passenger, cargo and mail movements for period of fourteen years (1999-2012) in retrospect. Contributions of the aviation industry to Nigeria economy are presented. With assessments of the IASA-FAA category 1 safety status attained, this chapter argues that this promotes not only international reputation but also has significant impact on domestic aviation.

2.2 Historical Development

In1925, the first aircraft that flew in Nigerian airspace landed on a polo ground in Kano, North West of Nigeria. It was the Royal Air Force (RAF) commissioned by the Ministry of Air Transport London and dispatched with experts to identify possible landing sites for its aircraft in Nigeria. Kano, Lagos (South West of Nigeria) and Maiduguri (North East of Nigeria) were identified and airstrips were established in these cities. These airstrips became functional specifically for military purposes (Ogunsanya, 2006).

In 1930, one of the first passenger flight operations was by De-Havilland DH -86, a privately owned aircraft, from Khartoum to Kano. The aircraft operated what was described as “horse route” traffic along Khartoum – Kano – Lagos route. In this same period, Mr Bud Carpenter undertook high-risk flights, guided by rail tracks between Kano and Lagos. Alongside a few fare-paying flights between Lagos and Warri in a sea-plane were considered the earliest commercial aviation activities in Nigeria (Depriye, 1999).

By 1935, civil aviation activities had commenced with the Imperial Airways that later became the British Overseas Airways Corporation (BOAC), started flight operations from London to Nigeria. In addition to this are activities, during the World War II (1939-1945) that necessitated the need to move supplies and troops across the country. These led to the development of several airstrips that were later converted to civilian use after the war (Ileoje, 2003).

In 1946, by an edict of the King of England the West African Air Transport Authority (WAATA) was established alongside the West Airways Corporation (WAAC). Although WAAC was formed by the four British colonies of West Africa, by Article 3 of the Colonial Civil Aviation Order of 1952, the Civil Aviation Act of 1949 in England was put to law in Nigeria (Peter, 1966; Omoleke, 2012). However, in 1957, Ghana gained its independence and pulled out of WAAC. Thus in 1958, WAAC was disbanded and the West African Airways Corporation (Nigeria) Limited which later became Nigeria Airways was established as a private company to take over the functions and services of WAAC. The Federal Government of Nigeria owned Nigeria Airways with a share of 51%, Elder Dempster Lines 33% and BOAC 17%. The new company operated domestic and international flights. The international flight was Lagos-Accra-Abidjan-Robert’s field-Freetown-Bathurst-Dakar, with headquarters in Lagos. This period can be said to be the actual commencement of air transport activities by the Nigeria aviation industry (Filani, 1975). As Nigeria became independent in 1960 and bought BOAC and Elder Dumpster Lines’ shares, Nigeria airways became fully operational as the only national air carrier (Ladan, 2012).

However, BOAC and Nigeria Airways shared the London route at this time, although Nigeria Airways chartered capacity from BOAC to provide its own share of the operation (Ogunsanya, 2006; Afolayan, Nurudeen & Adedayo, 2012).

2.3 Administrative Structure

The Nigeria aviation industry is generally administered by the Federal Ministry of Aviation (FMA) and is composed of six parastatals:

- The Nigerian Civil Aviation Authority (NCAA),
- The Federal Airports Authority of Nigeria (FAAN),
- Accident Investigation Bureau (AIB),
- Nigeria College of Aviation Technology (NCAT),
- The Nigerian Airspace Management Authority (NAMA), and
- Nigerian Meteorological Agency (NIMET).

The FMA is headed by a minister, appointed by the President of the Federal Republic of Nigeria. The ministry has five departments namely; Finance and Accounts Department, Human Resources Management Department, Planning, Procurement Analysis and Research Department, Safety and Technical Policy Department, and Air Transport Management Department. These departments are headed by directors in the ministry of aviation and all are responsible to the minister. In addition to processing inputs from the six parastatals, the aviation ministry is charged with the responsibility of developing aviation policies and managing the aviation industry in Nigeria. Principal of the mandates of the aviation ministry is the design, development and execution of security and safety procedures in the aviation industry according to the International Civil Aviation Organization (ICAO) standards and the World Meteorological Organization (WMO) code of practices (FMA, 2013).

Before 1977, the Civil Aviation Department (CAD) of the Ministry of Aviation carried out most of the activities of the six parastatals until the need for expansion, specialization and standardization with international best practices.

FAAN developed alongside the Nigeria aviation industry. It has mainly been responsible for the creation of enabling environments for the development of the economic potentials of the Nigeria aviation industry through efficient commercial activities of airports in Nigeria by providing services to both passengers and airlines. The development and maintenance of airports and other facilities in the Nigerian aviation industry is the sole responsibility of FAAN, as well as revenue generation to the federal government of Nigeria through Aeronautical and Non-Aeronautical services (FAAN, 2013).

NCAT, formerly known as Nigerian Civil Aviation Training Centre, was set up by Act. No 31 of 1964 (as amended). It was initially established as a multiparty programme between the Federal Government of Nigeria (FGN), the United Nations Development Programme (UNDP), and the International Civil Aviation Organisation (ICAO). This tripartite arrangement abolished in 1974 when the Federal Government of Nigeria took over the full responsibility for the sustenance of the College's operation. The main functions of NCAT were to carry out specialized trainings on flights, airport operations management, technical equipment installation and other relevant courses and advances in aviation for approved persons in the aviation industry. This is aimed at improving the operational safety of civil aircraft (NCAT, 2013).

NCAA was established by Decree 49 of 1999 and launched its operational activities on 1st January, 2000, and became autonomous in 2006. It was born out of the need to bring up to international standards, the operations of the Nigeria aviation industry. Thus NCAA is the regulatory agency of the aviation industry with the principal function of regulating aviation safety through issuance of license, restoring and regulating aircraft performance. It also ensures accident control and regulations of airports, airspace, meteorological services, plus economic regulations of the industry.

The country's success in ICAO Security follow-up Audit of May 2006, the ICAO Universal Safety Oversight Audit in November 2006 and consequently the American FAA IASA Category 1 Certification can be attributed to the efficient operations of NCAA (NCAA, 2013).

NAMA was established on 29th of May 1999, by the Act of parliament No. 48 with the principal objective of providing safe and functional air navigation services in accordance with international standards (ICAO SARPs). Its operational services affects the efficient management of Air Traffic control with consequent reduction in air traffic delays due to the increasing challenges of air traffic volumes, boost service quality and reduction of airspace cost for users in Nigeria (NAMA, 2013).

NIMET was established in the year 2003 by an Act of the National Assembly – NIMET (Establishment) ACT 2003. The primary functions of NIMET are to ensure regular and reliable dissemination of weather and climate forecasts, issue forewarnings and relate information concerning meteorological, hydrological, and climate matters for the welfare and protection of life and properties of the Nigerian public. There are three basic specialized departments in NIMET that runs its activities. These are Weather Forecasting Services (WFS), Applied Meteorological Services (AMS), and Research and Training (R&T). Other directorates providing support services include Engineering and Technical Services, Finance and Accounts, Administration and Supplies, and Legal Services (NIMET, 2013).

AIB was established by Civil Aviation Act 2006 under the Ministry of Aviation with the primary responsibility of investigating civil aircraft accidents and serious incidents within Nigeria and/or any aircraft registered in Nigeria. Thus improving aviation safety is the main purpose of setting up AIB. The investigative activities of AIB brings to fore (especially through publication of investigation reports) circumstances and causes of air accidents and incidents and providing safety recommendations intended to avoid recurrence of similar accidents or serious incidents in future. This was also in the bid to conform to ICAO Annex 8 – Airworthiness of Aircraft and ICAO Annex 13 – Investigation of Aircraft Accidents (AIB, 2013).

2.4 Types of Air Transport Operations

As with many countries' aviation sector, there are two major categories of air transport operations in Nigeria, which have developed out of the growing need for them. These are civil aviation and non-civil aviation. The civil aviation is classified into Commercial, General and Special category operations. The commercial aviation can further be classified as scheduled air transport operations, which consists of all passenger and cargo flights operating on a scheduled and non-scheduled basis and on assigned routes, General Aviation (GA), comprises all other public flights that may be private or commercial (Crane, 1997). From the later the term commercial aviation emanated and refers to aviation flying specifically as a business enterprise. Although GA encompasses a broad sphere of air transport operation, in the case of Nigeria's it may consist of operation for non-commercial purpose and as such referred to as private operation. However, all scheduled flights can be termed commercial operations. Special category in this study encompasses all aerial works, border patrol, government (including presidential), oil rigs and training flights.

Aircraft accidents and incidents have occurred in all the categories of the aviation sector in Nigeria. The results of detailed analysis of major types of operation for the assessments period (1983-2013) are presented in Chapter 7 of this study.

2.5 Air Transport Facilities

Airports are the major hubs of air transport facility in the aviation industry worldwide. The distribution of air transport facilities across Nigeria (FAAN, 2010) is illustrated in Fig 2.1.

International scheduled flights are mainly run from five airports in Nigeria. These airports are located in Abuja, Enugu, Kano, Lagos and Port Harcourt. Although domestic flights are being operated at these airports, domestic flights also operate to and from thirteen other airports across Nigeria.

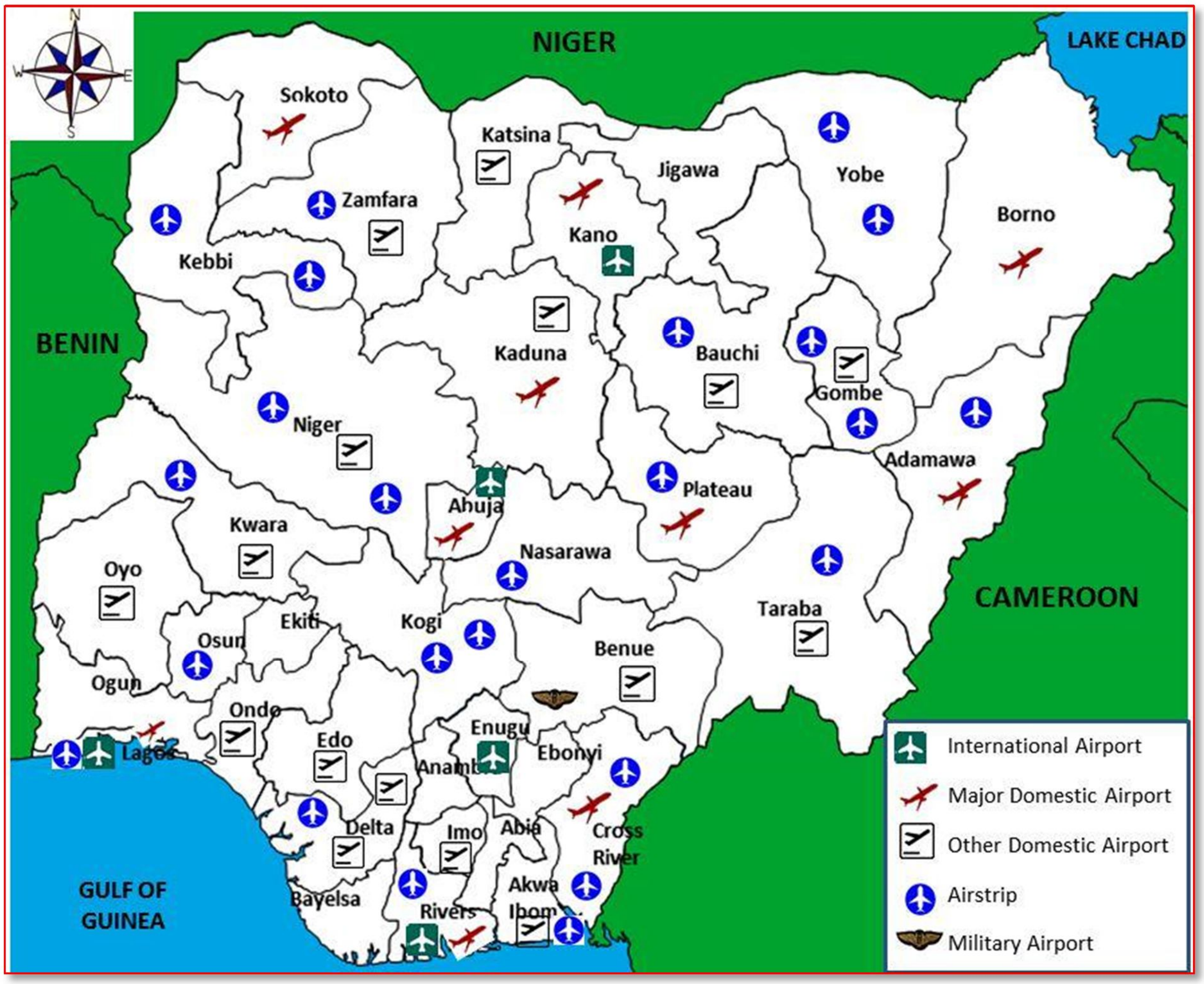

Fig. 2.1: Locations of Air transport facilities in Nigeria
(Source: FAAN Data, 2010)

There are 24 airstrips in Nigeria, majority were built by the Nigerian Air Force and multinational oil firms. While the FAAN 2010 data indicated that there are more than one airstrips in some states, it also indicates the presence of a specialised military airport in Makurdi; Benue State.

Aircraft accidents and incidents also occur at many airports in Nigeria. Details of such accidents and incidents that occurred at those airports are presented in Chapter 7 for the study period 1983-2013.

2.6 Air Transport Movements

In the last fourteen years (1999-2012), air transport movements in Nigeria have improved significantly in terms of both reliable documentation of activities and service delivery, which include increased aircraft arrivals and departures at airports, as well as passenger, cargo and mail movements.

2.6.1 Aircraft Movement

Domestic aircraft movement are about eight times, on annual average, more than international aircraft movements in Nigeria airports. Due to lack of data, domestic aircraft movement for the period (1999-2012) is presented for illustration (Fig. 2.2). There has been a general steady increase in both domestic and international aircraft movements at a rate of 4% and 6%, year-on-year average, respectively. Domestic aircraft movements rose from 100,739 in 1999 to a sharp peak of 180,418 movements in 2005 and then dropped between 2005 and 2008, until another steady rise between 2009 and 2011(Fig. 2.2).

The highest aircraft movement attained was in 2011 (215,294). The cause of the sharp drop of aircraft movement in 2012 is unclear, but the DANA air crash of 3rd June 2012 coupled with jet fuel price increase in 2012 may be attributed to it, as 50 per cent of airlines’ cost of operation is attributed to aviation fuel.

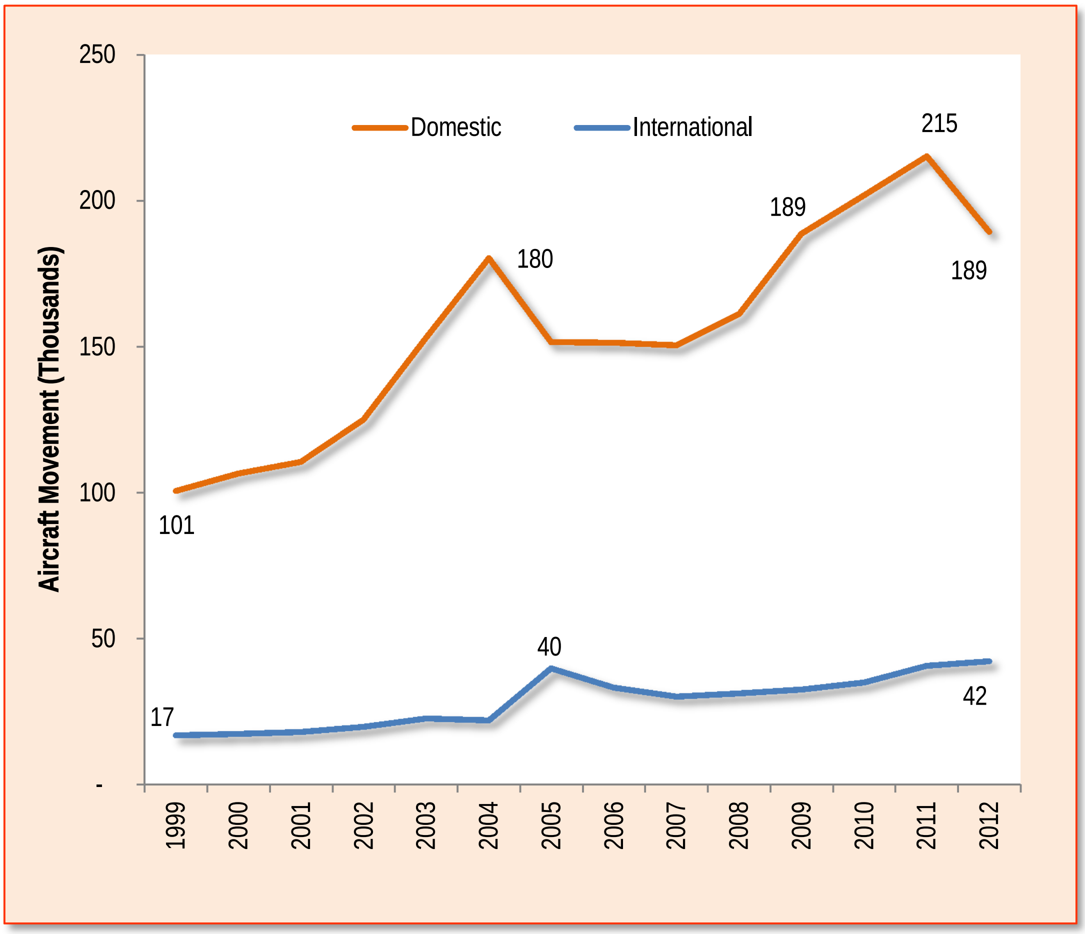

Fig. 2.2: Domestic and International Aircraft Movements in Nigeria (1999-2012)
(Source: FAAN, 2012)

International aircraft movements rose from 17,030 in 1999 to a sharp peak in 2005 (39,906), which has been sustained to the height in 2012 (42,209). However, in addition to the increased number of airlines and new air routes created in Nigeria air space within this period (1999-2012), political activities are also attributable to the general increase in aircraft movements. Data of the total movements in Nigeria show that on average, MMA Lagos accounts for 41.0% of the movements, Abuja 22.7% and 36.3% by other airports (FAAN, 2012).

2.6.2 Passenger Movement

An annual average of about 60% difference between domestic and international passenger movements was recorded within the assessment period (1999-2012). Similar to aircraft movements, domestic passenger movements experienced a substantial drop in 2007 (5.64 million passengers) against preceding steady rise from 1999 (2.76 million) to 2004 (6.19million passengers), (Fig. 2.3).

Excepting the drop in 2012, passenger movement rose steadily from the drop in 2007 to a peak in 2011 (11.19 million passengers). However international passenger movements rose steadily from 1999 (1.19 million passengers) to a peak in 2012 (3.92 million passengers). A general annual average increase in passenger movements through domestic and international flights is estimated at 8% respectively for the period, 1999-2012. Consequent to the high rates of aircraft movements at MMA Lagos and Abuja airports, the rates of passenger movements at these airports are similarly significantly higher than other airports in Nigeria. Though Abuja is the capital city of Nigeria, international passenger movement is about 10 times more in MMA Lagos, on average.

2.6.3 Cargo and Mail Movement

Cargo movements sustained an almost steady rise within the period (1999-2012) at a rate of about 15% on annual average.

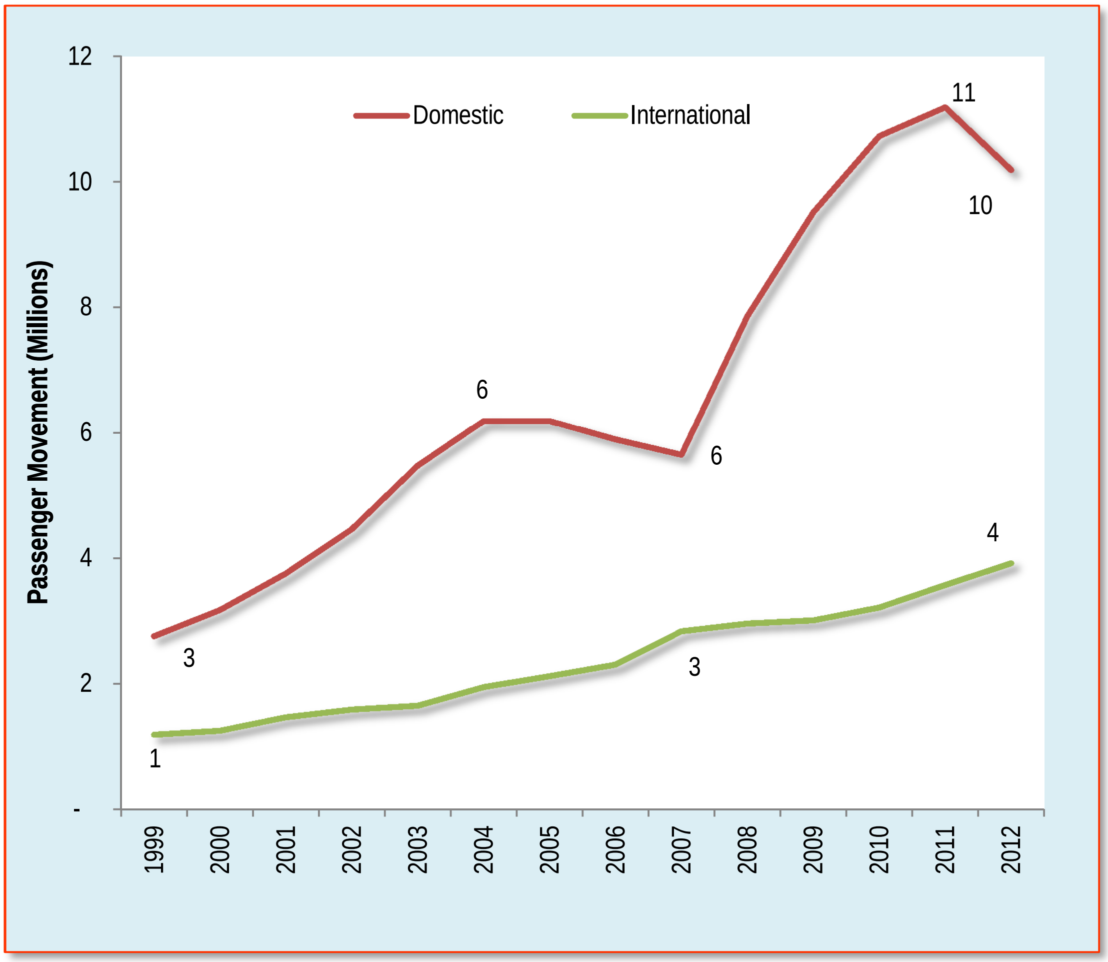

Fig. 2.3: Domestic and International Passengers' Movement in Nigeria (1999-2012)
(Source: FAAN, 2012)

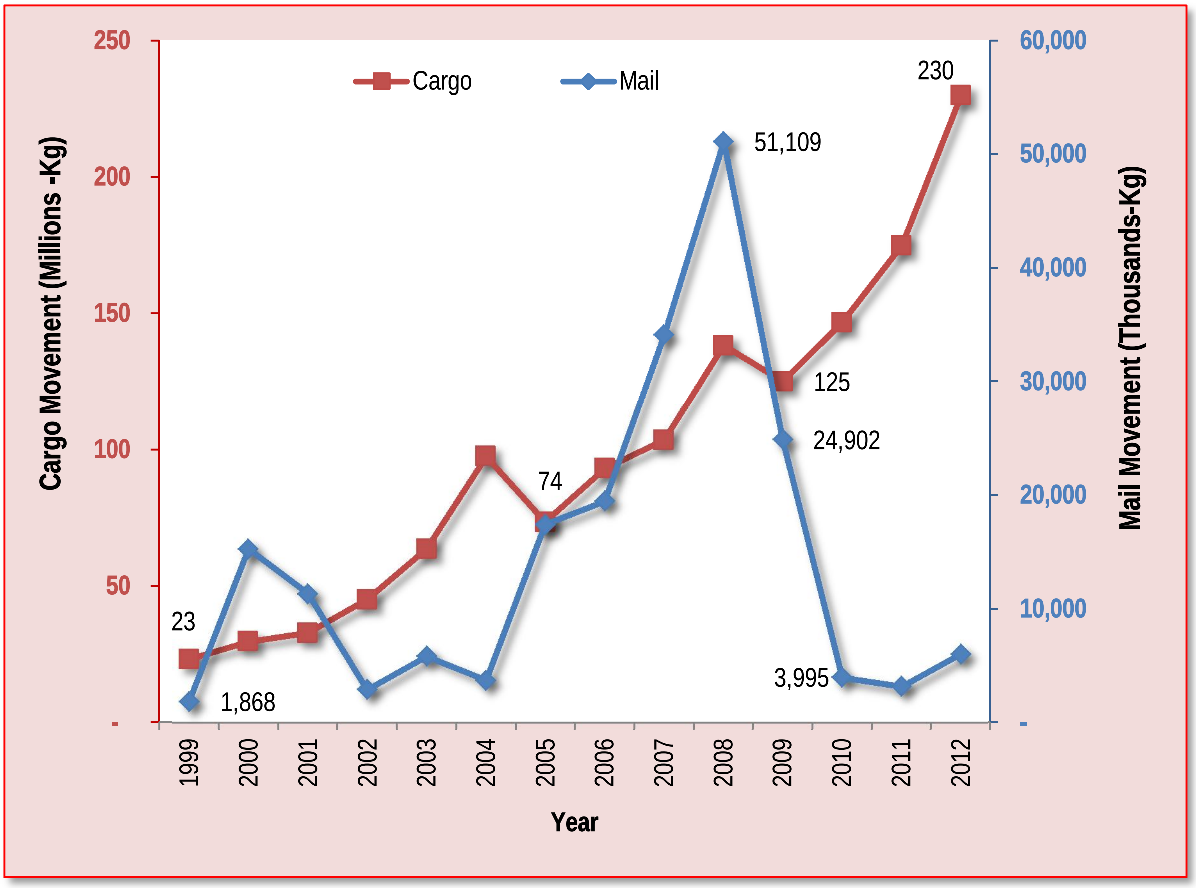

Fig. 2.4: Cargo and Mail Movements in Nigeria (1999-2012)
(Source: FAAN, 2012)

With exceptions of sporadic drops in 2005 (73.6 million kg) and 2008 (125.1 million kg), cargo movements rose steadily from 23.3million kg in 1999 to the highest bulk of 229.6 million kg in 2012 (Fig.2.4). Mail movements have been erratic during the period (1999-2012). A remarkable high peak of 51,109kg was recorded in 2008 after which a significant drop followed in 2009 (24,902kg) and 2010 (3,995kg) onwards. The reason for the rise in mail movement from 2005 to 2008 may be due to the boom in courier companies within this period and high patronage of air transport as a faster and safer means of transportation. However the sharp collapse in 2009 is unclear, but lowered patronage is a likely cause.

Although mail movements consist of deliveries made to postal administrations via an airline, it generally includes correspondences and smaller items. The steady rise between 2004 and 2008 falls within the second term of transition in Nigeria's democratic governance and may be connected with certain government policies.

2.7 Economic Contributions of the aviation Industry to Nigeria

Analysis of year 2010 data (Oxford Economics, 2012) indicated that with the catalytic growth of the tourism sector contributing up to NGN78 billion (Fig. 2.5), the Nigeria aviation industry contributed 0.6% to Nigeria GDP.

In addition to this sector of the aviation industry, are contributions from airline, airport and ground services (NGN59 billion), supply chain (NGN34 billion) and spending by employee and supply chain (NGN27 billion). Considering the current effort in developing Aerotropolis Nigeria (FMA, 2013) in the four historic and commercial airports (Lagos, Abuja, Kano and Port Harcourt) the economic impact of the aviation industry to Nigeria GDP will certainly improve immensely.

Another major contribution of the aviation industry to the Nigeria economy is the job creation.

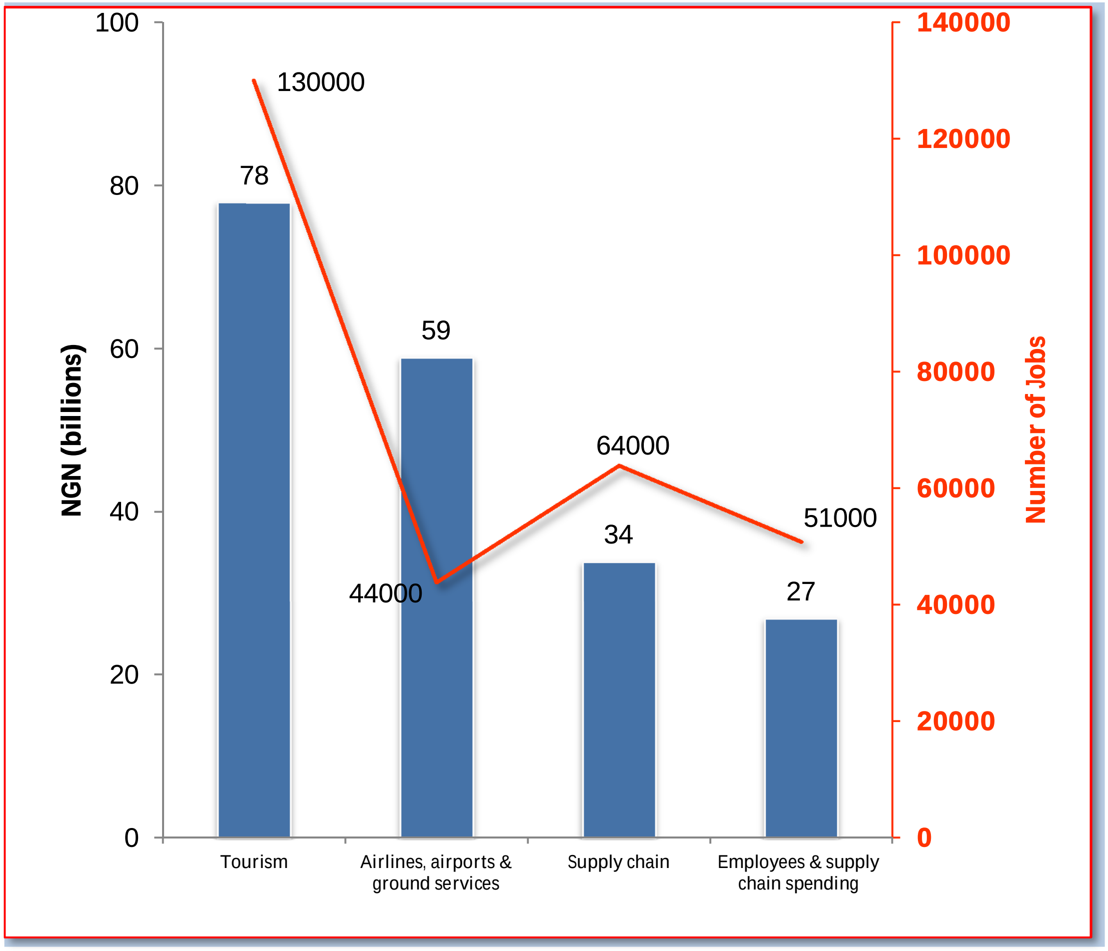

Fig. 2.5: Sectorial contributions of Nigeria aviation industry to GDP and job creation (Source: Oxford Economics, 2012)

According to the report of Oxford Economics (2012), the catalytic tourism sector provides the highest number of employment to one hundred and thirty thousand (130000) people and up to 44000 direct jobs to people in the airline, airports and ground services (Fig. 2.5).

On the whole, the aviation industry provides jobs to more than 159,000 people in Nigeria. Jobs in the aviation industry is considered a high productivity job, as on average, an annual Gross Value Added (GVA) of NGN 3.5 million is contributed by employees of the air transport service. In addition to this, are contributions to public finances through taxes (personal income and social security contributions, corporate profit tax and value added tax- VAT) and supply chain that culminate over NGN 41.5 billion (Oxford Economics, 2012).

2.8 Assessment of Safety Status

Nigeria aviation operations attained the International Aviation Safety Assessments (IASA) Program of the Federal Aviation Administration (FAA) Category 1 flight safety status in 2010. It was a remarkable milestone in the development of the Nigeria aviation industry. According to US Embassy (2012), there were four major accidents that occurred between 2005 and 2006 that necessitated the implementation of the Nigerian Civil Aviation Act and International Civil Aviation Organization (ICAO) Universal Safety Oversight Audit Program (USOAP) that were carried out in 2006.

In this study’s assessment period (1983 to 2013) FAA’s (2013) accident data revealed that between 2005 and 2006, the Nigeria aviation industry recorded the highest number of accidents, 12 in 2005 and 8 accidents in 2006. The number of casualty in two accidents of 2005 was over 200 and, also casualty in two accidents of 2006 was over 90. Details of these are presented in Chapter 6, data analysis, of this study. However, these circumstances were a cause for concern and thus support the postulate that it facilitated the USOAP of 2006.

It is now much clearer also, as indicated earlier in Fig. 2.2, that this may be the reason why domestic aircraft movements declined in 2005 and 2006 by about 16% from previous year's (2004) record. Nevertheless, four years later, following the USOAP of 2006, in 2010 the FAA category 1 safety status was attained. The question is: what does this portend for the operations of the Nigeria aviation industry?

Undoubtedly, the USOAP of 2006 was a precursor exercise to attaining the FAA Category 1 flight safety status (US Embassy, 2012; NCAA, 2013). It entails satisfactory compliance with the established air safety standards by the International Civil Aviation Organization (ICAO) and compliance with the established international standards and endorsed practices of aircraft operations and maintenance by United Nations' technical agency for aviation (NCAA, 2013). In real terms, this safety status translates to the fact that aircraft from Nigeria can operate a regular schedule to and from the airspace of the United States (FAA, 2013). There are economic implications to this as well, such as aircraft insurance premium costs reduction, improved facile access of leasing aircraft from manufacturers and essentially drawing foreign investments into Nigeria (NCAA, 2013).

However, the overall goal of the IASA-FAA program is the significant reduction in the number of technical hitches related to aviation safety, which includes aviation accidents, incidents, and sustained improvements of safety and operational practices for consumers of air transportation in Nigeria. Accordingly, preceding the IASA 2010 certification, a number of safety measures and efficient aviation operational requirements were put in place by the Nigeria aviation ministry. Typical indicators of deficiencies that must be met by country's CAA undergoing both ICAO and FAA assessments, including FAA ramp checks generally consists of, as outlined by FAA (2013), the followings:

- "*inadequate and in some cases non-existent regulatory legislation; and lack of advisory documentation;*
- *shortage of experienced airworthiness staff;*

- *lack of control on important airworthiness related items such as issuance and enforcement of Airworthiness Directives, Minimum Equipment Lists, investigation of Service Difficulty Reports, etc.;*

- *lack of adequate technical data, absence of Air Operator Certification (AOC) systems and non-conformance to the requirements of the AOC System*

- *lack or shortage of adequately trained flight operations inspectors including a lack of type ratings;*

- *lack of updated company manuals for the use by airmen;*

- *inadequate proficiency check procedures; and*

- *Inadequately trained cabin attendants".*

Besides Cape Verde, Egypt, Ethiopia, Morocco and South Africa, Nigeria is the sixth African nation to attain the FAA Category 1 status.

3. Causes of Aviation Accidents and Incidents

3.1 Introduction

Fundamental to understanding the perspective of this chapter are the delineations and definitions of accident, serious incident and incident. Detail definitions as applied by the ICAO's Standards and Recommended practices for Aircraft Accident and Incident Investigation (ICAO, 2010) are presented in the glossary section of this work. Thus in this study, including literature materials cited, the definitions were applied. However, the term incident is often used in a general way to refer to either "Incident" or "Serious Incident", except in specific instance of investigation and analysis.

The human factor analysis and classification system (HFACS) is now at the centre of attention where aviation accident investigation and analysis is concerned. In the last two decades HFACS has developed in practical applications as much as it's theoretical growth. This chapter focuses on the causes of aviation accidents or incidents in relation to development of HFACS and justification for its application.

3.2 Development of the Human Factors Analysis and Classification System (HFACS)

The brass tacks for appreciating the context of HFACS is in the abundant evidences concerning human factor implications in aviation accidents or incidents, buttressed by the clear demarcation between it and mechanical factor. The latter has been significantly downplayed as a causal factor in aviation accidents and incidents because much of the "needs based" and "data-driven" efforts have provided efficient operational mediation approaches that either inhibited mechanical causes from arising, or allay their effect when they occur. Causes of accidents or incidents due to mechanical factors were easily identified and measured, while human factors are generated largely from a long transcript of several complexities by qualitative data requiring further translation for quantification (Wiegmann & Shappell, 2001).

Simply put, until human intelligence evolves failure free inventions, perhaps by different technological methods, then human factor will always be implicated in human endeavours, such as the aviation industry. This is key justification for considering HFACS model in the analysis of aviation accident. Although there is greater emphasis on human causal factor in the HFACS model, it also includes non-human factors which other previous models considered, such as environmental factors under precondition to unsafe acts.

Early accident models such as Heinrich's Domino model (Heinrich, 1931) expressed in flexible logic that accidents occur from a sequence of events developing in series. Thus, in furtherance to this idea is the generally acknowledged fact that there is always more than just an individual or event responsible for the cause of an accident (Heinrich, Petersen, and Roos, 1980).

In 1990 the revolutionary "Swiss Cheese" model developed by James Reason (1990), put together a more coherent and versatile human involvement accident model that is applicable in diverse spectrum of human endeavours. The "Swiss Cheese" is the precursor model applied, amongst several others, by ICAM: Incident Cause Analysis Method (Reason, Hollnagel & Paries, 2006; ACT Safety, 2014), ATSB: Australian Transport and Safety Bureau (ATSB, 2007) and prodigiously explored by the aviation accident investigation as HFCAS by FAA (Shappell & Wiegmann, 2000; 2006). Thus, HFACS model is not to be considered to be in competition with other model but the only comprehensive model that has evolved from previous efforts elucidating those latent aspects of human involvement in aviation accidents not explored hitherto.

3.2.1 The Reason's "Swiss Cheese" Model

A typical representation of the Reason's "Swiss cheese" model of human error causation (Reason, 1990) is shown on Fig. 3.1. The model identifies three levels that latent failures emanate from, and a fourth level from which active failures result to accident. The levels of operations comprising latent failures are levels where the activities of those components of the system are not easily discernable. Since in reality, for instance aviation accident involves the physical aircraft with its crew and passengers. The crew, being the obvious components, operators of the aircraft at the time of accident are denoted active failure level. But latent failures may exist over a long period of time unnoticed, and spreading its harmful effects throughout the system down to the obvious and active level of operation.

Latent failures may commence effect in *organisational influences* at top management decision level that affects processes performance at all levels.

For instance, a management policy to conserve funds for a new project cuts down on training and oversight budgets. This will certainly impact on the effective control leading to *Unsafe Supervision*. Consequent to this, like a chain reaction, is the *Preconditions for Unsafe* Acts; such as a weakened crew resource management (CRM) resulting from this policy.

Finally these forms of weaknesses depicted as holes (failed or absent defenses) on the "Swiss Cheese" at each level of operations translate through the last stage as *Unsafe Acts* of Operators to complete system failure resulting in an accident/incident generally, discussed in aviation as pilot/aircrew error. Previously, this was the main point of focus in aviation accident investigation.

In a more recent revision of the "Swiss Cheese" model, Reason, Hollnagel & Paries (2006) observed that there are three main functions of the model, hence the reason why it has become very useful in diverse field of human endeavours.

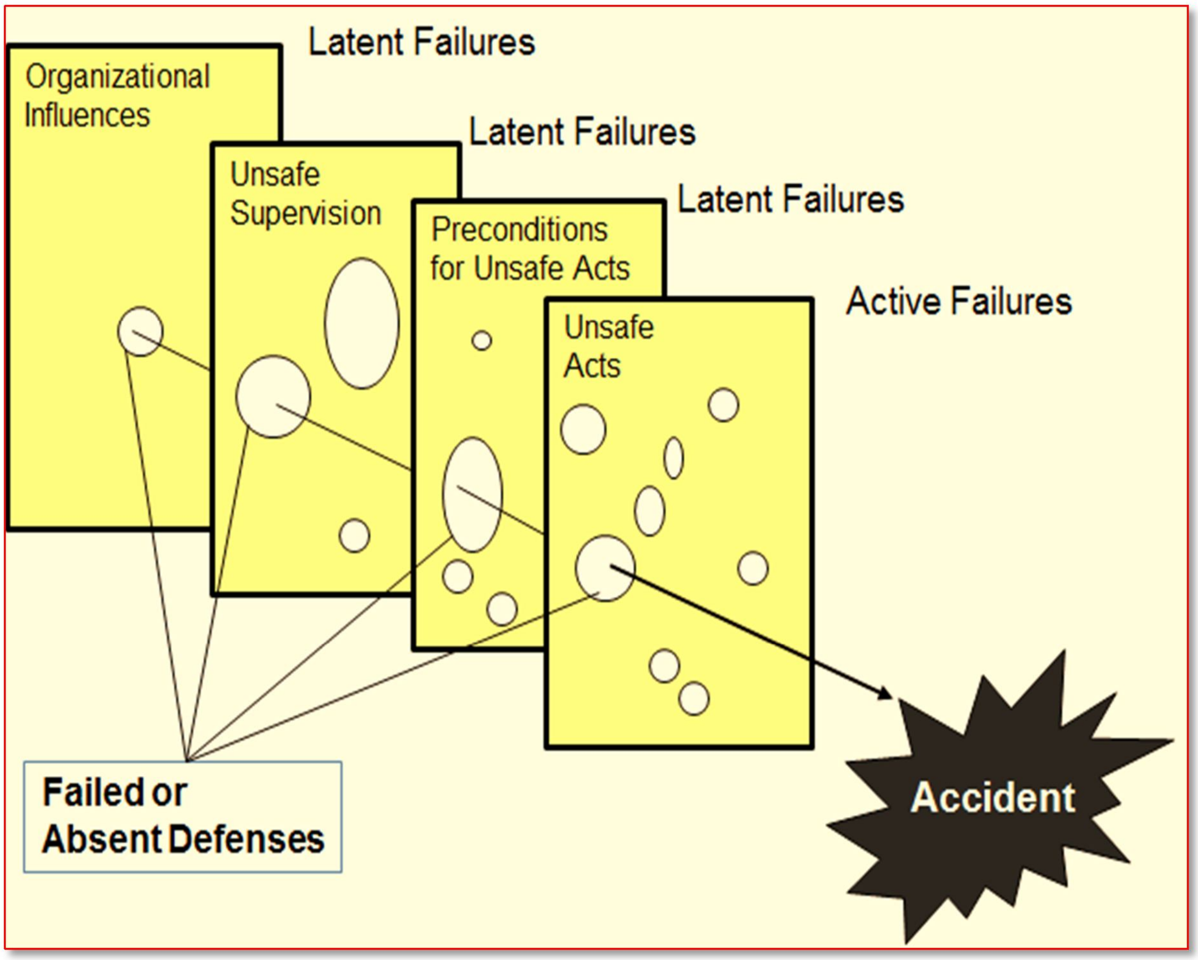

Fig. 3.1: The “Swiss cheese” model of human error causation
(Adapted from Reason, 1990)

First, the model functions as *Conceptual Framework*, which allows easy breakdown of complex system into distinct but indivisible interconnectivities accounting for the overall failure. Secondly, the model functions as a *Tool for Communication*, allowing customization of its generic nature in demonstrating human error involvement in accidents, and thirdly, as a *Basis for Analysis,* functional in pre-emptive process evaluation through continuous assessment of indicators of the safety state of a system.

3.2.2 The HFACS Framework

Since the development of Reason's "Swiss Cheese" model, aviation accidents researchers have given consideration to evolving the model from a skeletal framework with holes to a more fleshy detailed level. Prominent in the cause of this endeavour are the works of Shappell & Wiegmann (1997a; 2000). The principal concern for developing this model further is to enable facile intervention strategies for identified casual factors (Wiegmann & Shappell, 1997a). In other words, if a causal factor is identified, it is then easy to develop a strategy that can monitor, control and prevent the further occurrence of the identified cause of accident.

This was aptly put by Reason, Hollnagel & Paries (2006):

> *"Shappell and Wiegmann's most important contribution is the degree to which they operationalized the application of the model so that it can be used by a wide range of investigators. They criticise the original model for failing to identify the cheese holes more precisely. But such specificity was never the original intention. The model was intended to be a generic tool that could be used in any well-defended domain—it is for the local investigators to supply the local details".*

The resultant understanding "… *for the local investigators to supply the local details"* abundantly supported the development of the HFACS framework for aviation accidents by Shappell & Wiegmann (2006) illustrated in Fig. 3.2. The illustration shows that, *pro tem*, a number of categories and sub-categories distinctly assessable have been identified at each of the four originally designated levels of operations in the

“Swiss Cheese” model. It is arguable that no further modification to this framework would be made to it in the near future, and remains to be seen.

Beginning from the level of organisational influences, three categories of factors were identified. These are Resource Management, Organizational climate and Operational Process. Organizational resources include financial, human and working implements/facilities. In their detailed discussion of each of these causal factors, Shappell & Wiegmann (2003) extensively relied on contributions from other previous researchers on specific aspects. For instance, on the issue of crew resource management (Helmreich & Foushee, 1993), a component of Substandard Practices of Operators in the development of HFACS (Shappell & Wiegmann, 2000) was noted. Muchinsky (1997) also drew attention to the issues of organizational communications as an important resource.

Organizational climate factor discussed by Jones (1988) was finely represented by (Shappell & Wiegmann, 2000) as *“the working atmosphere within the organization. One tell-tale sign of an organization’s climate is its structure, as reflected in the chain-of-command, delegation of authority and responsibility, communication channels, and formal accountability for actions”*.

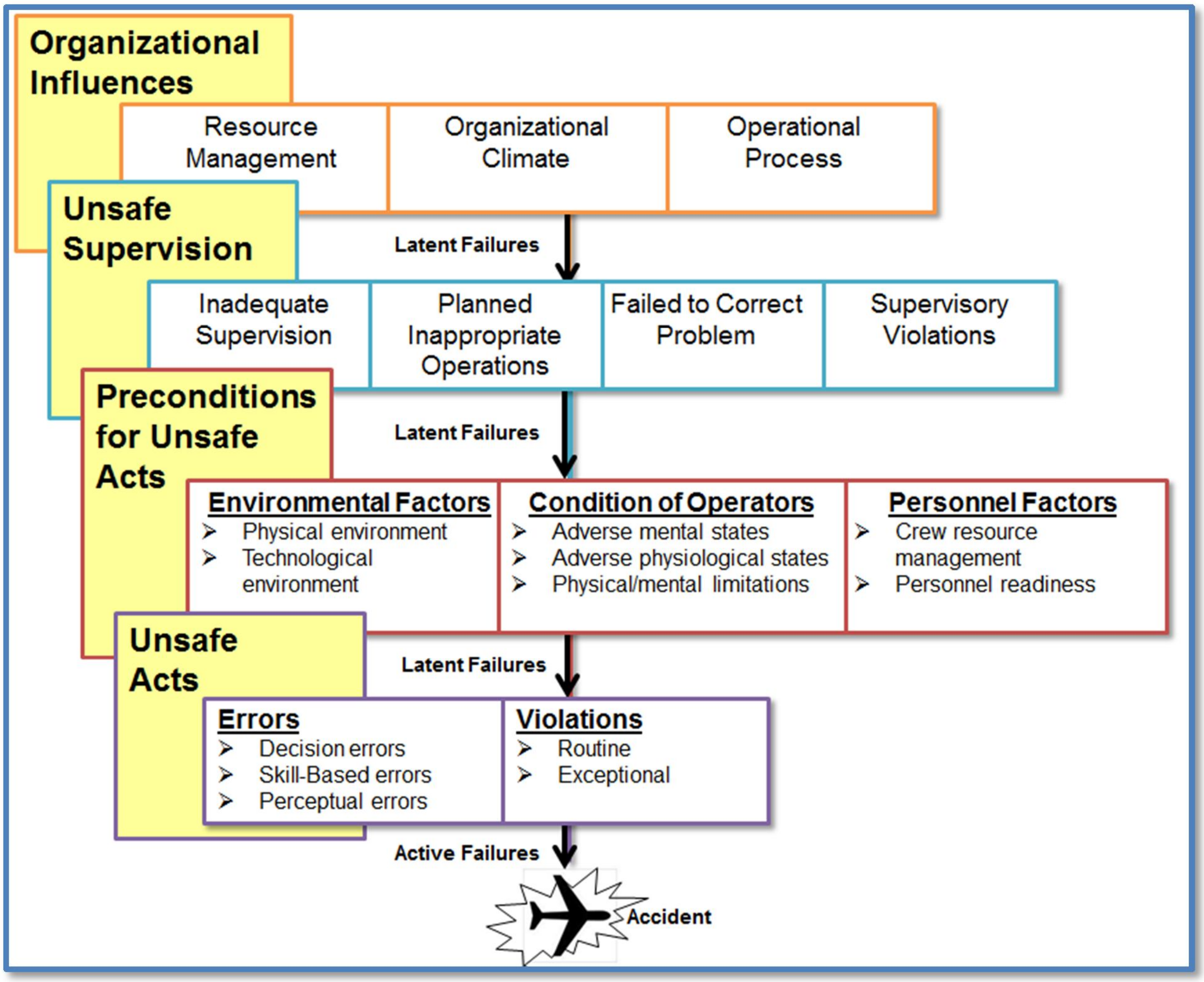

Fig. 3.2: The HFACS framework
(Adapted from Shappell & Wiegmann, 2006)

The structure, policies and culture were identified as primary elements of a sound organizational climate. On the other hand, operations (such as schedule and planning), procedure and oversight were identified as key elements of Operational Process. These are products of decisions made at corporate levels and the guidelines running the day-to-day undertakings in an organization. It entails recognized approaches for sustainability such as the use of standardized operating procedures and adequate supervision concerning management and workforce (Shappell & Wiegmann, 2000).

Unsafe supervision is another category in the HFACS framework that enables the understanding of causal factors relating to latent contributions from those who supervise the operations of the aircrew. Nevertheless, aircrew must be held responsible for their actions, but they inherit failures from their supervisors. In this major category, Shappell & Wiegmann (2000) identified four sub-categories that include inadequate supervision, planned inappropriate operations, failed to correct known problems, and supervisory violations. The lapse from inadequate supervision generates a gap between the supervisor and aircrew. The issue of Planned Inappropriate Operations can be well illustrated by the details from Potomac River crash outside of Washington, DC, in January of 1982 as reported by NTSB (1982). In the crash detail include the flight crew's failure to use engine anti-ice during ground operation and take off, their decision to take off with snow/ice on the air foil surfaces of the aircraft, and the captain's failure to reject the take-off during the early stage when his attention was called to anomalous engine instrument readings. Thus, the sub-categories: failed to correct known problems and supervisory violations are related because of the deliberate nature in the decision of supervisors, but were classified separately due to the specified circumstances associated with the acts.

Preconditions for Unsafe Acts is a crucial latent category in the HFACS frame work as it identifies those latent issues linking the preceding category Unsafe supervision and the next category, Unsafe Acts of Operators. This is appropriately expressed by Shappell & Wiegmann (2000): *"Simply focusing on unsafe acts, however, is like focusing on a patient's symptoms without understanding the underlying disease state* *that caused it. As such, investigators must dig deeper into the preconditions for unsafe acts".* Three sub-categories with further classification in each were identified in the category of Preconditions for Unsafe Acts. These are **1) environmental factors** (physical and technological), **2) condition of the operator** (adverse mental states and adverse physiological states), and **3) personnel factors**, (crew resource management and personal readiness).

Unsafe Acts of Operators formally thought to be the only major causal factor in aviation accidents when human factors are considered, because from this active phase (converse to the latent preceding phase) direct linkage to accidents occurrence is made. The category of Unsafe Acts of Operators as presented in the HFACS by framework Shappell & Wiegmann (2000) maintained the two sub-categories adopted from Reason(1990), but further identified classifications to **1) errors** (decision, skill-based, and perceptual) and **2) violations** (routine and exceptional). Although both error and violation hinges on the rule and regulation of the system, in practice they differ as violations, similar to the sub-categories: failed to correct known problems and supervisory violations in relation to supervisors, but in this case a deliberate nature in the decision by aircrew. On the other hand, errors results from failure to attain the anticipated results while adhering to the systems rules and regulations.

3.3 Application of HFACS

Earlier application of HFACS for reliability and content validity was carried out by the developers of the framework (Shappell & Wiegmann, 1997b). The proven result formed the basis for its application in the analysis and investigation of U.S. civil aviation accidents (Shappell & Wiegmann, 1999), Commercial Aviation Accidents (Wiegmann & Shappell, 2001) and more recently to Civil Aircraft Accidents in India (Gaur, 2005) and Shappell et al (2006). The later study was to extend the frontiers of HFACS application beyond general aviation and the special category of aviation operations and to take into account of human error involvements in commercial aviation.

While the HFACS framework is fast taking roots in analysing human error involvement in aircraft accidents, a number of researches such as Kumar & Malik (2003) and Hart & Griffith (2003) drawing from previous works such as Billings & Raynard (1984) and O'Hare, D. (2000), have applied methods that is not strictly HFACS, but on a very close assessment indicated variable not captured in the HFACS framework as a matter of semantics, but the aggregate of which may be compared to the basis of HFACS framework.

It is essential however, to note that application of the HFACS framework is predicated on the strength of a well-documented accidents/incident investigation final report and the capabilities of a team of at least two experts in HFACS framework to carry out extraction and categorizations deducible from the aircraft accident investigation final report.

4. Connecting Nigeria Aircraft Accident Investigation Reports to HFACS Framework

4.1 Introduction

Aircraft accident investigation reports are usually presented in two forms (Shappell et-al, 2006): 1) the factual investigation report, which is a preliminary, interim and descriptive report, consists of rudimentary information pertaining to the accident. It does not contain information of causal factors, but basically enlists information such as the case number, location, date, aircraft/operator, meteorological conditions, number of passenger/air crew, and 2) the final investigation report, which contains details of the information presented in the factual report. It also reports the causal factors associated with the accident. While a factual report may be prepared and released within 3 months, final reports may take as long as 2 years depending on several factors, such as unavailability of funds, magnitude of effects of accidents and certain complexities associated with forensic investigations and communication gaps between collaborating agencies.

However not all aspects of causal factors are covered in the final investigation reports in some cases observed. Consider for instance the following statements (AIB, 2009):

> *"The absence of forensic evidence prevented the determination of the captain's medical condition at the time of the accident. The missing flight recorders to reconstruct the flight also precluded the determination of his performance during the flight. Due to lack of evidence, the investigation could not determine*

the effect, if any, of the atmospheric disturbances on the airplane or the flight crew's ability to maintain continued flight."

The foregoing statement suggests that even in some final reports, the HFACS category: "condition of the operator", in which evaluations of adverse mental states, adverse physiological states and physical and/or mental limitations of the operators are evaluated are not obtainable due to the reasons mentioned in the above statement. Thus complete information relating to human causal factors not collected for assessment.

This chapter reviews the general features of aircraft accidents investigation report and attempt to demonstrate its utilization in HFACS. As mentioned earlier, HFACS framework is predicated on the strength of a well-documented accidents/incident investigation report, thus a representative final aircraft accidents investigation report in Nigeria was exploited for the demonstration. Nevertheless, investigative agencies involved in preparing the report must show a high level of adherence to the ICAO standards.

4.2 Features of Nigeria Aircraft Accident Investigation Report and HFACS Categorization

The features of a typical aircraft accident investigation final report is generally guided by the international standards and recommended practices outlined in chapter 6 of Annex 13 to the Convention on International Civil Aviation (ICAO, 2010). Country or States reporting aircraft accident or incident are required to adapt the circumstances of the occurrences to the format of the report. This is to ensure uniformity and global standardization. Quite thoughtful, otherwise it may have been difficult to connect the Nigeria accident investigation report to HFACS analysis.

AIB in Nigeria has adapted its report to this format and hence making it easy for use in the extraction of items indicated in the human factors categories of the HFACS framework. A typical outline of major headings and sub-headings in a final accident investigation report is presented in the appendix (A3).

Although in the Conclusion section of the final report a summary of causal factors are also presented, thus beginning with the category of Organisational Influences, statements such as *“The Captain’s training as PIC on B-737 were inadequate”* extracted from a typical AIB (2009) final report can be seen. This statement alone draws attention to failure in resource management under the category of Organisational Influences and more precisely inadequate supervision under the category of Unsafe Supervision.

Typical statements derivable from the same report of AIB (2009), which will always indict human causal factors to aircraft accident, are:

“Defects were not properly entered and rectification were either ignored or not properly carried out in aircraft tech log”.

And

“Deferred defects were not placed in Hold Item List in accordance with the airline’s maintenance procedures”.

However, while the concluding summaries offer such statements, the detailed nature of the event or circumstances are to be gleaned from the body of the report, thereby providing further clarification on the actual category and item addressed in the HFACS framework. The efforts of Shappell & Wiegmann (2000) in providing examples of phrases that can be matched with the content of a statement found in the final report are commendable and prove effective. So much so that it can be stated that the HFACS framework was actually developed from contents of final report of an accident investigation, thus enabling the ease of application of accident’s final report for HFACS analysis.

5. Methods of Data Collection and Analysis

5.1 Study Design

This study was designed in retrospect to cover the period between 1983 and 2013 utilising secondary data collected from reliable gazetted documents of aircraft accidents/incidents occurring within Nigeria airspace. Therefore, in addition to reasons mentioned earlier; such as comparability for adopting the study period 1983-2013, this period mainly also serve as a study frame within which all forms of data analysis related to specific issues, questions, hypothesis testing and HFACS quantification were conducted using comprehensive data available to enable a meaningful explanations and drawing of conclusions.

For instance, data utilised for HFACS quantification, summarily presented on Table 6. 10 are a subset of the entire data collected, but that were considered eligible for HFACS analysis due to completeness of the accident report and that it falls within the study frame 1983 and 2013.

5.2 Source of Research Data

Accident data for the study period (1983-2013) were obtained from AIB Nigeria database. Complimentary source of research data for the study were also obtained from ASN website (aviation-safety.net/database).

Data collected from the ASN website constituted 45% of total accident data collected and analysed in this study. This was necessary as some of the accidents reported were not accessible from the report archive in AIB.

5.3 Ethical considerations

Authorization was obtained from the AIB's Commissioner/CEO for access and use of accident data.

5.4 Causal Factor Analysis Using HFACS

Only final reports of all aircraft accidents that occurred within the study period 1983 to 2013 obtained from the database of AIB were used for HFACS analysis. Categorization of the HFACS was carried out according to standard procedures (Gaur, 2005; Shappell & Wiegmann, 2006). A total of 48 accident cases with full reports were analysed using HFACS. This constitutes 31.4% of 153 accident cases in the study period. It was considered significantly sufficient (Cochran, 1963) as it was greater than 12% of total sample.

A team of five, consisting of Capt. Danraka (myself/accident investigator operations), Capt. Lawal (a colleague/accident investigator operations), Senior Flight Engineer Clement O. (a colleague/accident investigator, human factor), Engineer Alao (a colleague/ accident investigator, engineering) and Dr. S. S. Hati (Data analyst) proficient with the HFACS framework carried out the categorisation. Proficiency activities of the team in getting abreast with HFACS framework took about three months. This team was then divided into two groups (3:2) and one group categorized independently 20 of the 48 final reports (41.72%). A percentage agreement (Kappa test) of 82% (k = 0.82) comparison of the sample revealed between one group and the other group was achieved. Common differences observed were then discussed over several sessions until a harmonization was obtained in all the cases with discrepancies.

5.5 Data Analysis Technique

5.5.1 Software

Microsoft Excel version 2010 spread sheet application was used for collation/data entry. Subsequently data analysis was performed using Analyse-it v.2.26 statistical software for Microsoft Excel (Analyse-it, 2013).

5.5.2 Statistical analysis

Summary descriptive results of relevant variables and factors are presented as frequency distributions (number and percentages), and mean and standard deviation (Mean ± SD).

Non-parametric inferential statistical analysis (e.g. Mann-Whitney and Kruskal-Wallis tests) were performed to indicate statistical significance when conditions for parametric analysis, such as failure to pass normality test (Shapiro-Wilks, <.96) are observed (Sheskin, 2003). Mann-Whitney and Kruskal-Wallis tests are non-parametric counterparts of t-test and one way analysis of variance (ANOVA) respectively.

The equation for Mann-Whitney U test can be presented as:

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum_{i=n_1+1}^{n2} R_i$$

Where samples of size n_1 and n_2 are pooled and R_i are the ranks. U can be resolved as the number of times observations in one sample precede observations in the other sample in the ranking.

The equation for Kruskal-Wallis tests is as follows:

$$T = \frac{1}{s^2}\left(\sum_{i=1}^{k} \frac{R_i}{n_i} - N\frac{(N+1)^2}{4}\right)$$

Where N is the total number (all n_i) and R_i is the sum of the ranks (from all samples pooled) for the ith sample and:

$$S^2 = \frac{1}{N-1}\left(\sum_{all} R_{ij}^{\ 2} - N\frac{(N+1)^2}{4}\right)$$

Chi-squared test was also used to determine relationships for discrete variables. The Chi-squared tests equation is represented in the equation below:

$$\chi^2 = \Sigma \frac{(Observed\ value - Expected\ value)^2}{(Expected\ value)}$$

Its use also involves the determination of the observed (actual) and the expected frequencies, the deviation squared and the summations of the deviations squared divided by the summations of the expected frequencies (Conover, 1999).

Polynomial regression analysis was also performed to assess the association between two continuous variables and was used in this study to fit the nonlinear relationship between the number of accidents and number of casualty. The regression equation is presented as:

$$\hat{Y} = b_0 + b_1 x + b_2 x^2 + \ldots + b_k x^k$$

Where $\hat{Y}$ is the predicted outcome value for the polynomial model with regression coefficients b_1 to k for each degree and intercept is b_0. The model is basically a general linear regression model with predictors of k raised to the power of i where i=1 to k. Therefore a second order (k=2) polynomial forms a quadratic expression (parabolic curve), a third order (k=3) polynomial forms a cubic expression and a fourth order (k=4) polynomial forms a quartic expression.

Kappa (*k*) aggrement test was conducted as mentioned in section 5.3 as a measure for inter-rater agreement for two raters' assessments of observations on a categorical scale. Kappa equation is presented as:

$$\kappa = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)}$$

In which Pr(*a*) = relative observed agreement among raters;

Pr(*e*) = hypothetical probability of chance agreement, using the observed data to calculate the probabilities of each observer randomly.

The interpretation of the resulting *k-values* is made as follows:

Kappa (*k*)statistic	Agreement
< 0.20	Poor
< 0.40	Fair
< 0.60	Moderate
< 0.80	Good
to 1	Very good

Decision rule for statistical significance was considered at 95% confidence interval (p<.05 or $\alpha = .05$). Therefore either of the following positions was taking in the cause of hypothesis testing:

i) Reject H_0: If $X^2 \geq X2_\alpha(n-2)$ df

and $X2_\alpha(n-2)$ df = table value for X^2 at $\alpha = 0.05$ degree of freedom.

ii) Accept H_0 otherwise

6. Results of Data Analysis

This chapter presents the results and interpretation of aviation accident data analysed in this study. The results were expected to provide answers to research questions and tests of hypotheses that are raised in this study. Accordingly the presentation in this chapter was made in the order in which the objectives (2 and 3) of this study appeared. These objectives require statistical analysis to deal with and thus:

- **Objective 2:** Evaluate the trend of aircraft accidents/incidents and casualties in Nigerian airspace between 1983 and 2013,
- **Objective 3:** Attempt quantifying the role human error contributes to aircraft accidents data (Nigeria) using the HFACS framework.

6.1 Trend Analysis of Aircraft accidents/incidents and casualties in Nigerian airspace between 1983 and 2013

6.1.1 Accidents, Serious Incident and Incidents

Table 6.1 presents the nature of occurrences within the study period (1983-2013). The result shows that there is at least one accident occurring each year. The least (1) number of accident occurred in 1993. This was followed by two occurrences (1 accident and 1 incident, each respectively) in 2007. Up to 10 aviation accidents were recorded in 1991 and 1992 consecutively and respectively, been the highest numbers of accident occurrences recorded in Nigeria airspace within the last three decades. But the cumulative highest number of occurrences was recorded in 2005, though with 4 accidents, 3 serious incidents and 5 incidents.

Table 6.1: Number of Aircraft accident/incident for the period (1983-2013)

YEAR	Nature of Occurrence			Total Occurrences
	Accident	Serious Incident	Incident	
1983	6	-	-	6
1984	6	-	-	6
1985	4	-	-	4
1986	4	-	-	4
1987	4	-	-	4
1988	8	-	-	8
1989	6	-	-	6
1990	4	-	-	4
1991	10	-	-	10
1992	10	-	-	10
1993	1	-	-	1
1994	6	-	-	6
1995	9	-	-	9
1996	6	-	1	7
1997	3	-	-	3
1998	8	-	-	8
1999	5	-	-	5
2000	6	-	-	6
2001	8	-	-	8
2002	5	-	1	6
2003	4	-	4	8
2004	2	-	3	5
2005	4	3	5	12
2006	2	5	1	8
2007	1	-	1	2
2008	5	1	-	6
2009	2	2	-	4
2010	3	1	5	9
2011	3	2	2	7
2012	5	-	-	5
2013	3	2	2	7
Total	**153**	**16**	**25**	**194**
(%)	78.9%	8.2%	12.9%	

(Source: AIB and ASN, 2013)

Note: Accidents were in the majority (i.e. 153/194*100 = 78.9%), followed by incidents (12.9%) and then serious incidents (8.2%).

The result generally shows absence of serious incidents and incident between 1983 and 2014. This was due to the fact that data for this period were unavailable, but did mean that there were no serious incidents or incidents. Lack of effective documentation before the inception of AIB is the likely attributable reason.

By classifying the study period into a five year cluster (Fig. 6.1) it was easy to provide answer to the research question: **What is the Accidents Trend between 1983 and 2013?** The five year cluster actually concluded the last band on year 2012, and clearly shows that there has been a 5year periodic rise and fall in accident trend between 1983 and 2013. Thus while the last cluster (2008-2012) shows the last rise, it is anticipated that the next phase (2013-2017) may observe a fall in the trend of aviation accidents in Nigeria.

Statistical test (Kruskal-Wallis with Bonferroni *post hoc* test) for differences between the numbers of accidents in the clustered periods indicated that the number of accidents in the period 2003-2007 was significantly lower than the number of accidents in the period 1998-1992 (Difference = 25, p = .010) and 1998-1992 (Difference = 19, p = .038) respectively.

Figure 6.1 also revealed that records of serious incidents and incidents began to emerge in the last 20 years and actively for serious incidents in the period 1993-1997 and incidents in the period 1998-2002. Serious incidents (8) and incidents (14) were both highest in the period 2003-2007 but declined simultaneously in the succeeding period 2008-2012, serious incidents (6) and incidents (7).

Mann-Whitney's statistic revealed no significant difference between the two periods 2003-2007 and 2008-2012 in terms of numbers of serious incidents (p = .420), but a significant decline in the number of incidents (p = .015).

In testing the Hypothesis: **There is no significant decline in the number of accidents for the study period 1983 and 2013,** a second order polynomial regression analysis was performed and illustrated on Fig. 6.2. It show that there was a significant (F =4.1, p = .026) decline in the number of accidents between the period 1983 and 2013.

Therefore the Hypothesis which states that "*there is no significant decline in the number of accidents for the study period 1983 and 2013*", is hereby rejected.

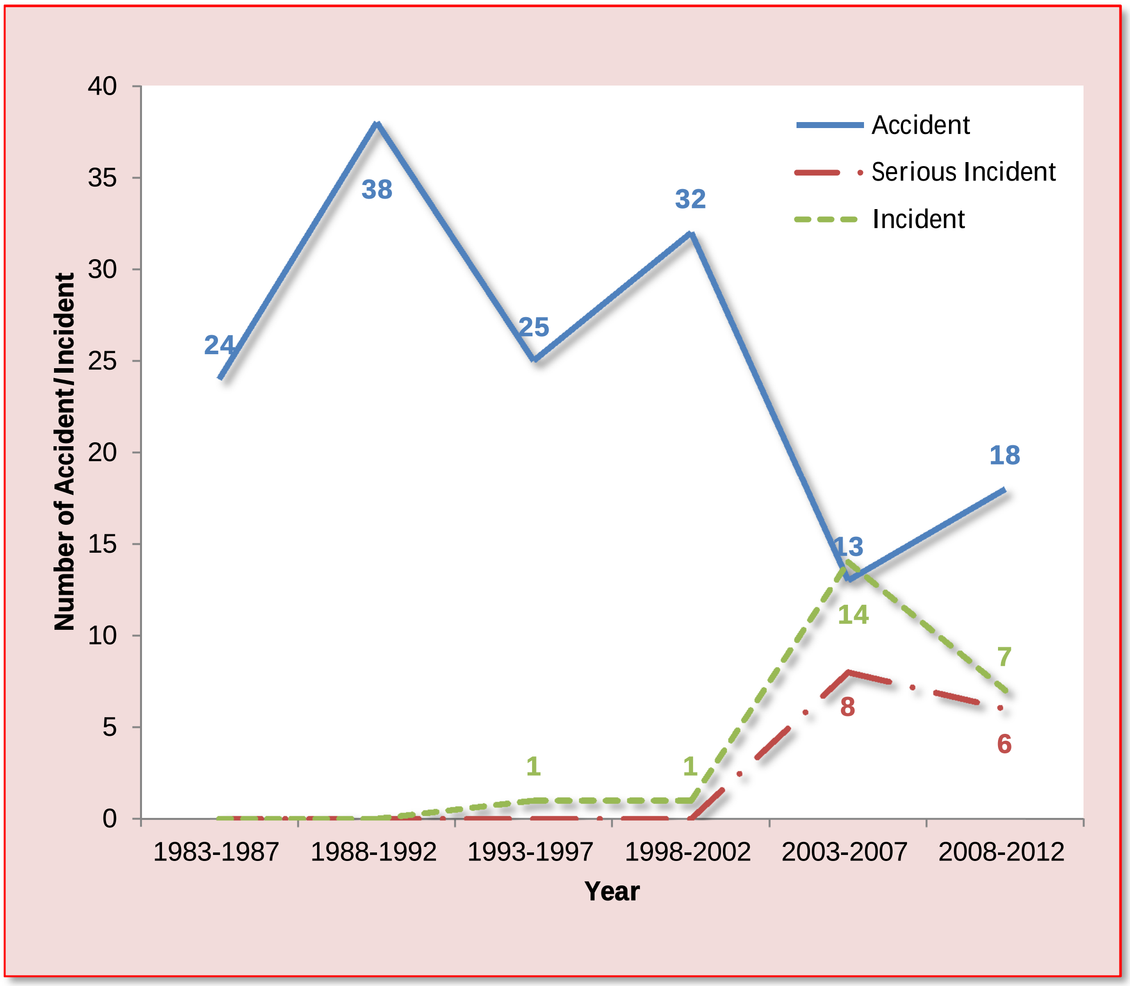

Fig.6.1: Number of Aircraft accident/incident for the period (1983-2013)

Fig. 6.2 shows that the projected trajectory of the polynomial curve over a five year period into the future also reveals this decline thereby supporting the earlier trend of Fig. 6.1 that the next cluster of 5years (2013-2017) may observe a decline in aircraft accidents in Nigeria Airspace. Further illustration of both 3 and 5 year moving averages of the accidents data can be seen to buttress this decline trend, especially when considered on a 5year term. Thus an average forecast value of less than 2 accidents is likely to occur over the period (2013-2017). This is about 45% reduction from past trend.

6.1.2 Casualties from Aircraft Accidents

Table 6.2 shows the trend of casualties from aircraft accidents for the period 1983-2013. It revealed that only accidents resulted in casualties (death or injuries), while serious incidents and incidents indicated no casualty.

The result revealed that not all accidents resulted in casualty, therefore in some years (1984, 1987, 1989, 1990, 1993, 2008, and 2010), no casualty was recorded. It is also obvious that 30.7% of all accidents occurring within the period 1983-2013 were responsible for casualties. Thus casualty number ranged between 1 in an accident in some years (1986, 1992, 1999, 2007 and 2009) and a peak of 260 casualties from 3 out of 5 accidents in year 2002.

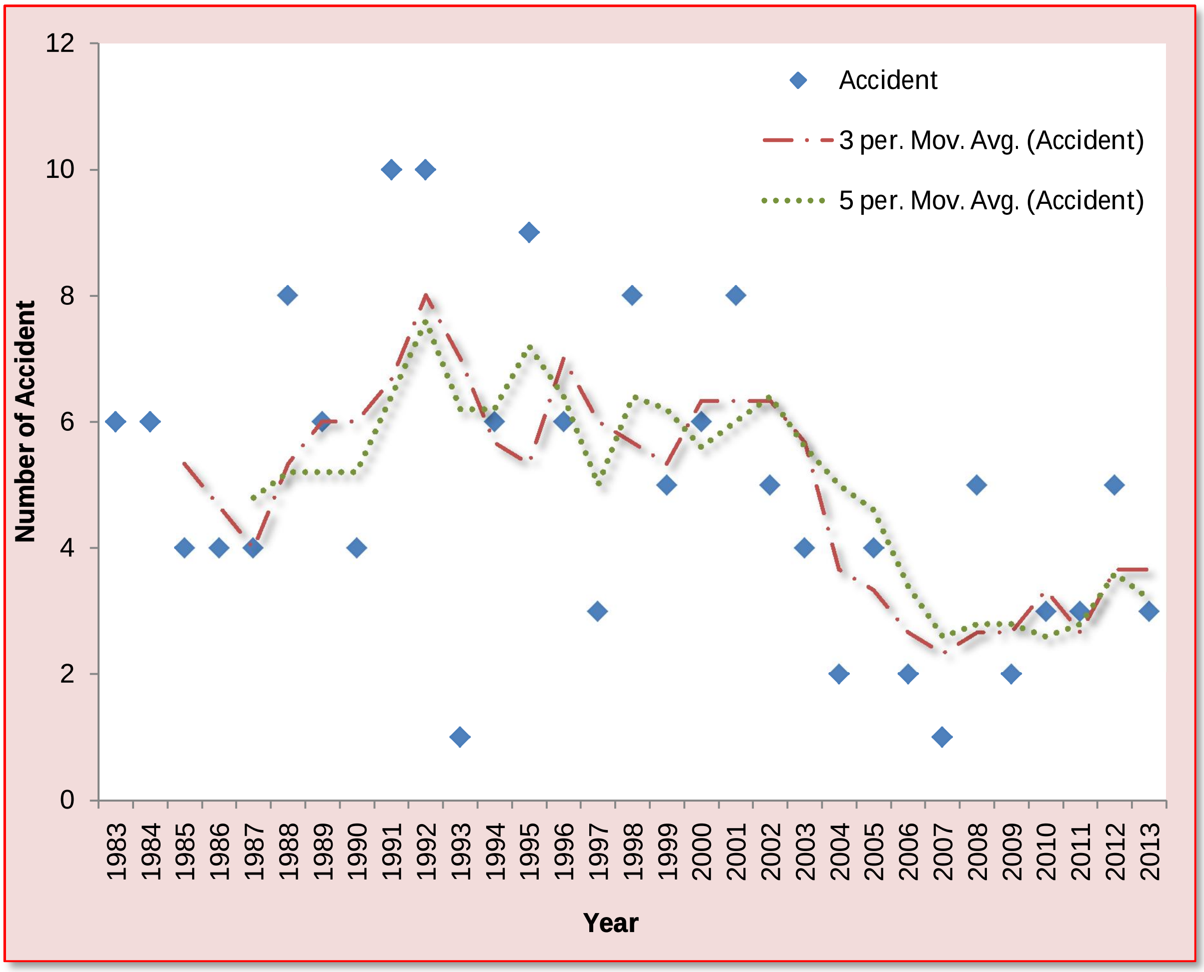

Fig.6.2: Trend plots of Aircraft accident/incident for the period (1983-2013)

Table 6.2: Number of Casualties from Aircraft accident within the period (1983-2013)

YEAR	Total Accident	Number of Accident Resulting in Casualty	Minimum	Maximum	Mean	Standard Deviation	Sum of Casualty
1983	6	1	0	53	8.8	21.6	53
1984	6	0	0	0	0.0	0.0	0
1985	4	1	0	5	1.3	2.5	5
1986	4	1	0	1	0.3	0.5	1
1987	4	0	0	0	0.0	0.0	0
1988	8	2	0	6	1.5	2.8	12
1989	6	0	0	0	0.0	0.0	0
1990	4	0	0	0	0.0	0.0	0
1991	10	5	0	9	2.2	2.9	22
1992	10	1	0	1	0.1	0.3	1
1993	1	0	0	0	0.0		0
1994	6	3	0	3	1.2	1.3	7
1995	9	4	0	15	4.2	6.2	38
1996	6	3	0	143	24.4	52.7	171
1997	3	3	1	5	2.7	2.1	8
1998	8	1	0	5	0.6	1.8	5
1999	5	1	0	1	0.2	0.4	1
2000	6	2	0	2	0.5	0.8	3
2001	8	2	0	1	0.3	0.5	2
2002	5	3	0	149	43.3	66.6	260
2003	4	1	0	4	0.5	1.4	4
2004	2	1	0	4	0.8	1.8	4
2005	4	3	0	117	18.9	43.8	227
2006	2	2	0	96	12.3	33.8	98
2007	1	1	0	1	0.5	0.7	1
2008	5	0	0	0	0.0	0.0	0
2009	2	1	0	1	0.3	0.5	1
2010	3	0	0	0	0.0	0.0	0
2011	3	2	0	3	0.7	1.3	5
2012	5	2	0	155	31.8	68.9	159
2013	3	1	0	15	2.1	5.7	15
Total	**153**	**47**					**1103**
%		**30.7**					

(Source: AIB and ASN, 2013)

To answer the question: **What is the relationship between the total number of accidents in a year and the number of accidents responsible for casualties?** And the test of the hypothesis: **There is no significant relationship between total number accidents in a year and the numbers of accidents responsible for casualties** were achieved by a linear regression analysis.

Table 6.3 shows the result of regression model revealing an Adjusted R^2 = 0.16 or suggesting that there is a correlation r = 39.5% level of relationship between the total number of accidents in a year and the number of accidents that result in casualty. In other words, about 40% of total aviation accident in Nigeria is responsible for accidents resulting in cases of casualty. This level of correlation is considered moderately weak (Sheskin, 2003).

The result of the regression (Table 6.3) also revealed a significant value for the constant in the regression model (F = 7.11, p= .011) and Slope (t = 2.67, p= .011) suggesting that there is significant relationship between total accidents per year and the number of accidents resulting in casualties. Therefor the null hypothesis which states that "*there is no significant relationship between total number accidents in a year and the numbers of accidents responsible for casualties*" is rejected.

Table6.3: Linear regression analysis of total number of accidents per year and number of accidents resulting in casualties for the period (1983-2013)

R^2	0.18						
Adjusted R^2	0.16 = (r = 0.395 or 39.5%)						
SE	1.1						
Term	**Coefficient**		**95% CI**	**SE**	**t statistic**	**DF**	**P**
Intercept	0.4239		-0.4688 to 1.3166	0.43824	0.97	32	0.3407
Slope	0.2197		0.0519 to 0.3875	0.08239	2.67	32	0.0119
Equation	Accidents with Casualty = 0.4239 + 0.2197Accident						
Source of variation	Sum squares	DF	Mean square	F statistic	p		
Model	9.2	1	9.2	7.11	0.0119		
Residual	41.3	32	1.3				
Total	50.5	33					

Fig. 6.3 revealed that the number of accidents resulting in casualties in the period 1993-1997 was highest, with 13 resulting in a total of 224 casualties and lowest number of accidents resulting in casualties was observed in the period 1983-1987, with 3 accidents resulting in 59 casualties. It also clearly revealed the remarkable period 2003-2007 in which the highest number of casualties (334) was recorded. Although 8 accidents resulted in this huge casualty, a similar number of accidents resulted in 35 casualties in the period 1988-1992.

This leads to answering the question: **What is the relationship between the number of accidents resulting in casualties and the total number of causalities recorded in study period 1983-2013?** And the test of the hypothesis: **There is no relationship between the number accidents resulting in casualties and the total number of causalities per year for the study period 1983-2013** was also achieved by a linear regression analysis.

Table 6.4 revealed r = 0.47, a moderately weak correlation or relationship between the number of accidents resulting in casualties and the number for casualties per year for the period 1983-2013.

Again, the result of regression analysis (Table 6.4) revealed a significant value for the constant in the regression model (F = 8.92, p= .005) and Slope (t = 2.99) suggesting the number of accidents resulting in casualties and the number for casualties per year for the period 1983-2013. Therefore the null hypothesis which states that "*there is no significant relationship between the number of accidents resulting in casualties and the number for casualties per year for the period 1983-2013*" is rejected.

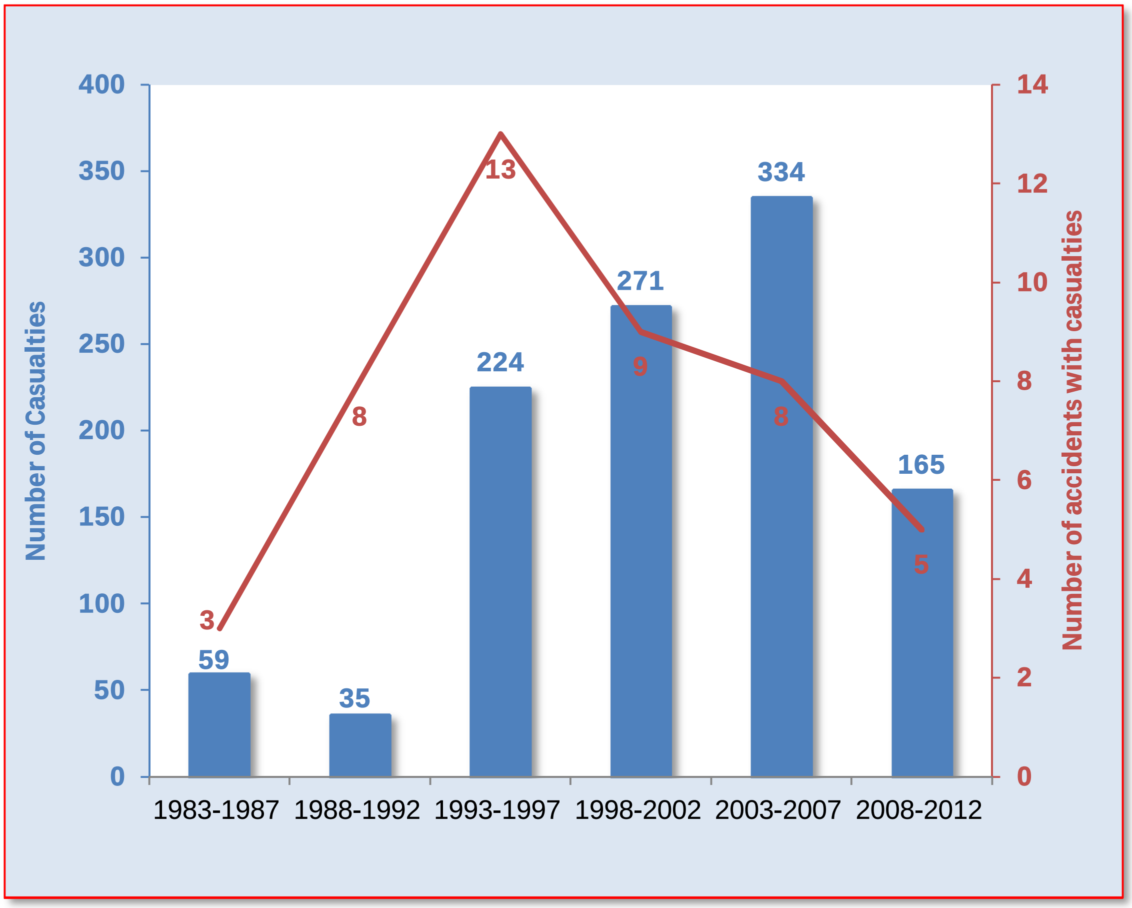

Fig.6.3: Number of casualties and accidents resulting in casualties with each 5year cluster period

Table6.4: Linear regression analysis of number of accidents resulting in casualties and number of casualties per year for the period (1983-2013)

R^2	0.22						
Adjusted R^2	0.19 (r = 0.467 or 46.7%)						
SE	60.6						
Term	Coefficient		95% CI	SE	t statistic	DF	P
Intercept	-3.728	-36.937	to 29.480	16.3033	-0.23	32	0.8206
Slope	25.5	8.1	to 42.9	8.54	2.99	32	0.0054

Casualty =-3.728 + 25.5Accidents with Casualty

Source of variation	Sum squares	DF	Mean square	F statistic	p
Model	32806.5	1	32806.5	8.92	0.0054
Residual	117705.6	32	3678.3		
Total	150512.1	33			

6.2 General Features of the Aircraft Accidents in Nigerian Airspace

Since only accidents resulted in casualties as against serious incidents/incidents, though some accidents did not result in casualties, the following analysis relates to the 153 accidents constituting the majority (78.9%) of the total occurrences (194 - accidents/incidents) within the study period 1983-2013. It is essential to present the general features of these accidents as it elucidates a number of relationship factors leading to these accidents.

Statistical comparison, where applicable, was conducted excluding year 2013 due to the unequal sampling period, although features of year 2013 is presented for descriptive purposes only.

6.2.1 Accident Involvement

Table 6.5 shows that aircraft accidents data analyzed for the study period (1983-2013) captured three major forms. These are accidents involving one aircraft (97.4%), which are in the majority, accidents involving more than one aircraft (2 aircraft, 2%) and accidents involving an aircraft with ground equipment (<1%).

In the one aircraft accident, the period 1988-1992 recorded the highest (37, 24.2%) and in this same period accident involving 2 aircraft was recorded. The highest (2, 1.3%) of more than one aircraft accident occurred in the period 2003-2007 and in this same period the lowest of one aircraft accident was recorded (11, 72%).

Only one accident involving an aircraft and ground equipment occurred in the period 2008-2012.

Table 6.5: Accident involvement (1983-2013)

Year	Accident Involvement Number (%)		
	One Aircraft	More than 1 Aircraft	Aircraft & Ground Equipment
1983-1987	24(15.7)	0(0.0)	0(0.0)
1988-1992	37(24.2)	1(0.7)	0(0.0)
1993-1997	25(16.3)	0(0.0)	0(0.0)
1998-2002	32(20.9)	0(0.0)	0(0.0)
2003-2007	11(7.2)	2(1.3)	0(0.0)
2008-2012	17(11.1)	0(0.0)	1(0.7)
2013	3(2.0)	0(0.0)	0(0.0)
Total	**149(97.4)**	**3(2.0)**	**1(0.7)**

(Source: AIB and ASN, 2013)

6.2.2 Nature of Aircraft Operation involved in Accident

Table 6.6 present the type of aircraft operation involved in the accidents for the period (1983-2013). It revealed that commercial aviation accidents was highest (71, 46.4%), followed by special category operation (49, 32.0%) and then aircraft in general aviation operation (31, 20.3%).

The result now clearly revealed that the 2 accidents involving more than one aircraft in Table 6.5 above, actually involved a general and a commercial operation aircraft, though these accidents occurred over a decade between one another.

The result also revealed that commercial aviation accidents were consecutively high over a fifteen year period (1988-2002) constituting the bulk of the accidents responsible for the high proportions of commercial aviation accidents within the study period (1983-2013).

Aircraft accident in the general aviation sector indicated no occurrences in periods (2003-2007) and in year 2013.

Table 6.6: Type of Aircraft operation involved in accidents for the period (1983-2013)

Year	Operation Number (%)			
	General	**Commercial**	**Special**	**General and Commercial**
1983-1987	8(5.2%)	9(5.9%)	7(4.6%)	0(0.0%)
1988-1992	7(4.6%)	19(12.4%)	11(7.2%)	1(0.7%)
1993-1997	5(3.3%)	15(9.8%)	5(3.3%)	0(0.0%)
1998-2002	7(4.6%)	13(8.5%)	12(7.8%)	0(0.0%)
2003-2007	0(0.0%)	8(5.2%)	4(2.6%)	1(0.7%)
2008-2012	4(2.6%)	5(3.3%)	9(5.9%)	0(0.0%)
2013	0(0.0%)	2(1.3%)	1(0.7%)	0(0.0%)
Total	**31(20.3%)**	**71(46.4%)**	**49(32.0%)**	**2(1.3%)**

(Source: AIB and ASN, 2013)

6.2.3 Category of Aircraft Accident Involvement

Table 6.7 shows that majority of the accidents involved aircraft with multi engine (109, 71.2%). Single engine aircraft were involved in about 28% of the accidents. The result further revealed that the 2 accidents involving a general and a commercial operation aircraft were both multi engine.

Also the trend of multi-engine aircraft accidents tends to show correspondence with the trend of commercial aviation accidents, consecutively high over a fifteen year period (1988-2002), and responsible for the bulk of the accidents involving multi engine within the study period (1983-2013).

6.2.4 Class of Aircraft Involved in Accident

Table 6.8 shows that a little more than half (of the accidents involved aircraft with Jet engines (78, 51.0%). This was followed by Propeller (42, 27.5%) and Rotor (31, 20.3%).

A Propeller and Jet engine were the 2 multi-engine accidents involving a general and a commercial aviation operation aircraft. The highest number of accidents (38, 24.8%) was generally recorded in period 1988-1992 and indicated that the highest contributors were Jet (23, 15.0%) and Rotor (10, 6.5%) engine aircraft. Accidents involving aircraft with Propeller engines peaked in the periods 1983-1987 (11, 7.2%) and1998-2002 (10, 6.5%).

6.2.5 Type of Aircraft (Fixed wings or Helicopter)

Table 6.9 present the type of aircraft involved in the accidents, in terms of fixed wings or helicopter for the period (1983-2013). It revealed that majority of the aircraft involved in the accidents are Fixed wings (122, 79.7%) and the remaining are Helicopters (31, 20.3%).

The 2 fixed wings aircraft accidents were a Propeller and a Jet multi engine involving a general and a commercial aviation aircraft.

Table 6.7: Number of engines of aircraft involved in accident within the period (1983-2013)

	Aircraft Category Number (%)		
Year	**Single Engine**	**Multi Engine**	**2 Multi Engines**
1983-1987	9(5.9%)	15(9.8%)	0(0.0%)
1988-1992	11(7.2%)	26(17.0%)	1(0.7%)
1993-1997	3(2.0%)	22(14.4%)	0(0.0%)
1998-2002	6(3.9%)	26(17.0%)	0(0.0%)
2003-2007	4(2.6%)	8(5.2%)	1(0.7%)
2008-2012	9(5.9%)	9(5.9%)	0(0.0%)
2013	0(0.0%)	3(2.0%)	0(0.0%)
Total	**42(27.5%)**	**109(71.2%)**	**2(1.3%)**

(Source: AIB and ASN, 2013)

Multi Engine = Accidents or incident involving multi engine aircraft

2 Multi Engine = Accidents or incident involving 2 aircraft, both of which has multi engine

Table 6.8: Class of aircraft involved in accident within the period (1983-2013)

	Class of Aircraft Number (%)			
Year	**Rotor**	**Propeller**	**Jet**	**Propeller and Jet**
1983-1987	3(2.0%)	11(7.2%)	10(6.5%)	0(0.0%)
1988-1992	10(6.5%)	4(2.6%)	23(15.0%)	1(0.7%)
1993-1997	2(1.3%)	7(4.6%)	16(10.5%)	0(0.0%)
1998-2002	6(3.9%)	10(6.5%)	16(10.5%)	0(0.0%)
2003-2007	4(2.6%)	3(2.0%)	5(3.3%)	1(0.7%)
2008-2012	6(3.9%)	5(3.3%)	7(4.6%)	0(0.0%)
2013	0(0.0%)	2(1.3%)	1(0.7%)	0(0.0%)
Total	**31(20.3%)**	**42(27.5%)**	**78(51.0%)**	**2(1.3%)**

(Source: AIB and ASN, 2013)

Table 6.9: Aircraft Type (fixed wing or helicopter) involved in accident within the period (1983-2013)

	Aircraft Type Number (%)		
Year	**Fixed Wing**	**Helicopter**	**2FixedWings**
1983-1987	21(13.7)	3(2.0)	0(0.0)
1988-1992	27(17.6)	10(6.5)	1(0.7)
1993-1997	23(15.0)	2(1.3)	0(0.0)
1998-2002	26(17.0)	6(3.9)	0(0.0)
2003-2007	8(5.2)	4(2.6)	1(0.7)
2008-2012	12(7.8)	6(3.9)	0(0.0)
2013	3(2.0)	0(0.0)	0(0.0)
Total	**120(78.4)**	**31(20.3)**	**2(1.3)**

(Source: AIB and ASN, 2013)

6.3 Quantifying Human Error involvement in aircraft accidents in Nigerian Airspace using the HFACS Framework

6.3.1 Accident Data for HFACS

Of the 153 aircraft accidents data collected, about 31.4% (48) of them have final reports from which HFACS categorization was conducted. Table 6.10 present the distributions of these final reports over the study period (1983-2013) and in accordance with the type of operation.

The final reports utilised represented 24 out of the 31 years, constituting 80% representation of the study period (1983-2013).The distribution also shows that both years in the upper and lower bounds were represented and the highest number of final reports utilized emanated from year 1995 in which a total of 9 accidents occurred. The seven years from which challenges of obtaining final reports consist 1984, 1989, 1993, 1999, 2004, 2007 and 2010.

The distribution (Table 6.10) generally shows that half of the aircraft accidents analysed in the HFACS framework were commercial aviation (50%), followed by general aviation (27.1%), and special category (22.9%).

6.3.2 HFACS Causal Category

Table 6.11 present detailed results of the different HAFCS causal category for each of the aviation operations. At a glance on the overall (total) contribution of HAFCS causal factor, decision error under the Unsafe Act of the Operator was the highest (32, 66.7%). It should be noted that due to the multiple nature of causal factor indicated by each particular item in the different type of operation, summation of percentage (values in parenthesis) does not give 100%.

Table 6.10: Dataset for HFACS analysis with indicating type of aviation within the period (1983-2013)

YEAR	Type of Operation Number (%)			Total
	General	Commercial	*Special	
1983	0	1	0	1
1985	1	0	1	2
1986	0	0	1	1
1987	0	1	0	1
1988	0	1	0	1
1990	1	0	0	1
1991	1	1	1	3
1992	1	1	1	3
1994	0	3	0	3
1995	3	2	0	5
1996	0	2	1	3
1997	0	1	1	2
1998	1	1	0	2
2000	0	0	1	1
2001	1	2	0	3
2002	1	1	1	3
2003	0	1	0	1
2005	0	3	0	3
2006	0	1	2	3
2008	0	1	1	2
2009	1	0	0	1
2011	1	0	0	1
2012	1	0	0	1
2013	0	1	0	1
Total	**13**	**24**	**11**	**48**
%	27.1%	50.0%	22.9%	

(Source: AIB and ASN, 2013)

*Special category = Aircraft used for activities such as fumigation, aerial photography, etc

For instance, the decision error under the Unsafe Act of the Operator was estimated by dividing the sum of counts for the three types of operations (8+18+6 = 32) by total number of study cases (48) yields 66.7%. But in estimating the decision error under the Unsafe Act of the Operator for commercial aviation is 18/24 = 75.0%.

For Preconditions of Unsafe Acts, crew resource management was highest (31, 64.6%) and consequently for the sub-category of personnel factors. Adverse physiological states was prominent (8, 16.7%) as causal factor responsible for conditions of the operator, while physical environment was a higher (23, 47.9%) causal factor in environmental conditions.

The variations of causal factors in the Unsafe Supervision category were not so diverse, but planned inappropriate factor operation was the highest (19, 39.6%) as a causal factor. Operational process was highest (21, 43.8%) as a causal factor under the Organizational Influence.

Generally the result, Table 6.11, revealed that Commercial aviation consistently showed the highest number of casual factors observed among all four major categories of HFACS causal factors. Comparative analysis revealed that, while there was apparently a huge difference between the number of causal factors noted for commercial aviation against others, which was statistically significant ($p <.000$), there was no statistically significant ($X^2 = 21.26$, difference =5.42, $p = .581$) difference between the numbers of causal factors recorded for general aviation and special category.

Thus the forgoing analysis provides answer to the hypothesis: **There is no significant difference between the proportions of human error causal factors in the three different aviation operations if compared.** On a general note this hypothesis is rejected as there are significant differences between the proportions of causal factors in commercial aviation against both general and special category respectively.

Table 6.11: Distribution of HFACS causal category for aircraft accidents analyzed by aviation operations

HFACS Category	Aviation operation Number (%) General Aviation	Commercial Aviation	Special category	Total
Organizational Influences				
Resource Management	4(30.8)	10(41.7)	2(18.2)	16(33.3)
organisational climate	6(46.2)	7(29.2)	2(18.2)	15(31.3)
Operational Process	5(38.5)	12(50.0)	4(36.4)	21(43.8)
Unsafe Supervision				
Inadequate Supervision	4(30.8)	10(41.7)	2(18.2)	16(33.3)
Planned Inappropriate Operation	4(30.8)	10(41.7)	5(45.5)	19(39.6)
Failed to correct Known Problems	2(15.4)	9(37.5)	3(27.3)	14(29.2)
Supervisory Violations	2(15.4)	8(33.3)	4(36.4)	14(29.2)
Preconditions of Unsafe Acts				
Environmental Conditions				
Technological environment	5(38.5)	9(37.5)	3(27.3)	17(35.4)
Physical Environment	6(46.2)	14(58.3)	3(27.3)	23(47.9)
Conditions of the Operator				
Adverse Mental Status	0(0.0)	2(8.3)	0(0.0)	2(4.2)
Adverse Physiological States	2(15.4)	5(20.8)	1(9.1)	8(16.7)
Physical/Mental Limitations	1(7.7)	2(8.3)	0(0.0)	3(6.3)
Personnel Factors				
Crew Resource Management	8(61.5)	17(70.8)	6(54.5)	31(64.6)
Personal Readiness	4(30.8)	6(25.0)	5(45.5)	15(31.3)
Unsafe Acts of the Operator				
Skill-Based Errors	8(61.5)	11(45.8)	6(54.5)	25(52.1)
Decision Errors	8(61.5)	18(75.0)	6(54.5)	32(66.7)
Perceptual Errors	6(46.2)	11(45.8)	7(63.6)	24(50.0)
Violations	6(46.2)	11(45.8)	2(18.2)	19(39.6)

(Source: AIB and ASN, 2013)

Detail list of 153 accidents for HFACS on Appendix A4.

But the absence of significant difference between general aviation and special category therefore requires that hypothesis be considered for specificity in phrasing where more than two groups are compared on a particular issue.

The Box-Whisker plot (Fig. 6.4) further illustrates the results on Table 6.11 by presenting a summary spread of number of cases in which certain causal factors are not observed in the HFACS analysis of accidents involving both operations of general aviation and special category.

The illustration clearly shows that in addition to the noticeably wide spread of number of cases recorded for commercial aviation which ranged between a minimum of 2 cases of “Adverse mental status” and a maximum of 18 cases of “Decision Errors”. Conversely, in both general and special category operations there were instances, mainly under the Conditions of the Operator, in which not a single case indicated count for a casual factor such as Adverse Mental Status for both general and special category and Physical/Mental Limitations for special category.

Fig. 6.5 shows in a descending order, on average, that Unsafe Acts of the Operator constitute the highest (52.1±11.2%) causal factor in the HFACS analysis. Preconditions of Unsafe Acts was lowest (29.5±22.17%), on average, but was a category with the most diverse range of observation of HFACS rating.

Thus on the whole, answering the research question**: Does human error accounts for up to 70% of causes of accident in the Nigeria airspace?** The result from this study also confirms this generally acclaimed position that human factor accounts for 60-80% cause of aviation accidents, as slightly over 80% of the causal factors were indicated.

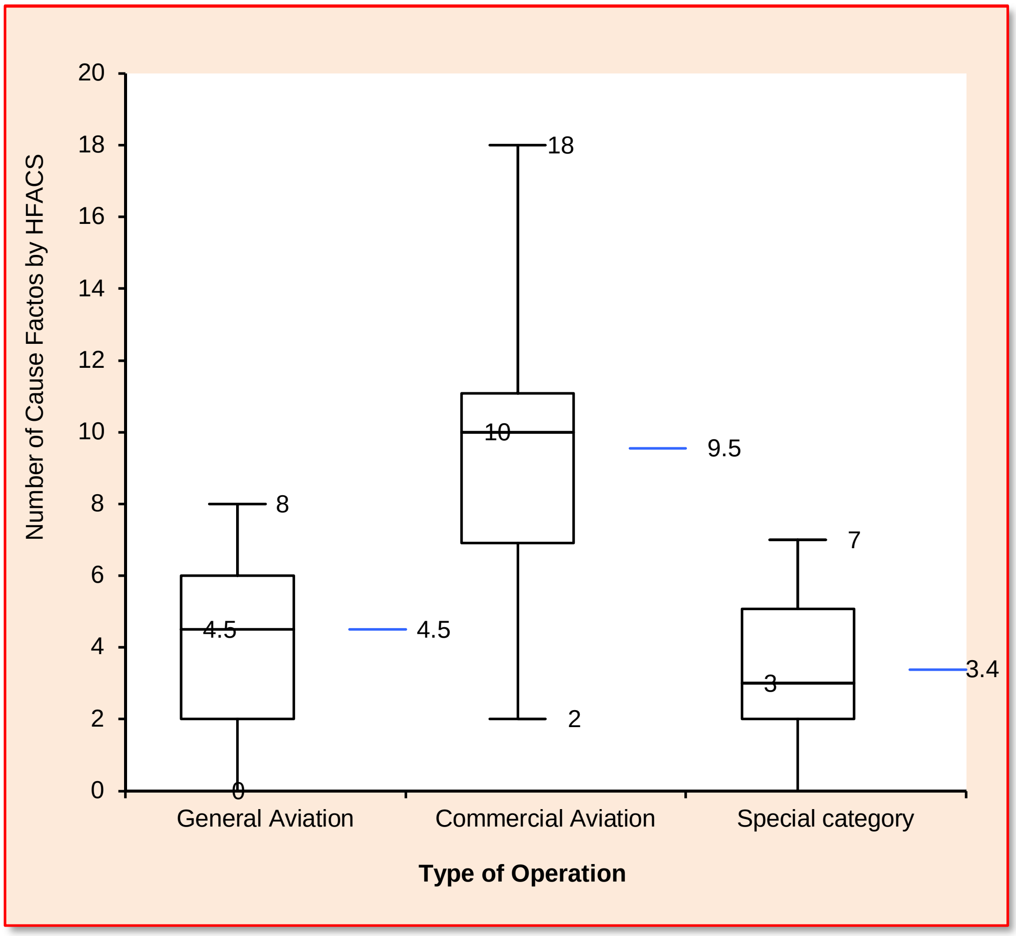

Fig.6.4: Box-Whisker plot showing comparative spread of number of causal factors by HFACS recorded between each of three aviation operations

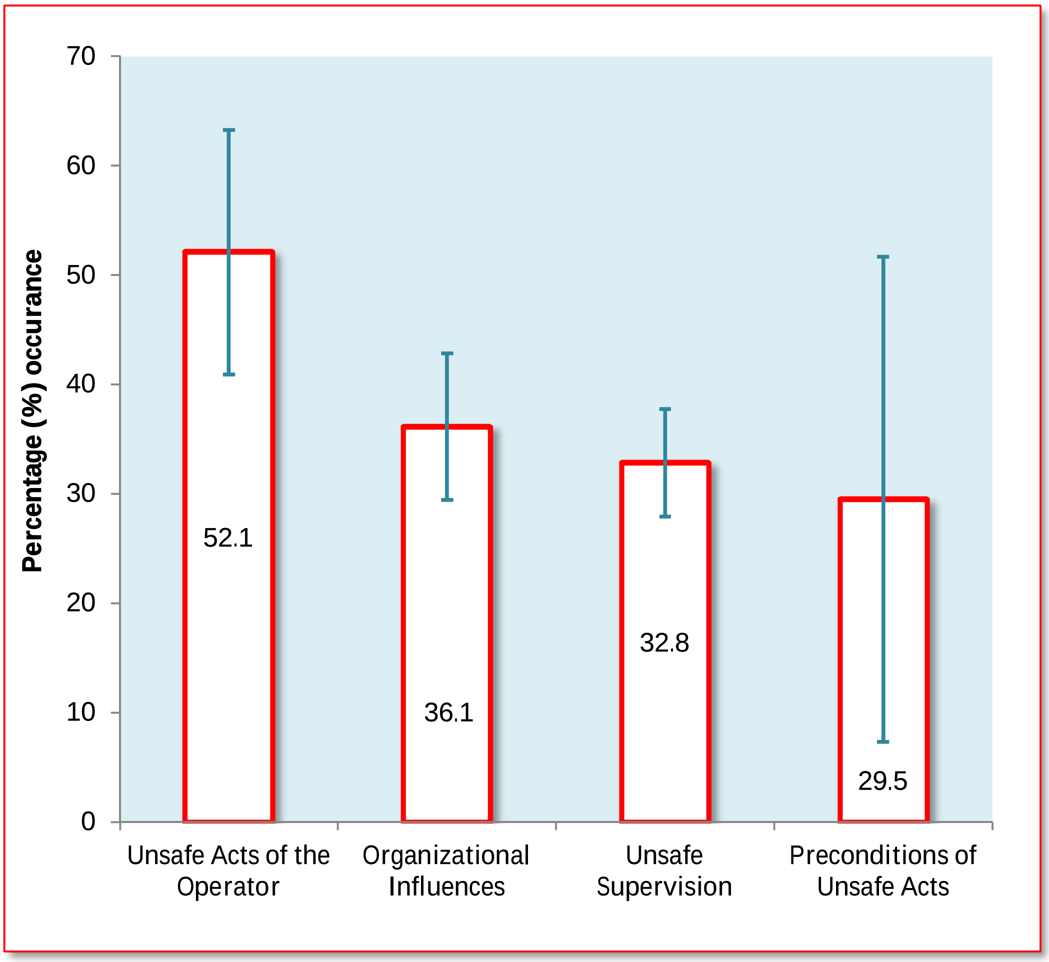

Fig.6.5: Percentage occurrence of each category of HFACS in the overall period and aviation operations

7. Discussion

7.1 Introduction

In the preceding chapter 6, the results of data analysis was presented and very little implication of the interpretation can be gleaned therefrom, thus in this discussion chapter an in-depth assessment of findings from this study is presented.

This discussion section is similarly presented in the sequence of the study objectives, however, while the strength of this discussion is based on the judicious explanations of the findings of this study, a concise comparison with leading literatures in the field of aircraft accidents and related matters were explored.

7.2 Aircraft Accident Trend in Nigeria Airspace

The foremost reason that could be adduced to why there are so few incidents compared with accidents data reported within the study period as revealed in the results (section 6.1) is the issue of documentation of aircraft accidents/incidents. This is an activity which was probably weak in the early period of Aviation operations in Nigeria, especially before the establishment of AIB in 2006. The results showed clearly that available data for aircraft incidents were for occurrences commencing from the year 2002. Prior this period, it is likely that less concern and documentation was given to occurrences involving aircraft that by taxonomy of events do not count as an "accident", i.e. occurrence that are not described with key terms such as "fatal", "injury" and "damage to aircraft". However, access to available officially gazetted document on aircraft accident/incidents in the Nigeria airspace before 2002 were some of the challenge and limitation to the study.

Despite the fact that results of this study revealed that from the remarkably high number of up to 10 accidents recorded in 1990 and 1991 respectively, and an average of 5 accidents per year over the assessment period (1983-2013); there has been a generally significant decline in the number of aircraft accidents in Nigeria airspace. This is certainly attributed to the influence of government policy on the aviation sector. This is well furnished with the five year periodic trend of accidents decline, with a positive prospect in anticipation within the next phase (2013-2017). Although the five year cluster used in this study does not synchronise with the trend of changes in political regime for a direct linkage to be made to the policy influence of a particular regime, but it is justifiable to appreciate that it usually takes about four to five years for a short term policy implementation to yield a desired impact.

The Nigeria aviation sector experienced a boost of safety and infrastructural facility that comes with the deregulation of aviation sector in 1980.

Another important question that this trend answers is whether the decline in aircraft accidents in Nigeria airspace reflects any general trend on the international level? Certainly yes, because when an accident occurs, irrespective of the location and country, the resultant impact is shared between a number of domestic and international stakeholders.

For instant, the general framework set up by the FAA to reduce accidents/incidents from the 1994-1996 data up to 80%, to be met by 2007 (Herrera &Vasigh, 2009). According to ASN (2014) a general decline in global aviation accident is being observed. This is presented in the statement made by ASN President Harro Ranter that: *"Since 1997 the average number of airliner accidents has shown a steady and persistent decline, probably for a great deal thanks to the continuing safety-driven efforts by international aviation organisations such as ICAO, IATA, Flight Safety Foundation and the aviation industry".*

7.3 Casualty Trend from Aviation Accidents in Nigerian Airspace

Casualty trend from this study is portrayed as a complex and unpredictable outcome from aircraft accidents. This is due to the fact that not all accidents result in casualty, and while there exist only a moderately weak relationship between these variables, but the number of casualty resulting from aircraft accidents should be considered significant, no matter how small. For instance, data in this study revealed that in the single event of a commercial accident of the year 2012, over 150 people were fatally injured, while the entire number of accidents in the general aviation operations, for the study period recorded, was less than half of the people affected in this single commercial accident. Therefore in discussing the fact that about 40% of aircraft accident results in casualty it should be borne in mind that commercial aviation contributes more than half of the resultant casualties in this figure.

In comparing the casualty trend in this study with trend globally, as mentioned earlier (ASN, 2014), there has been a decline in casualties as "… *the number of fatalities is significantly lower than the ten-year average of 720 fatalities."*

7.4 Features of Aviation Accident Involvement in Nigerian Airspace

The accident data analysed in this study revealed certain feature of aircraft accidents not commonly reported in many studies are the facts that aircraft accident does not only consists of single aircraft experience, although it is the predominant. Instances of aircraft involvement with another aircraft and or with ground equipment were also elucidated. The implications of these are diverse, for instance, in more than one aircraft accidents reports utilised for HFACS analysis would certainly be separated and treated as an independent case since human causal factors emanating from the different aircraft would certainly vary.

Another important aspect of this feature is in the economic and environmental impact that can be guessed from the type of operations, aircraft type and category of aircraft. For example, this study indicated that there were more multi engine accidents, over a fifteen year period (1988-2002), and responsible for the bulk of the accidents involving multi engine within the study period (1983-2013). This does certainly allays the fact that most commercial aviation utilises multi engine aircraft and the question may thus arise as to why this particular stretch of period. Probable reasons that come in mind are technological inadequacies.

Again in the case of multi-engine aircraft in which a specified number of crew members are expected, a strong linkage to crew resource management and communication problems leading to decision based error (e.g. Dana crash of 2012).

On the whole, understanding the features of the occurrences directs attention to areas requiring the most attention, preparation and implementation of suitable mitigation protocol in practical terms, but also useful in a desk assessment of scenarios presented.

7.5 Human Error Analysis -HFACS

In this study an attempt was made at combined application of the human error analysis using HFACS on three types of operations (commercial aviation, general aviation and special category) at once. The earlier works of Shappell & Wiegmann, (1999), Wiegmann & Shappell, (2001) and Shappell et-al, (2006) validated this possibility and provided a basis for the combined possibility of combined application in this study.

The diverse nature of causal factors observed in the HFACS category of Preconditions of Unsafe Acts may have been due to the large number of component factors evaluated in this category. The large number of components may not be only cause for the huge variations but may also be attributed to the fact that this components impact diverse effects even though on a literal scale they tend to relate to a particular theme (Pre-condition of Unsafe Acts), perhaps a matter of semantics, rather than a practical relational effect as observed on the assessment. This is certainly a cause for concern and one suggestion that can be proffered is re-categorization.

Due to the forgoing concern, an estimation of the results from Shappell et al, (2006) was carried out to make comparison with the findings of this study and incidentally the result show a standard deviation value (representing the variations) that is about two times higher than the average percentage was observed. On one hand, this may just be a way of ensuring and validating an assessment for Preconditions of Unsafe Acts in the cause of analysing HFACS. On the other hand, it is the call for re-categorization of the sub-categories of this major category of HFACS for uniform scalability.

Result of HFACS analysis in this study revealed that commercial aviation indicated the highest proportion of human factor causes of aircraft accidents compared to both general aviation and special category operations. This position was similarly observed in the studies of Shappell *et al* (2006), specifically for commercial aviation operations, and generally as observed by Gaur (2005). In this study, however the special category recorded the lowest in HFACS analysis of human causal factors, this may be due to the fact special category as the name implies, deal with operations that are not so actively in airspace utilization. Though special category in this study is similar to the area of the military aviation studied by Shappell & Wiegmann, (1999), the findings from this study may not be compared due to the intense military and sophisticated operations of this sector in advanced country as the US. Special category in this study comprised of aerial works, air ambulance, agricultural, border patrol, crop spray and fest control, government (including presidential), oil rigging and training.

The category of HFACS factors with the most cause for concern from the findings of this study is the Unsafe Act of the Operators (air crew), generally emanating from errors. This finding shows concordance with the findings in the works of (Wiegmann & Shappell, 2001a, 2001b, 2006; Gaur, 2005).

7.6 Effects of Aircraft Accident on Aviation Industry

In discussing the effects of aircraft accidents on aviation industry, it is essential to appreciate the benefits the sector contributes to global economy.

A number of social and economic benefits associated with air transport industry make it one of the fastest growing sectors of the economy. However, it is also identified with a range of environmentally damaging consequences. In addition to a significant contribution to the global inventory of greenhouse gases emissions implicated in climate change, according to Ishutkina and Hansman (2009), the economic activity relating to air transport usage are known to be interdependent as air transportation provides employment and supports certain economic activities which are reliant on the ease of use of air transportation services. This economic potential, in turn, drives the demand for air transportation services creating a strong linkage between aviation growth and economic benefits. Although the relationship between air transportation and economic activity is complex, details of inputs over the last three decades, in both air transportation usage and economic activity have grown steadily worldwide. For instance, between 1970 and 2005 there has been a tremendous increase of 6.5 times air passengers' movements from 310 million to 2 billion delivered by the world's airlines. For the same period of time, global Gross Domestic Product (GDP) tripled from 12 to 36 trillion US$. Thus as air transportation usage improved, it came to play an important role in the global economy. In 2004, international tourists travelled by air while air cargo accounted for 40% of inter-regional exports of goods. Air transportation is the only practicable long-distance transportation mode for high-value perishable commodities and time-sensitive people, and is often the most efficient means of access to geographically isolated areas. Air transportation enables access to markets, people, capital, knowledge and skills, opportunity and resources (Ishutkina Hansman, 2009). As a result, the availability of air transportation services effectively increases the geographic scope and cycle time of economic activity.

Ishutkina and Hansman (2009) further added that, depending on the combination of unique economic and air transportation attributes, different mechanisms dominate the relationship between air transportation and economic activity. Because of these unique attributes, the nature of air transportation flows differ among the economies. In some countries, international visitors account for most of the travellers, while domestic traffic flows dominate in other economies. For example, the domestic traffic flows within the United States account for 90% of all U.S. passengers, Nigeria 76.91% domestic flow whereas almost 90% of Ireland's air passengers travel internationally. Therefore the dominant purpose of air travel for passengers varies between the economies as well.

The roles that air transport played significantly impacted positively on Nigeria economic development (Akpoghomeh, 1999; Adeniyi & Cmilt, 2011). This consists of entrepreneurial efficiency and innovations leading to revenue enrichment and increased productivity with rapid market growth through globalization, multinational institutions, cultural and political integration. According to Ogunkoya (2008), aviation services have facilitated competition in tourism and associated industries in Nigeria recently.

Air travel in Nigeria is an important transportation mode because it provides an efficient way to link many cities spread across the six geo-political zones in the country. As shown in Table 5.25, air passenger growth in Nigeria experienced a deterred behaviour. The number of air passengers grew through the early 1990s, declined rapidly between 1995 and 2000, grew at average rates between 2001 and 2005, dropped sharply between 2006 and 2007 and then increased rapidly above average between 2008 and 2010.

Figure 5.3 and Table 5.27 shows cost of aircraft accidents and GDP, growth in air passenger traffic and GDP. Between 1985 and 2005, the average growth rates for the number of passengers carried by Nigeria's airlines and GDP were 7.4% and 5.1% respectively.

Starting in the mid-1980s, the Federal government of Nigeria began eliminating regulatory obstacles to economic activity, stimulating employment, encouraging foreign investment and growth in the non-oil export sectors by de regulating and liberalizing the airline industry. As a result, between 1987 and 1997, the annual GDP growth averaged nearly 7%. As the economy grew, so did the number of passengers transported by the airlines registered in Nigeria. During that time, air passenger needs were satisfied by both private and national carrier (Nigeria Airways) whose operation was fully supported by the government.

In 1995, Nigerian economy suffered from the financial and economic crisis, which was accompanied by political instability, and falling prices for commodity exports. The crisis resulted in the drop of air travel demand both in domestic and regional markets. In order to stimulate growth following the crisis, the government decided to proceed with domestic deregulation. Since then, a number of private operators have emerged with most of them competing under the low-cost carrier business model. The support has been manifested through the years through government bailout loans and regulatory changes, which helped the carriers, avoid competition, particularly on international routes as at 2008. The international aviation framework in Nigeria was still based on bilateral air service agreements. As a result, the scope of low-cost carriers and their further development was suppressed because they were restricted to operations only on domestic and on specific international routes.

Aviation safety concerns had a major influence on the development of Nigeria's civil aviation. As can be seen in Appendix 1, the number of aviation fatalities peaked (157) in 1996. In 1997, Nigeria had only 7 aviation fatalities following series of accidents, which included two crashes in 2000 and 2003 that claimed 162 and 111 lives respectively. These accidents exacerbated the effects of the financial crisis and resulted in the suppression of air passenger demand starting in 1997. This decrease in demand is reflected in the decrease of international air passenger arrivals in 1997 and 1998.

The improvement of Nigeria's aviation safety oversight has shown that only marginal improvements have been made since 1990s. For example, following a string of two crashes that killed at least 305 people between 2005 and 2006, the Nigeria authorities attempted to regulate the nation's deficient airlines. Government grounded some airlines and demanded inspections of their aircraft after the airlines were involved in accidents. However, despite these improvement efforts, Nigeria still had 3.77 fatal accidents for every 1 million take offs in three years that ended March 31, 2007 while the global average was 0.25 (IATA, 2008).

Even though air passenger growth was suppressed due to aviation safety concerns, the overall growth of the airline industry aided in the development of Nigeria's transport and tourism industry. However, the growth has been stagnant since 2003 partly due to the suppressed leisure passenger demand following the aviation fatalities summarized in Appendix 1. In addition to aviation safety concerns, international visitors were deterred by the poor safety conditions of other transportation modes and other security issues arising in the country.

In Nigeria, when aircraft accident occur the first step taken by aviation authorities is to ban the affected airline from flying in Nigerian airspace, and all aircraft of the same type irrespective of the airline that operated the aircraft. For example, Nigeria Airways F28 crash on 28th November 1983 during Low Visibility on approach to landing at Enugu airport that resulted in the loss of 2 crew and 51 passengers (FMCA, 1983). Also Executive Air Service's BAC 1-11 aircraft that crashed on 4thMay, 2002 at Gwammaja; Kano city where 67 passengers, 6 crew, 30 people on the ground lost their lives, and 23 people were seriously injured, 23 residential buildings, two mosques and a school were destroyed as a result of the crash and post-crash fire (FMCA, 2002). These airlines and the entire BAC1-11 fleet operating in Nigerian airspace were banned from flying in the country. This resulted in the total collapse and forceful closure of major airlines operating same aircraft type, such as Albarka and Savannah airlines.

Most recently, on 2nd June 2012 a DANA Air MD-90 aircraft crashed over public buildings, and more than 153 persons including all persons on board and the occupants of the buildings died (AIB, 2012b). The airline was banned and its licence was suspended as a result of the accident. Dana Air operates 9 MD-90 aircraft on 27 domestic routes. The resultant effect of this was job loss thereby increasing unemployment rate coupled with logistic problems for passengers and goods transported on the affected routes in particular, and economic loss to the aviation industry.

7.6.1 Lives, Property and Direct Financial Loss

The number of casualties estimated from the result of this study, and for the period (1983-2013) is 1103. Although this figure is far less than what is obtainable from other modes of transportation, the resultant effects of compensations makes it a lot more complex situation for operators. Property loss is usually huge when the crash site is in a residential or in a high commercial activity area of a metropolis. This study data also revealed that there were 153 accidents with more than 40% hull loses resulting thereby. Direct financial loss from this loss is enormous loss of an aircraft.

7.6.2 Flight Cancellations and Delays

Flight cancellations and delay usually results from aircraft accidents even in locations far from the point of occurrences, especially where these remote locations are destination points or transit points for the aircraft involved. One of the recent aircraft accidents that occurred in 2013 in Lagos lead to several cancellations and delays until safety clearance was received. As mentioned earlier, the airport in Lagos is the largest by far in respect of all forms of aviation activities in Nigeria.

It is expected that air traffic flow would be negatively affected in the event of aircraft accidents. Wong & Yeh (2003) conducted a study on the “Impact of flight accident on passenger traffic volume of the airlines in Taiwan” and found that the impact duration of an accident is about 2.5 months on average. Besides, this impact would cause not only the passenger traffic of involved airline to decline significantly, but also would affect the whole market.

7.6.3 Stock Market and Brand Name

However, assessing the impact of aircraft accidents on economic development entails monitoring certain coherent indicators. The acclaimed efficient stock market reactions to aircraft accident have been well documented (Chance and Ferris, 1987, Scheraga & Ornstein, 1991, Borenstein & Zimmerman, 1988, Mitchell and Maloney, 1989; Bosch, Eckard & Singal, 1998). The equity value of airlines' response to flight accidents was a key factor examined in these studies. They found significant impact of accidents on the equity of involved airline. Mitchell & Maloney (1989) indicated that if the accidents were proven to be the fault of the airline, the equity value significantly dropped by 2.2%. If not, there was a 1.2 % decline. Further, Borenstein & Zimmerman (1988) pointed out that the cost imposed by the stock market on the involved airline was less than the social cost of the accident. For other non-involved airlines, Chance & Ferris (1987) found no significant impact of accidents on them, but Bosch, Eckard & Singal (1998) indicated that the close rivals gain from a consumer-switching effect while the distant rivals lose from a general fear-of-flying effect. This can lead to investor loss, job loss, income loss and productivity loss which impact negatively on airline contribution to GDP.

8. Conclusion

8.1 General Conclusions

This study set out to examine aircraft accidents and its effects on Nigeria aviation industry. This aim was achieved through four specific objectives that guided the study, which include a critical assessment of the state of Nigeria aviation industry in terms of the IASA-FAA category 1 safety status attained in 2010, trend analysis of aircraft accidents/incidents and casualties in Nigerian airspace between 1983 and 2013, and an attempt to quantify the role of human error on aircraft accidents in Nigerian Airspace using the HFACS framework; and to evaluate the effects of aircraft accidents on Nigeria aviation industry.

8.1.1 Nigeria aviation industry towards the IASA-FAA category-1 safety status

Towards the IASA-FAA category 1 safety status attained by Nigeria in 2010, the assessment in this study elucidated the enormous revolutionary changes that took place preceding the attainment. This include the establishment of AIB in 2006 as a specialized unit in the Nigeria Aviation Ministry; four years before this attainment. The changes were deliberate and purposeful suggesting equally great financial expenses committed.

However the Nigeria aviation industry has recorded tremendous growth especially in terms of international passenger movements which is an important indication of the benefits of the IASA-FAA category-1 safety status. This also portends positive socio-economic value with potential of reduction of future aircraft accident/incident in Nigeria airspace.

8.1.2 Aircraft accidents/incidents and casualties Trends

The trend assessment of aircraft accidents/incidents and casualties in this study confirms that the establishment of AIB within the Nigeria aviation industry significantly improved the documentation of accident/incident and casualty data. This became obvious regarding the appropriate classification and documentation of aircraft mishaps such as serious incidents. The improvements consisted of the deliberate effort by AIB to collate and document as much as possible accident/incident data that occurred even before its establishment. Hence the accident/incident data showed improvements in documentation from year 2002.

The assessment provided a strong basis for asserting that there is a high likelihood of accident reduction by about 45% within the next five years (2013 – 2017) as the trend analysis revealed a significant decline in aircraft accident. Also not all accidents results in casualties, the relationship between the number of accidents and the number of resultant casualties are not correlated due to the number of persons that may be involve in a particular accident.

Accidents in commercial aviation was noted to be a great cause for concern and more attention is needed to address the factors relating to its causes, although it has the volume of aircraft activities than general and special aviation categories respectively.

8.1.3 Human error involvement in aircraft accidents

Prevention of aircraft accidents or incidents rely on identifying the causes of accidents and incidents and introducing measures essential to the enhancement of safe aircraft operation and the overall safety related activities of the country's aviation sector. The baseline attempt in this study to quantify human error involvement in aircraft accident in the Nigeria airspace provides reference material for future studies. The findings also indicated that it is possible to adopt and apply the HFACS framework to aircraft accidents in Nigeria using fully documented accident reports.

Again human error involvement in commercial aviation operation was highest with decision errors as the most influential under the category of Unsafe Act of the Operators being the most causal factor, although all factors are to be considered a significant cause for concern.

Therefore it is now possible to utilize the findings from this study to implement recognized intervention and mitigation strategies based on the type and volume of human error assessed and quantified.

8.1.4 Effects of aircraft accidents on Nigeria aviation industry

Obviously, without mention aircraft accidents would impact adverse socio-economic effect on any aviation industry sector and country's economy at large, but it is noteworthy to mention that for the manufacturers of aircraft and the country of origin, immense technological education can be gained as well as the economic benefit resulting from replacing the lost aircraft.

However, as discussed in Chapter 7 of this study, the findings can be used as a guide to improve the overall safety performance of Nigeria's aviation industry so as to reduce or prevent further occurrences of aircraft accidents or incidents in Nigerian airspace. Thus the effects of aircraft accidents on the Nigeria aviation sector most significantly affected the commercial aviation operations like many other countries in the world.

8.2 Recommendations

In line with ICAO and IATAs' zero accident and zero fatality program, coupled with Annex 13 of the Chicago Convention, recommendations are made to strengthen the functions of AIB as well as collaborating agencies in the Nigeria aviation sector. It is hoped that these will be considered as tools for implementing safety recommendations issued by AIB.

From the findings of this study, the following recommendations could be drawn:

1. The study revealed that aircraft accident/incident data improved following the establishment of AIB. This therefore calls for sustainable policy framework to enable the agency maintain the pace of accident data collection, collation, storage and processing.

2. In Nigeria, funding is generally a major cause for concern, but funding AIB is immensely required to fully integrate the HFACS framework into use in Nigeria aviation sector, as this will provide adequate resources for specialised training, further research works on accident prevention programmes using the HFACS framework.

3. Human error involvement in commercial aviation operation was shown to be the highest with decision errors under the category of Unsafe Act of the Operators being the most causal factor. It is therefore recommended that coupled with the current Safety Management System (SMS) being introduced into the aviation industry in Nigeria; these will effectively minimize or prevent aircraft accidents/incident in Nigerian airspace.

4. Review of CRM and the associated simulator training programmes in order to enhance crew decisions especially in situations of abnormal performance. Also the review crew pairing and scheduling policies in order to ensure a safe cockpit environment is advised.

8.3 Limitations and Challenges of the Study

Two major constraints were faced in the cause of undertaking this study. These constraints were mainly financial and consequently time factor. These challenges surmounted with the best of efforts required.

The enormous amount of financial resources required to fund this research was mainly experienced in the several months of engagement with the team on familiarization and categorization of final reports components on to the HFACS framework. Although the set objectives of the study was eventually met, but a deeper analytical approach would have been achieved had there been more time.

Another crucial challenge was the issue of accessibility of accident data at the relevant departments and agencies of government involved. A hundred and one calls and visits are required to the attention amidst their busy schedules.

8.4 Suggestion for further Studies

- Further analysis not conducted in the work will be very useful in elucidating finer details such as understanding the five year trend of human causal factor revealed by HFACS
- Application of a more sophisticated predictive models to determine the expected aircraft accident trend in the Nigeria airspace
- Comparative analysis of findings within Nigeria airspace of likelihood of location dependent occurrences of aircraft accident.
- Examination of the main primary and secondary safety measures in developed countries and their effectiveness at enhancing safety.
- An investigation into the constraints associated with aviation safety related issues in developing countries like Nigeria in meeting ICAO standards and how these constraints can be reduced or eliminated.

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APPENDICES

A1: List of airports in Nigeria

City served	State	ICAO	IATA	Airport name
International airports				
Abuja	FCT	DNAA	ABV	Nnamdi Azikiwe International Airport
Enugu	Enugu	DNEN	ENU	Akanu Ibiam International Airport (Enugu Airport)
Kano	Kano	DNKN	KAN	Mallam Aminu Kano International Airport
Lagos / Ikeja	Lagos	DNMM	LOS	Murtala Muhammed International Airport
Port Harcourt	Rivers	DNPO	PHC	Port Harcourt International Airport
Major domestic airports				
Calabar	Cross River	DNCA	CBQ	Margaret Ekpo International Airport (Calabar Airport)
Jos	Plateau	DNJO	JOS	Yakubu Gowon Airport (Jos Airport)
Kaduna	Kaduna	DNKA	KAD	Kaduna Airport
Maiduguri	Borno	DNMA	MIU	Maiduguri International Airport (Maiduguri Airport)
Sokoto	Sokoto	DNSO	SKO	Sadiq Abubakar III International Airport (Sultan Saddik Abubakar Airport)
Yola	Adamawa	DNYO	YOL	Yola Airport
Other domestic airports				
Asaba	Delta	DNAS	ABB	Asaba International Airport
Akure	Ondo	DNAK	AKR	Akure Airport
Bauchi	Bauchi	DNBA	BCU	Bauchi Airport
Benin	Edo	DNBE	BNI	Benin Airport
Gombe	Gombe	DNGO	GMO	Gombe Lawanti International Airport
Ibadan	Oyo	DNIB	IBA	Ibadan Airport
Ilorin	Kwara	DNIL	ILR	Ilorin Airport
Katsina	Katsina	DNKT	DKA	Katsina Airport
Makurdi	Benue	DNMK	MDI	Makurdi Airport
Minna	Niger	DNMN	MXJ	Minna Airport
Owerri	Imo	DNIM	QOW	Sam Mbakwe Airport
Warri	Delta	DNSU	QRW	Warri Airport
Zaria	Kaduna	DNZA	ZAR	Zaria Airport
Other airports not owned/managed by FAAN				
Uyo	Akwa Ibom	DNAI	QUO	Akwa Ibom Airport (Uyo Airport)

City served	State	ICAO	IATA	Airport name
Airstrips				
Ajaokuta	Kogi			Ajaokuta Airstrip
Ashaka	Gombe			Ashaka Airstrip
Azare	Bauchi			Azare Airstrip
Bacita	Kwara			Bacita Airstrip
Bebi	Cross River			Bebi Airstrip
Bida	Niger	DNBI		Bida Airstrip
Birnin Kebbi	Kebbi			Kebbi Airstrip
Bonny	Rivers			Bonny Airstrip
Eket	Akwa Ibom	DNEK		Eket Airstrip
Escravos	Delta			Escravos Airstrip
Gusau	Zamfara	DNGU	QUS	Gusau Airstrip
Kaltungo	Gombe			Kaltungo Airstrip
Lokoja	Kogi			Lokoja Airstrip
Magbon	Lagos			Magbon Airstrip
Mambilla	Taraba			Mambilla Airstrip
Miango	Plateau			Miango Airstrip
Mubi	Adamawa			Mubi Airstrip
Nguru	Yobe			Nguru Airstrip
Obudu	Cross River			Obudu Cattle Ranch Airstrip
Odegi	Nassarawa			Odegi Airstrip
Osogbo	Osun	DNOS		Osogbo Airstrip
Potiskum	Yobe			Potiskum Airstrip
Shiroro	Niger			Shiroro Airstrip
Tuga	Kebbi			Tuga Airstrip
Military airports				
Makurdi	Benue	DNMK	MDI	Makurdi Air Force Base

A2: List of airlines in Nigeria

Airline	**ICAO**	**IATA**	**Call sign**
Aero Contractors: flyaero.com	NIG	AJ	AEROLINE
Allied Air	AJK		BAMBI
Arik Air	ARA	W3	ARIK AIR
Associated Aviation	SCD		ASSOCIATED
Capital Airlines	NCP		CAPITAL SHUTTLE
Chanchangi Airlines	NCH	3U	CHANCHANGI
Dana Air	DAN	9J	DANACO
Dornier Aviation Nigeria	DAV		DANA AIR
First Nation Airways	FRN		FIRST
IRS Airlines	LVB		SILVERBIRD
Kabo Air	QNK	N2	KABO
Max Air	NGL		
Med-View Airline	MEV		MED-VIEW
Overland Airways	OLA	OJ	OVERLAND
Pan African Airlines		PF	
TAT Nigeria			
Wings Aviation	TWD		TRADEWINGS

A3: Sample Format of Accident Investigation Final Report

Major Header	
1. Factual Information	**Sub-headings** • History of the Flight • Injuries to Persons • Damage to Aircraft • Other Damage • Personnel Information o Captain o First Officer o Maintenance Engineer 4 • Aircraft Information o General Maintenance Records o Technical Logbook Records and Management of Deferred Defects o General Hydraulic System Description of Boeing 737-200 o Maintenance checks, Schedules and Intervals o Maintenance Culture o Weight and Balance o Application of MEL Items/Repair intervals ▪ MEL Certification and Recording • Quality Assurance Programmes • Meteorological Information o METAR o Satellite Imagery Report • Aids to Navigation • Communications • Aerodrome Information • Flight Recorders • Wreckage and Impact Information • Medical and Pathological Information • Fire • Survival Aspects o Search and Rescue • Tests and Research o Burnt Fuselage Section o Thrust Reversers • Organizational and Management Information o Operations Manual: Flight Operations Manager, Crew Training, Department , Flight Crew Department(s), Safety Officer, Command Course, Records, Minimum Qualification Requirements, Recency of Experience, Route and Aerodrome Competence, Qualification

2. Analysis	• Nigerian Civil Aviation Authority (NCAA) o Civil Aviation Air Navigation Regulation (ANR) Part 2.1.2.7 (H&I), Records of Training Time 2.1.4.7 (ANR), Initial Crew Resource, Management, Human Factor • Additional Information • Human Factor in this accident o (Fatigue and Stress) • Conduct of Maintenance Procedures (Defects Entries and Rectification Actions) • Main Rudder Power Control Unit (PCU) • Lower Aft Cargo Hold Burnt Section • Bellview Airlines Organizational Behaviour • Inconsistencies of Document • Captain's Hour Log Records • Analysis of the crash time • Weather Conditions • Flight Recorders • Analysis of the Burnt Section of the fuselage • Nigerian Civil Aviation Authority (NCAA • Bellview Airlines Quality Assurance Programmes
3. Conclusions	• Findings • Causal Factor
Safety Recommendations	

A4: Dataset consisting list of accidents and incidents analysed in this study

S/No	Operator2	Number of Engine	Accident Party	Aircraft Type	Aviation	Aircraft Engine	State of Occurrence	YEAR	Casualty	Nature of Occurrence	HFACS	Resource Management	organisational climate	Operational Process	Inadequate Supervision	Planned Inappropriate Operation	Failed to correct Known Problems	Supervisory Violations	Environmental Conditions	Technological environment	Physical Environment	Conditions of the Operator	Adverse Mental Status	Adverse Physiological States	Physical/Mental Limitations	Personnel Factors	Crew Resource Management	Personal Readiness	Skill-Based Errors	Decision Errors	Perceptual Errors	Violations
1	Nigeria Airways	2S	1	FW	C	J	Cross Rivers	1983	0	A	2																					
2	AirAA	ME	1	FW	C	J	Kano	1983	0	A	2																					
3	Nigeria Airways	ME	1	FW	C	J	Enugu	1983	53	A	1	2	2	2	2	1	2	1	2	2	1	2	2	2	2	2	1	2	2	1	1	2
4	Imani Aviation Limited	ME	1	FW	G	J	Lagos	1983	0	A	2																					
5	NCAT Zaria	SE	1	FW	S	P	Kaduna	1983	0	A	2																					
6	Dornier	ME	1	FW	G	P	Kaduna	1983	0	A	2																					
7	Pan African Airlines	SE	1	H	S	R	Delta	1984	0	A	2																					
8	Lagos Flying Club	SE	1	FW	G	P	Oyo	1984	0	A	2																					
9	Bxa	ME	1	FW	G	P	Kano	1984	0	A	2																					
10	Presidential Air Wing	ME	1	FW	C	J	Kwara	1984	0	A	2																					
11	NCAT Zaria	SE	1	FW	S	P	Kaduna	1984	0	A	2																					
12	Dornier	ME	1	FW	G	P	Edo	1984	0	A	2																					
13	Aero Contractors	ME	1	FW	C	P	Delta	1985	0	A	2																					
14	Aero Contractors	SE	1	H	S	R	Off-Shore	1985	0	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	Nigeria Airways	ME	1	FW	C	J	Rivers	1985	0	A	2																					
16	Presidential Air Wing	ME	1	FW	G	J	Plateau	1985	5	A	1	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	1	2	1	2	1	2
17	Lagos Flying Club	SE	1	FW	G	P	Lagos	1986	0	A	2																					
18	Min. Of Agriculture	SE	1	H	S	R	Kaduna	1986	1	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2
19	Kabo Air	ME	1	FW	C	J	Cross Rivers	1986	0	A	2																					

S/No	Operator2	Number of Engine	Accident Party	Aircraft Type	Aviation	Aircraft Engine	State of Occurrence	YEAR	Casualty	Nature of Occurrence	HFACS	Resource Management	organisational climate	Operational Process	Inadequate Supervision	Planned Inappropriate Operation	Failed to correct Known Problems	Supervisory Violations	Environmental Conditions	Technological environment	Physical Environment	Conditions of the Operator	Adverse Mental Status	Adverse Physiological States	Physical/Mental Limitations	Personnel Factors	Crew Resource Management	Personal Readiness	Skill-Based Errors	Decision Errors	Perceptual Errors	Violations
20	Lagos Flying Club	SE	1	FW	S	P	Lagos	1986	0	A	2																					
21	Nigeria Airways	ME	1	FW	C	J	Kwara	1987	0	A	2																					
22	Lagos Flying Club	SE	1	FW	S	P	Oyo	1987	0	A	2																					
23	Nigeria Airways	ME	1	FW	C	J	Rivers	1987	0	A	1	2	2	2	2	2	2	2	2	1	1	2	2	2	1	2	1	2	2	1	1	2
24	Julius Berger Nig. Ltd	ME	1	FW	G	P	Borno	1987	0	A	2																					
25	Basst	SE	1	H	S	R	Kano	1988	0	A	2																					
26	Sudan Interior Mission	SE	1	H	S	R	Plateau	1988	0	A	2																					
27	Aero Contractors	SE	1	H	S	R	Delta	1988	0	A	2																					
28	Nigeria Airways	ME	1	FW	C	J	Kaduna	1988	0	A	2																					
29	Angola Air Charter	ME	1	FW	C	J	Lagos	1988	6	A	2																					
30	AIrAA	ME	1	FW	G	J	Lagos	1988	0	A	2																					
31	Nigeria Airways	ME	1	FW	C	J	Rivers	1988	0	A	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	1	2	2	1	2	1
32	Aero Contractors	SE	1	H	S	R	Delta	1988	6	A	2																					
33	GAS Air Cargo	ME	1	FW	C	J	Kaduna	1989	0	A	2																					
34	NCAT Zaria	SE	1	FW	S	P	Rivers	1989	0	A	2																					
35	Nigeria Airways	ME	1	FW	C	J	Kano	1989	0	A	2																					
36	Okada Air	ME	1	FW	C	J	Lagos	1989	0	A	2																					
37	Nigeria Airways	ME	1	FW	C	J	Yobe	1989	0	A	2																					
38	Dornier	SE	1	H	S	R	Lagos	1989	0	A	2																					
39	Pan African Airlines	SE	1	H	S	R	Cross Rivers	1990	0	A	2																					
40	Concord Airlines	ME	1	FW	G	J	Lagos	1990	0	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
41	Nigeria Airways	ME	1	FW	C	J	Lagos	1990	0	A	2																					
42	Aero Contractors	2M	>	2H	G	P	Lagos	1990	0	A	2																					

S/No	Operator2	Number of Engine	Accident Party	Aircraft Type	Aviation	Aircraft Engine	State of Occurrence	YEAR	Casualty	Nature of Occurrence	HFACS	Resource Management	organisational climate	Operational Process	Inadequate Supervision	Planned Inappropriate Operation	Failed to correct Known Problems	Supervisory Violations	Environmental Conditions	Technological environment	Physical Environment	Conditions of the Operator	Adverse Mental Status	Adverse Physiological States	Physical/Mental Limitations	Personnel Factors	Crew Resource Management	Personal Readiness	Skill-Based Errors	Decision Errors	Perceptual Errors	Violations
			1		C	J																										
43	Air Guinea	ME	1	FW	C	J	Lagos	1991	0	A	2																					
44	Bristow Helicopters	SE	1	H	S	R	Off-Shore	1991	9	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	2
45	Nigeria Airways	ME	1	FW	C	J	Lagos	1991	0	A	2																					
46	Ashaka Cement Co.	ME	1	FW	G	J	Gombe	1991	3	A	2																					
47	Okada Air	ME	1	FW	C	J	Sokoto	1991	3	A	1	2	2	1	2	1	2	2	2	2	1	2	2	2	2	2	1	2	2	1	2	1
48	Ashaka Cement Co.	ME	1	FW	G	J	Bauchi	1991	3	A	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	1	2	2	1	2	1
49	Okada Air	ME	1	FW	C	J	Sokoto	1991	4	A	2																					
50	Nigeria Police Force	SE	1	H	S	R	Lagos	1991	0	A	2																					
51	Kabo Air	ME	1	FW	C	J	Rivers	1991	0	A	2																					
52	Pan African Airlines	SE	1	H	S	R	Delta	1991	0	A	2																					
53	Nigerian Police Force	SE	1	H	S	R	Rivers	1992	0	A	1	2	2	1	2	1	1	1	2	2	2	2	2	2	2	2	1	1	2	1	1	2
54	M.K. Cargo Airline	ME	1	FW	C	J	Kano	1992	0	A	2																					
55	Dornier	ME	1	FW	G	P	Akwa-Ibom	1992	0	A	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1
56	Trans Air/Kabo Air	ME	1	FW	C	J		1992	0	A	2																					
57	N.N.P.C	ME	1	FW	G	P	Kaduna	1992	1	A	2																					
58	GAS Air Cargo	ME	1	FW	C	J	Kwara	1992	0	A	2																					
59	Hold Trade Air	ME	1	FW	C	J	Kaduna	1992	0	A	2																					
60	DAS Cargo Airline	ME	1	FW	C	J	Kano	1992	0	A	1	2	2	1	2	1	2	2	2	1	1	2	2	2	2	2	1	2	1	2	1	1
61	Kabo Air	ME	1	FW	C	J	Sokoto	1992	0	A	2																					
62	Express Airways Ltd	ME	1	FW	G	P	Lagos	1992	0	A	2																					
63	Bristow Helicopters	SE	1	H	S	R	Rivers	1993	0	A	2																					

S/No	Operator2	Number of Engine	Accident Party	Aircraft Type	Aviation	Aircraft Engine	State of Occurrence	YEAR	Casualty	Nature of Occurrence	HFACS	Resource Management	organisational climate	Operational Process	Inadequate Supervision	Planned Inappropriate Operation	Failed to correct Known Problems	Supervisory Violations	Environmental Conditions	Technological environment	Physical Environment	Conditions of the Operator	Adverse Mental Status	Adverse Physiological States	Physical/Mental Limitations	Personnel Factors	Crew Resource Management	Personal Readiness	Skill-Based Errors	Decision Errors	Perceptual Errors	Violations
64	Kabo Air	ME	1	FW	C	J	Kano	1994	0	A	2																					
65	Aero contractors	ME	1	FW	C	P	Abuja	1994	2	A	1	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	1	1	1	1	1	2
66	ADC Airlines	ME	1	FW	C	J		1994	0	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2
67	NCAT Zaria	SE	1	FW	S	P	Sokoto	1994	0	A	2																					
68	AIrAA	ME	1	FW	C	P	Abuja	1994	2	A	2																					
69	Nigeria Airways	ME	1	FW	C	J	Bauchi	1994	3	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2
70	Namco Nigeria Ltd	ME	1	FW	G	J	Plateau	1995	12	A	1	1	1	2	2	2	2	2	2	1	1	2	2	1	2	2	1	1	1	1	1	1
71	Nigerian Border Patrols	ME	1	FW	G	P	Kaduna	1995	0	A	2																					
72	Harka Airlines	ME	1	FW	C	J	Lagos	1995	15	A	1	1	2	1	1	2	2	2	2	2	1	2	2	2	2	2	1	2	2	1	2	1
73	Bristow Helicopters	ME	1	FW	G	P	Lagos	1995	1	A	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	1	1	1	2
74	Aero Contractors	ME	1	FW	G	J	Lagos	1995	0	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
75	GAS Air Cargo	ME	1	FW	C	J	Rivers	1995	0	A	2																					
76	Bxa	ME	1	FW	C	J	Kaduna	1995	0	A	2																					
77	Axs	SE	1	H	S	R	Off-Shore	1995	0	A	2																					
78	Nigeria Airways	ME	1	FW	C	J	Kaduna	1995	10	A	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1	1	2
79	Aero Contractors	ME	1	FW	C	P	Delta	1996	0	A	2																					
80	Presidential Air Wing	ME	1	FW	G	J	Kano	1996	14	A	2																					
81	Nigerian Government	ME	1	FW	S	J	Kano	1996	14	A	1	2	2	2	2	1	2	2	2	1	2	2	2	2	2	2	1	1	1	2	1	2
82	Aeroflot	ME	1	FW	C	J	Lagos	1996	0	I	2																					
83	Okada Air	ME	1	FW	C	J	Plateau	1996	0	A	2																					
84	ADC Airlines	ME	1	FW	C	J	Lagos	1996	143	A	1	1	1	1	1	2	1	2	2	1	1	2	2	1	2	2	1	1	1	1	2	2
85	Mk Airlines Ltd	ME	1	FW	C	J	Rivers	1996	0	A	1	1	1	1	1	2	1	1	2	1	2	2	1	2	2	2	1	1	1	1	1	1

S/No	Operator2	Number of Engine	Accident Party	Aircraft Type	Aviation	Aircraft Engine	State of Occurrence	YEAR	Casualty	Nature of Occurrence	HFACS	Resource Management	organisational climate	Operational Process	Inadequate Supervision	Planned Inappropriate Operation	Failed to correct Known Problems	Supervisory Violations	Environmental Conditions	Technological environment	Physical Environment	Conditions of the Operator	Adverse Mental Status	Adverse Physiological States	Physical/Mental Limitations	Personnel Factors	Crew Resource Management	Personal Readiness	Skill-Based Errors	Decision Errors	Perceptual Errors	Violations
86	Skypower Express Airways	ME	1	FW	S	P	Adamawa	1997	5	A	1	1	1	1	1	1	1	1	2	1	1	2	2	1	2	2	1	1	1	1	1	1
87	ADC Airlines	ME	1	FW	C	J	Cross Rivers	1997	1	A	1	1	1	1	1	1	1	1	2	1	1	2	2	1	2	2	1	2	1	1	2	1
88	Aviation Development Company	ME	1	FW	C	J	Cross Rivers	1997	2	A	2																					
89	Skypower Express Airways	ME	1	FW	S	P	Kwara	1998	0	A	2																					
90	Chanchangi Airlines	ME	1	FW	C	J	Kaduna	1998	0	A	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	1
91	Jaffe Group	ME	1	FW	C	J	Rivers	1998	0	A	2																					
92	Bristow Helicopters	SE	1	H	S	R	Rivers	1998	5	A	2																					
93	Bristow Helicopters	SE	1	H	S	R	Lagos	1998	0	A	2																					
94	Civil Aviation Flying Unit	ME	1	FW	G	J	Lagos	1998	0	A	2																					
95	Mk Cargo Airlines	ME	1	FW	C	J	Rivers	1998	0	A	2																					
96	Pan African Airlines	ME	1	FW	G	P	Delta	1998	0	A	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	1	2	2
97	EAS Airlines	ME	1	FW	C	J	Lagos	1999	0	A	2																					
98	Network Aviation Services	ME	1	FW	G	P	Rivers	1999	0	A	2																					
99	Premium Air Shuttle	ME	1	FW	C	J	Lagos	1999	1	A	2																					
100	Madara Flying Club, Kaduna	ME	1	FW	S	P	Kaduna	1999	0	A	2																					
101	Pan African Airlines	ME	1	FW	G	J	Lagos	1999	0	A	2																					
102	Skypower Express Airways	ME	1	FW	S	P	Abuja	2000	2	A	2																					
103	Skypower Express Airways	ME	1	FW	S	P	Kaduna	2000	0	A	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	2	1	1	2	2
104	Bristow Helicopters	SE	1	H	S	R	Rivers	2000	0	A	2																					

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105	Kabo Air	ME	1	FW	C	J	Kano	2000	0	A	2																					
106	Albarka Air Ltd.	ME	1	FW	C	J	Lagos	2000	0	A	2																					
107	Pan African Airlines	SE	1	H	S	R	Delta	2000	1	A	2																					
108	Mk Cargo Airlines	ME	1	FW	C	J	Rivers	2001	1	A	1	2	2	1	1	1	1	1	2	1	2	2	2	2	2	2	1	1	1	1	2	1
109	Sky Executive Aviation Service	ME	1	FW	G	P	Borno	2001	0	A	2																					
110	Associated Airlines	ME	1	FW	C	P	Kebbi	2001	0	A	2																					
111	Aero Contractors	SE	1	H	S	R	Rivers	2001	0	A	2																					
112	Mk Airlines Ltd	ME	1	FW	C	J	Lagos	2001	0	A	2																					
113	Network Aviation Services	SE	1	H	S	R	Lagos	2001	1	A	2																					
114	Chrome Air Services Ltd	ME	1	FW	G	J	Lagos	2001	0	A	1	1	1	1	1	1	1	1	2	1	2	2	2	1	2	2	1	1	1	1	2	1
115	Eagle Aviation	ME	1	FW	C	P	Borno	2001	0	A	1	1	1	1	1	1	1	1	2	1	1	2	2	1	2	2	1	2	1	1	2	1
116	Sky Executive Aviation Service	ME	1	FW	G	P	Cross Rivers	2002	5	A	1	2	2	2	1	2	2	2	2	1	1	2	2	2	1	2	2	2	2	2	1	2
117	Chrome Air Services Ltd	ME	1	FW	C	J	Lagos	2002	0	I	2																					
118	Executive Airline Services	ME	1	FW	C	J	Kano	2002	106	A	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	2	2
119	EAS Airlines	ME	1	FW	C	J	Kano	2002	149	A	2																					
120	Savannah airlines	ME	1	FW	S	J	Abuja	2002	0	A	2																					
121	Albarka Air Ltd.	ME	1	FW	S	J	Abuja	2002	0	A	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2
122	NCAT Zaria	SE	1	FW	S	P	Kaduna	2003	0	I	2																					
123	NCAT Zaria	SE	1	FW	S	P	Kaduna	2003	0	I	2																					
124	Helicopter	SE	1	H	S	R	Lagos	2003	0	I	2																					

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125	Hydro Air Cargo	ME	1	FW	C	J	Lagos	2003	0	A	1	1	1	1	1	1	1	1	2	2	2	1	2	2	2	2	1	2	1	2	1	2
126	Aero Contractors	SE	1	H	S	R	Rivers	2003	4	A	2																					
127	Millennium Airline & Kabo Air	2M	> 1	2FW	G C	P J	Kano	2003	0	A	2																					
128	Millennium Airline	ME	> 1	FW	C	P	Kano	2003	0	A	2																					
129	NCAT Zaria	SE	1	FW	S	P	Kaduna	2003	0	I	2																					
130	Pan African Airlines	SE	1	H	S	R	Rivers	2004	4	A	2																					
131	Chanchangi Airlines	ME	1	FW	C	J	Lagos	2004	0	A	2																					
132	IRS Airlines	ME	1	FW	C	J	Kaduna	2004	0	I	2																					
133	Kabo Air	ME	A E	FW	C	J	Kano	2004	0	I	2																					
134	Wings Aviation	ME	1	FW	G	P	Akwa- Ibom	2004	0	I	2																					
135	Bellview Airlines	ME	1	FW	C	J	Ogun	2005	11 7	A	1	1	2	1	1	2	1	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2
136	Chanchangi Airlines	ME	1	FW	C	J	Lagos	2005	0	I	2																					
137	Presidential Air Wing	2M	> 1	2FW	S C	2 J	Abuja	2005	0	I	2																					
138	IRS Airlines	ME	1	FW	C	J	Lagos	2005	0	I	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2
139	Lufthansa Airline	ME	1	FW	C	J	Lagos	2005	0	S I	2																					
140	Associated Airlines	ME	1	FW	C	P	Lagos	2005	0	A	2																					
141	Air France	ME	1	FW	C	J	Rivers	2005	0	S I	2																					
142	Aero Contractors	SE	1	H	S	R	Rivers	2005	0	S I	2																					
143	Executive Airline Services	ME	1	FW	C	J	Plateau	2005	0	I	2																					

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144	EAS Airlines	ME	1	FW	C	P	Kaduna	2005	2	A	2																					
145	Chanchangi Airlines	ME	1	FW	C	J	Abuja	2005	0	I	2																					
146	Sosoliso Airlines	ME	1	FW	C	J	Rivers	2005	108	A	1	1	2	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	1	1	2
147	ADC Airlines	ME	1	FW	C	J	Abuja	2006	96	A	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	2	1	2	1
148	Bristow Helicopters	SE	1	H	S	R	Rivers	2006	0	SI	2																					
149	Mobil Nig. Unlimited	ME	1	FW	G	P	Akwa-Ibom	2006	0	SI	2																					
150	DAS Cargo Airline	ME	1	FW	C	J	Lagos	2006	0	I	2																					
151	DHL Cargo	ME	1	FW	S	J	Lagos	2006	0	SI	1	1	1	1	2	2	1	1	1	2	1	1	2	2	2	1	1	1	1	1	1	1
152	NCAT Zaria	SE	1	FW	S	P	Kaduna	2006	0	SI	1	2	2	2	1	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
153	OAS	SE	1	H	S	R	Delta	2006	2	A	2																					
154	Mobil Nig. Unlimited	ME	1	FW	G	P	Akwa-Ibom	2006	0	SI	2																					
155	Bristow Helicopters	SE	1	H	S	R	Akwa-Ibom	2007	1	A	2																					
156	IITA	ME	1	FW	G	P	Oyo	2007	0	I	2																					
157	Chanchangi Airlines	ME	1	FW	C	J	Rivers	2008	0	A	2																					
158	Aero Contractors	SE	1	H	S	R	Rivers	2008	0	A	2																					
159	NCAT Zaria	SE	1	FW	S	P	Kaduna	2008	0	A	1	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1	2
160	Arik Airlines	ME	1	FW	C	J	Lagos	2008	0	SI	2																					
161	Bellview Airlines	ME	AE	FW	C	J	Lagos	2008	0	A	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2
162	NCAT Zaria	SE	1	FW	S	P	Kaduna	2008	0	A	2																					

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163	Gitto Construction Company	SE	1	H	S	R	Akwa-Ibom	2009	1	A	2																					
164	Capital Airlines	ME	1	FW	G	P	Enugu	2009	0	SI	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
165	Bristow Helicopters	SE	1	H	S	R	Cross Rivers	2009	0	A	2																					
166	Bristow Helicopters	2S	>1	2H	2S	2R	Cross Rivers	2009	0	SI	2																					
167	Bristow Helicopters	SE	1	H	S	R	Delta	2010	0	SI	2																					
168	Chanchangi Airlines	ME	1	FW	C	J	Kaduna	2010	0	A	2																					
169	Aero Contractors	ME	1	FW	C	J	Lagos	2010	0	I	2																					
170	Aero Contractors	ME	1	FW	C	J	Plateau	2010	0	A	2																					
171	NCAT Zaria	AE	1	FW	S	P	Kaduna	2010	0	I	2																					
172	Arik Airlines	ME	1	FW	C	J	Cross Rivers	2010	0	I	2																					
173	Arik Airlines	ME	1	FW	C	J	Cross Rivers	2010	0	I	2																					
174	Arik Airlines	ME	1	FW	C	J	Lagos	2010	0	I	2																					
175	NCAT Zaria	ME	1	FW	S	P	Kano	2010	0	A	2																					
176	OAS	SE	1	H	S	R	Osun	2011	3	A	2																					
177	Associated Airlines & IRS	2M	>1	2FW	2C	2J	Lagos	2011	0	I	2																					
178	Shoreline Consul. Services Ltd	ME	1	FW	G	P	Kaduna	2011	2	A	2																					
179	Bristow Helicopters	ME	1	FW	G	J	Rivers	2011	0	A	1	1	1	1	2	1	2	2	2	2	1	2	2	2	2	2	1	1	1	1	2	1
180	SiatGarbon	ME	1	FW	G	P	Edo	2011	0	I	2																					
181	King Airlines	ME	1	FW	G	J	Bauchi	2011	0	SI	2																					

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182	Associated Airlines	ME	1	FW	G	J	Edo	2011	0	SI	2																					
183	Nigerian Police Force	SE	1	H	S	R	Plateau	2012	4	A	2																					
184	Pan African Airlines	SE	1	H	S	R	Delta	2012	0	A	2																					
185	Aero Contractors	ME	1	FW	G	J	Delta	2012	0	A	2																					
186	Dana Air	ME	1	FW	C	J	Lagos	2012	155	A	2																					
187	Taraba State Government	SE	1	FW	G	P	Adamawa	2012	0	A	1	1	1	1	1	1	1	1	2	1	2	2	2	2	2	2	1	1	1	1	1	1
188	Associated Airlines	ME	1	FW	C	P	Lagos	2013	15	A	1	1	1	2	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	1	1
189	Bristow Helicopters	SE	1	H	S	R	Lagos	2013	0	I	2																					
190	IAC	ME	1	FW	S	P	Ilorin	2013	0	A	2																					
191	NCAT Zaria	ME	1	FW	S	P	Kaduna	2013	0	SI	2																					
192	NCAT Zaria	SE	1	FW	S	P	Kaduna	2013	0	I	2																					
193	Kabo Air	ME	1	FW	C	J	Sokoto	2013	0	SI	2																					
194	VetranAvia	ME	1	FW	C	J	Abuja	2013	0	A	2																					

Keys to abbreviations on Table of Appendix A4

Category of Aircraft	SE	Single Engine
	ME	Multi Engine
	SS	2 Single Engine
	MM	2 Multiple Engine
Accident Party	1	One Aircraft
	>1	More than 1 Aircraft
	AE	Aircraft and GE
Aircraft Type	FW	Fixed Wing
	H	Helicopter
	2FW	2Fixed Wings
	2H	2Helicopters
	G	General Aviation
	C	Commercial Aviation
	S	Special category
	GC	General and Commercial
	2C	2 Commercial
	SC	Special and Commercial
	2S	2 Special Category
Aircraft Class	R	Rotor
	P	Propeller
	J	Jet
	2R	2 Rotor
	PJ	Propeller and Jet
	JJ	2 Jets
Nature of Occurrences	A	Accident
	SI	Serious Incident
	I	Incident

GLOSSARY

The following terms in this glossary were adopted from the ICAO (2013).

Accident: An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which: **a)** a person is fatally or seriously injured as a result of- being in the aircraft, or- direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or- direct exposure to jet blast, **except** when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew: or **b)** the aircraft sustains damage or structural failure which:- adversely affects the structural strength, performance or flight characteristics of the aircraft, and- would normally require major repair or replacement of the affected component, **exce**pt for engine failure or damage. When the damage is limited to the engine, its cowlings or accessories: or for damage limited to propellers, wing tips, antennas, tires, brakes, fairings, small dents or puncture holes in the aircraft skin: or **c)** the aircraft is missing or is completely inaccessible.

Aircraft departures: The number of take-offs of aircraft. For statistical uses, departures are equal to the number of landings made or flight stages flown.

Aircraft movement (airports): An aircraft take-off or landing at an airport. For airport traffic purposes one arrival and one departure is counted as two movements.

International: All flights of national or foreign aircraft whose origin or destination is located in the territory of a State other than that in which the airport being reported on is located.

Domestic: All flights of national or foreign aircraft in which all the airports are located in the territory of the same State. In both cases the flight shall be considered as consisting of the total of its flight stages (i.e. from take-off to its next landing); technical stops are not taken into account.

Navigation services: comprise ground-based radio navigation equipment (e.g. VOR, DME and NDB) and precision approach and landing aids (e.g. ILS equipment). Implementation of GNSS will add the satellite constellations providing the standard signal positioning service and the associated augmentation systems required, i.e. satellite-based (wide-area) and ground-based (local area) augmentations. Surveillance systems comprise primary surveillance radar (PSR), secondary surveillance radar (SSR), including SSR Mode S, surface movement radar (SMR) as well as automatic dependent surveillance (ADS), including the supporting network and maintenance personnel.

Commercial air transport operator: An operator that, for remuneration, provides scheduled or non-scheduled air transport services to the public for the carriage of passengers, freight or mail. This category also includes small-scale operators, such as air taxi operators, that provide commercial air transport services.

General aviation (GA): All civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire (Annex 6 Part II). For ICAO statistical purposes the general aviation activities are classified into instructional flying, business and pleasure flying, aerial work, and other flying.

Incident: An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation. **Serious incident:** An incident involving circumstances indicating that an accident nearly occurred. Note 1. The difference between an accident and a serious incident lies only in the result. Note 2. Examples of serious incidents can be found in Attachment D of Annex 13 and in the ICAO Accident/Incident Reporting Manual (Doc 9156)

International airport: Any airport designated by an ICAO Contracting State in whose territory it is situated as an airport of entry and departure for international air traffic, where the formalities incident to customs, immigration, public health, agricultural quarantine and similar procedures are carried out.

Mail: All correspondence and other objects tendered by and intended for delivery to postal administrations.

Non-scheduled revenue flights: Charter flights and special flights performed for remuneration other than scheduled flights.

Registered aircraft: An official State register listing all civil aircraft owned by operators for civil aviation purposes.