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PROMOTING AVIATION SAFETY IN AFRICA: ANALYSIS OF AIR ACCIDENTS IN THE REGION BETWEEN 2004 AND 2013

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The international air traffic in the Africa region is projected to grow at an average annual rate of 5.1% between 2012 and 2032. The air transport industry in the region has supported about 6.9 million jobs, contributed about \$ 67.8 million in economic activity, and about \$ 80.5 million in GDP. However, the African continent was ranked last in the Universal Safety Oversight Audit Program (USOAP) report for the year 2012. Efforts by the International Civil Aviation Organization (ICAO), airlines, and governments, and other institutions are currently underway to promote aviation safety. Aviation safety implementation in the Africa region is essential as air transport is expected to play a key part in the region's economic growth through variety of means such as the transportation of passengers and cargo to and from the region. This study analyses the underlying causes of the air accidents for scheduled commercial air transport within the African continent that happened between 2004 and 2014. The focus of the study is to determine whether there is a significant difference between accidents caused by aircraft mechanical issues and accidents caused by other reasons such as pilot error or poor weather. Preliminary results indicate that most scheduled commercial air transport accidents in the region are likely to result from non-mechanical issues. A discussion is presented on ways to minimize the occurrence of air accidents in the region.

Aviation industry in the African continent has been growing despite the setbacks brought by safety and economy whereas between the years 2012 and 2013, the international air passenger demand grew by 3 percent with continual growth afterward (Moodley, 2013). Although the aviation industry in the Africa region is currently contributing about 2.3% of the global air passenger traffic and 3% of the Global Domestic Product due to aviation, it is estimated that air transport will continue to grow in the region at an annual rate of 5.1% hence contributing to the economy (ATAG, 2014). Safety is one of the challenges facing the aviation industry in the region despite the presence of respected carriers such as Kenya Airways, South African Airways, Ethiopian Airlines, and Egypt Air (ATAG, 2014). One of the safety concerns that have been addressed include the aging of most aircraft (about 20 years on average while the world average is about 10 years), and old technology used for navigation and air traffic management (Thomas, 2010). The growth of the aviation industry in the region, which is boomed by the growing economies, is not parallel with the improvement of the air traffic capabilities and airport handling capacities hence contributing to safety concerns (Hinshaw and Meichtry, 2014). Unreliable weather information on the flight routes and unstable radar coverage due to outdated technology and unskilled professionals seem to contribute to the flying difficulty for pilots in the region (Hinshaw and Meichtry, 2014). As of currently, about 11 countries of the 54 countries have met at least 60% of the requirements laid down by one of the International Civil Aviation Organization (ICAO)'s audits aiming at improving aviation safety focusing on areas such as ground crew training and rehabilitation of hangar facilities (Hinshaw and Meichtry, 2014). In 2012, the ICAO initiated a Strategic Acting Plan to improve Aviation Safety in Africa by focusing several initiatives and programs namely addressing and identifying Significant Safety Concerns (SSCs) through established audits such as Universal Safety Oversight Audit Program (USOAP), and encouraging the use of the Runway Safety Toolkit (ICAO, 2012). Other initiatives that are being promoted for application in the region include compliance to the International Air Transport Association (IATA) Operational Safety Audit (IOSA) which contains reference for safety management systems evaluation, Flight Data Analysis toolkit which is useful to air carriers in Africa for optimum flight operations, and the new ICAO Safety Management Manual (ICAO, 2012). African nations are also working to establish regional associations to oversee issues challenging the aviation industry such as safety (Michaels, 2007). Several regional associations such as the East African Community's Civil Aviation Safety and Security Oversight Agency (CASSOA) have been established whose missions include to improve the safe conditions for flying in Africa (Michaels, 2007). While technology of the aircraft might be contributing to the safety development of the industry,

other areas such as air traffic control and navigation, ground handling, airport capabilities are of relatively equal importance when it comes to improving aviation safety in Africa. In this paper, commercial accidents that happened in Africa region between 2004 and 2013 are examined to determine the extent of technology as causal factor in those accidents. A discussion is also provided in light with the policies and technologies that have been adopted by most carriers in the region.

Possible Leading Causes of Air Accidents in Africa in the last decade

It is important to understand the causes of the air accidents in order to engage necessary policies and actions to mitigate the accidents. Although most accidents are the results of several causes, it is important to categorize the accidents in terms of a single major cause for both simplifications during the analysis and comparison of wider scope of accidents (Oster et al, 2013). While several approaches have been used to assign the cause of the air accidents, this paper applies a similar approach to that of Oster et al (2013) in which the cause of an accident is the element that triggered a chain of actions that led to an accident. Among several causes, equipment failure was the number one cause of accidents with highest number of both accidents and fatalities (about one-third of the accidents) for Part 121 related activities in the United States between 1990 and 2011 (Oster et al, 2013). Similarly, for Part 135 related activities, equipment failure was second major cause after pilot error for the same period in the United States (Oster et al, 2013). In the same duration, equipment failure seemed to be one of the major cause of air accidents in the Africa region (Oster et al, 2013). Understanding the major cause of air accidents might be a necessary step in determining potential policies and actions to pursue to reduce the occurrence of these accidents. This paper seeks to determine whether the leading cause of air accidents in the Africa region between 2004 and 2013 was also equipment failure or other causes. In the statistical analysis, the paper posits the hypothesis that equipment failure is the most significant cause of air accidents in the Africa region between 2004 and 2014.

Literature Review

General History of Aviation Safety in Africa Region

The aviation industry has experienced tremendous growth over the last few decades, boosted by a fast-growing economy and increasing domestic and foreign demand for air travel. In fact, over the 2003-2012 decade, there has been a 103% increase in the number of flights to and from the continent, approximately 5 times the global growth during the same period (Boehmer, 2013). According to IATA (2015), aviation in Africa affected more than 6.7 million jobs and fostered almost \$70 billion in economic activity in 2012. However, the continent remains a relatively small market, only accounting for 3% of global air traffic (Pasztor, 2014).

Despite holding such a small share of worldwide air travel, Africa has historically held one of the poorest safety records among all regions. Indeed, over the periods spanning from 1996-2000 and 2001-2005, the rates of accidents in the continent were 3.6 and 5 per million departures respectively. As a comparison, the rates in the United States were 0.7 and 0.4, and the only other region to experience a rise in these rates across the same period was the Middle East (Air Safety Week, 2007). More recently, the number of accidents in Africa has remained higher than the global averages. For instance, in 2012 for Western-built jets, African airlines had one accident for every 270,000 flights whereas globally the average was one per 5,000,000 (IATA). Similarly, in 2013, approximately 20% of the aviation crashes and fatalities occurred in Africa (Pasztor, 2014). This poor safety record is undeniably the result of multiple social, economic and political factors. For instance, according to some sources, the bad state of many economies on the continent, combined with social issues like corruption and wars have considerably hindered the growth of aviation and the implementation of better infrastructure and safety initiatives (). In addition, international organizations like IATA and ICAO have pointed out that nationalistic interests and lack of cooperation between African states have led to the same results. These organizations have put in place multiple plans and initiatives that aim to solve the safety issue in African air transport . For instance, IATA's focus is reflected by its director general Tony Tyler, according to whom the majority of the problems "could be addressed by adherence to global standards and expanded cooperation among governments" (Boehmer, 2013).

Effects of Air Accidents Happening in the Region

Human injury or fatalities due to air accidents affect the economy and the reputation of the air transport industry of the particular country (Shyur, 2007). Air accidents have been observed to suppress demand and several African countries while on the other hand, negative publicity is supposed to affect the perception of the airlines' safety (Ishutkina and Hansman, 2009). Across the globe, airlines are said to annually lose about \$10 billion to accidents which in turn result into other cost such as insurance claims, decline in productivity, damage of equipment and facilities, and decline in reputation of the carrier (Agabi, 2013). The air accident of Dana Air flight 9J 0992

which claimed 153 lives in Nigeria during resulted into increases of insurance premium for airlines depicting the fact that the operating cost challenge due rise of insurance rates caused by safety concerns is a challenge for most developing airlines in the region (Eze, 2012). Rose (1990), and Rhagavan et al (2005) conducted a study to determine if there was an association between airline profitability and airline safety and found out that higher profit margins were related to decrease accident and incident activities, especially for small carriers, assuming other operational factors are controlled.

Loss of lives may occasionally be accompanied with destruction of buildings and other facilities in the accident area. Such was the case for the Dana Air flight which happened in Nigeria on route from Abuja to Lagos (CNN, 2012). The aircraft crashed, about 4 kilometers from the Lagos International Airport, into a press company affecting near-by blocks of houses including a church hence (CNN, 2012). The loss of lives claimed through these accidents taint the image of the region to prospective investors who are looking forward to establish business ventures in the region. The air accidents that happened in in the border of Cameroon and Congo DRC involving a CASA C-212 twin turboprop claimed 11 lives, six of whom were Australian renowned mining investors (McCullough; et al, 2010). However, despite the safety and other challenges, connectivity in the African region is much needed to be able to access the resources in various places, hence aviation serves as a much potential transport tool (Thomas, 2010). The air accidents may also be both fueled and used for/as war catalyst such as the case of the Rwanda genocide. Despite the fact that suspicions of war had been boiling over time, the war was fully launched when both presidents were killed in a flight on April 6th, 1994 (Rosen, 2014).

Methodology: Data Collection and Analysis

This paper presents an analysis of the air accidents that happened between 2004 and 2014 in the African region. The type of accidents considered in this study involved commercial scheduled flights only. While there are several categories of major causes of air accidents (Airclaims, 2012; FAA, 2012), the study categorized the causes of air accidents as pilot error, technical failure, weather, and others (air traffic control, other aircraft, terrorism, crew etc.). The data for the accidents were collected through the Aviation Safety Database that is maintained by the Flight Safety Foundation Organization (ASN, 2015). A statistical comparison was conducted to determine the significance differences among the selected major causes of air accidents. Further analyses were conducted to determine differences among the major causes based on type of aircraft, and age of the aircraft.

The Aviation Safety Database contained information on the 13 factors that were used for this research. These factors were: date, location, aircraft model, date of its first flight, operator, engines equipped, on-board fatalities, total number of occupants, total number of fatalities (including on ground), type of flight (cargo, passenger, military), phase of flight, and summary from which the causes were extracted.

Analysis of variance was performed to determine if there was a significant difference between the technical causes of accidents (such as power plants, maintenance, or other technical failure) and other non-technical cause including pilot error, weather related accidents, other causes (including air traffic control failures), and other unknown causes. All statistical analysis was conducted using the Minitab software under the Purdue University license.

Results and Discussion

A total of 132 accidents fitting the selection criteria were retrieved from the database, spanning from January 3rd 2004 to November 29, 2013. An analysis of the location of crashes revealed that most accidents occurred in the Democratic Republic of Congo (42 accidents or 32%), the geographic area of Sudan and South Sudan (25 or 19%), Kenya and Tanzania (respectively 9 and 8 or 7% and 6%). Thus, the overwhelming majority (80%) of all accidents took place in the Eastern and Southern parts of the continent.

In terms of the causes of these accidents, 5 main categories were identified: technical failure, pilot error, weather, other and unknown. Indeed, in 23 cases, there was no conclusive information available regarding the cause of the accidents for different reasons such as the wreckage not having been found or the lack of accident investigation data. However, among the accidents for which the causes were identified, the two primary factors were technical failures and pilot errors, which accounted for 30% and 28% of all the accidents that happened during the time respectively. Weather related accidents contributed 10% of the all the accidents while other known and unknown accidents contributed about 32% of all the accidents. Figure (1) indicates; however, the frequency started to decrease although not very significantly as time progresses.

The high rate of technical failures could be linked to two other factors that this research analyzed: the origin of the aircrafts and their age. In fact, half of the aircrafts involved in these crashes were of Russian origin (Antonov, Ilyushin, etc.), while American aircrafts (Cessna, Boeing) made for 32% of the population and European-

made planes consisted of 14% (Figure 2). In addition, the median age of aircrafts that suffered these accidents, from their first flight to the date of the accidents, was 24 years, and 38% of the planes were more than 30 years old.

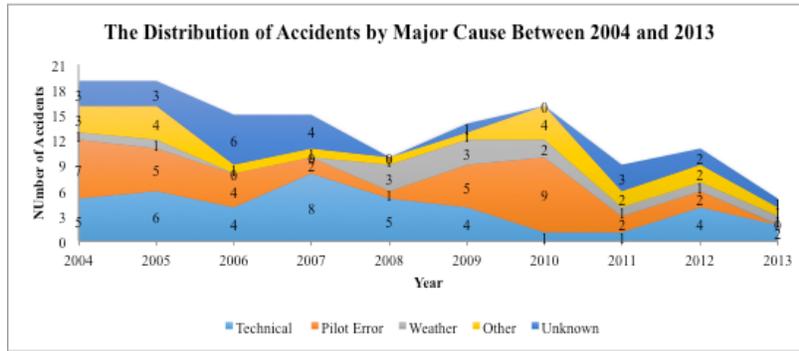


Figure 1. Distribution of Accidents by Major Causes Between 2004 and 2013

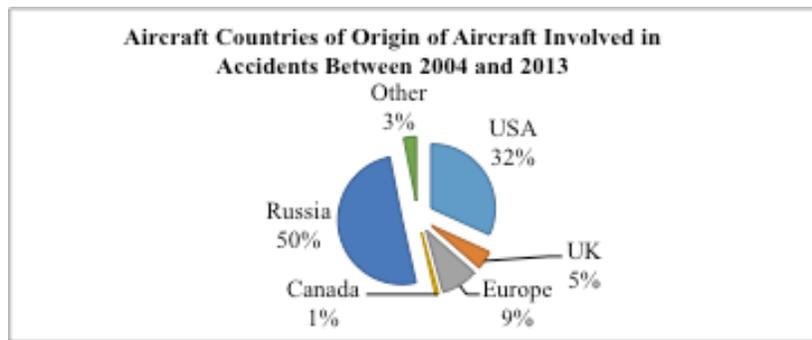


Figure 2. Countries of Origin of Aircraft Involved in Accidents in Africa Between 2004 and 2013

A further analysis of variance was performed to determine if there was any statistical significant difference among the causes. Pair comparison analysis for each pair of causes was performed using Tukey Method with significance level of 0.05. Table (1) and (2) indicate that the technical causes of accidents were not statistically significantly different from other causes except for weather related accidents. Hence, the fact that perhaps the concern of safety should be directed to all areas of improvements including aircraft technology, air traffic control regulations, air crew regulations and others.

Table 1.

Analysis of Variance for the Major Causes of Air Accidents Over the 2004-2013 Period

Source	DF	Seq	SS Contribution	Adjusted Sum of Squares	Adjusted Means Squares	F-Value	P-Value
Cause	4	52.92	23.50%	52.92	13.23	3.46	0.015
Error	45	172.3	76.50%	172.3	3.829		
Total	49	225.22	100.00%				

Table 2.
Confidence Intervals of the Causes of Accidents

Cause	N	Mean	StDev	95% Confidence Interval
Other	10	2	1.247	(0.754, 3.246)
Pilot Error	10	3.7	2.83	(2.454, 4.946)
Technical	10	4	2.211	(2.754, 5.246)
Unknown	10	2.3	1.889	(1.054, 3.546)
Weather	10	1.3	1.059	(0.054, 2.546)

Table 3.
Pair Comparison of the Major Causes of Accidents

Cause	N	Mean	Grouping	
Technical	10	4	A	
Pilot Error	10	3.7	A	B
Unknown	10	2.3	A	B
Other	10	2	A	B
Weather	10	1.3		B

In terms of fatalities, a total of 1204 aircraft occupants died from these 132 accidents and there were 72 deaths on the ground. Overall then, the total number of direct casualties from aircraft accidents that were analyzed in this research amounts to 1276 individuals.

The results indicate that despite the fact most of aircraft in the region are of old, safety emphasis should be equally placed on all areas surrounding the safety factor.

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