Performance Assessment of the Maintenance Reliability Programs for Flight Safety in the Zambian Aviation Industry

Milton Kasanga and Dr. Terence Malama

Department of Agricultural Engineering, School of Engineering, University of Zambia, Lusaka, Zambia

***Abstract*: In response to a recent increase in accidents in the Zambian aviation industry, a study was conducted to assess the reliability of maintenance programs in the sector. A questionnaire was distributed to 108 respondents, all of whom provided a response. The results of the study were analyzed using SPSS and Microsoft Excel, and presented in the form of frequency tables and pie charts. The results revealed that 99% of the respondents had Maintenance Reliability Programs (MRPs) in place, with 50% reporting that their MRPs were effective. The study also found that the aviation industry in Zambia places a strong emphasis on safety procedures, with many respondents agreeing that stringent safety procedures are implemented.**

***Keywords*: maintenance, reliability, programs, flight safety, Aviation Industry.**

I. INTRODUCTION

The purpose of this study was to examine the reliability of maintenance programs in the Zambian aviation industry in response to a recent increase in accidents [1] – [4]. The absence of a reliability department within the Zambia Civil Aviation Authority has resulted in a lack of reliability programs for some operators in the industry. These programs are essential for ensuring that aircraft maintenance tasks are effective and for providing appropriate techniques for monitoring the efficiency of the maintenance program. The absence of reliability programs can lead to increased costs for maintenance programs, as well as airworthiness limitations and an increased risk of aircraft accidents, due to either having too many or too few maintenance tasks.

Unreliable services can have significant consequences in the competitive and technical world of air transport, including increased operating costs, productivity losses, incidents, and an increased risk of accidents. These can lead to short and long-term customer dissatisfaction and damage a company's reputation. It is important for air carriers to maintain strict safety and reliability standards while also striving for profit. Maintaining a repairable system can be a challenging task due to the economic and reliability considerations. While high levels of reliability are necessary, they do not have to come at a high cost.

The multidisciplinary nature of aircraft maintenance, including management planning, human resources, facilities, equipment, and inventory, makes it difficult to view and manage maintenance tasks. If a system is not maintained to the manufacturer's recommended standards, it can result in a loss of functionality and, in the worst case, fatal injuries or death. Operational reliability, operational risk, and operational costs all contribute to aircraft operability and the airline policy may have to balance these requirements.

The purpose of this study was to gather data, analyze it, and make recommendations on the best ways to implement the findings in the aircraft maintenance and civil aviation authority's aviation reliability program for improved flight safety in Zambia. The aviation industry in Zambia faces significant operational costs and maintenance procedures are strictly regulated by the Zambia Civil Aviation Authority and international regulating authorities to ensure flight safety. These unscheduled maintenance tasks must be taken into account in system maintenance to avoid deviations.

II. PROBLEM STATEMENT.

The maintenance process in the aviation industry relies on the Maintenance Steering Group (MSG-3) logic and the Maintenance Review Board Report (MRBR) process to determine necessary maintenance tasks. While these processes may meet airworthiness requirements, they may not always be the most efficient or effective in terms of minimizing aircraft support costs without compromising the safety and airworthiness of the planes. In response to this issue, researchers have proposed an investigation into aviation security in Zambia, where the lack of a reliability department within the Zambia Civil Aviation Authority has been identified as a potential contributing factor. The researchers aim to collect data, analyze it, and make recommendations on how to improve the efficiency and effectiveness of aircraft maintenance and the civil aviation authority's processes in order to address this problem.

III. SIGNIFICANCE OF THE STUDY

The significance of this study lies in its focus on improving the reliability of maintenance programs in the aviation industry, which can benefit a wide range of stakeholders including investors, policymakers, researchers, and industry practitioners. The research aims to explore a methodology that can help to improve reliability in aviation maintenance programs, with the belief that proper implementation of these programs can lead to increased reliability and ultimately,

increased safety in the aviation industry. The findings of this study are expected to provide a better understanding of aviation maintenance programs and their importance in ensuring the safety and reliability of the industry.

IV. LITERATURE REVIEW.

In this section, the relevant literature on aviation maintenance and reliability programs is reviewed and analyzed. The focus is on the existence and impact of these programs in the Zambian aviation industry, as well as the challenges and strategies for their successful implementation. Additionally, any gaps in the existing body of literature are identified.

The importance of reliability in the aviation industry has a long history, with a focus on ensuring the safety and performance of aircraft dating back to the aftermath of World War I. The use of reliability principles has also been demonstrated in other industries, such as the missile and space sectors, where the reliability of systems and components is critical to their successful operation. It is essential for every project, regardless of its size or significance, to have a formal reliability program in place, as adding reliability features to an aircraft after it has entered service can be significantly more expensive and may not achieve the desired level of reliability.

Reliability engineering techniques have been developed to assess a system's ability to perform its mission under specific conditions and for a specified period of time. When plotted experimentally, the failure rate of a system often follows a "bathtub curve," as shown in Fig 1. During the initial "infant mortality" period, the failure rate decreases as the probability of a component failing decreases over time. The "useful life" period is characterized by a relatively low failure rate, while the "wear-out" period is marked by an increase in the failure rate as components reach the end of their useful life. Reliability can be defined in terms of these different stages, such as the likelihood of failure during the infant mortality period, the duration of the useful life, or the mechanisms of wear-out.

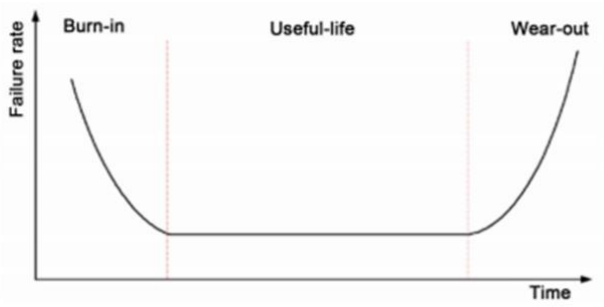

Fig 1: The shape of a bathtub

According to Ren et al. (2017) [5], both the manufacturer and operator benefit from a reliable product that requires less maintenance, resulting in cost savings for both parties. Engineering and management must have a thorough understanding of product reliability, failure modes, and consequences. A shift in corporate culture and the formation of project-integrated teams may be required for aftermarket service design. The quality of an airline's aircraft maintenance is a critical component of its profitability. Aircraft carriers should prioritize increasing the aircraft's reliability and monitoring the components and systems that comprise it.

Increased product reliability contributes to increased aircraft and system uptime, support for long-term maintenance agreements, and increased availability. System and subsystem reliability risks must be identified, and appropriate mitigation strategies developed. A reliable monitor will include fields for each reliability risk such as "owner," "potential effect on system level," "proposed mitigation," "status," and "predicted closure date". Many in-service failures are the result of operating conditions not anticipated by the designer. The reliability programme is a valuable tool for optimizing operational performance in an aircraft maintenance environment.

It aims to reduce maintenance-related issues and increase flight safety. This programme is typically tailored to the operators' specific requirements. There are two primary approaches to the concept of reliability in the aviation industry. The first approach assesses the airline's overall reliability. For instance, the airline's dispatch reliability can be used to determine how frequently scheduled flights depart on time. Airlines that adhere to this procedure maintain a log of delays and categories them as follows: maintenance, flight operations, and air traffic control (ATC). According to Vieira and Loures (2016) [6], M&E organizations are only concerned with maintenance delays. With this approach to reliability, airline maintenance issues that do not result in delays are frequently ignored, while those that do result in delays are thoroughly investigated. This is only partially effective in terms of establishing an effective maintenance program. In contrast to the first approach, the second approach views reliability as a programme that is specifically designed to address maintenance issues, regardless of whether they cause delays, and to provide analysis and corrective actions for those items to improve the equipment's overall reliability. Additionally, this contributes to the overall reliability of the operation.

Further according to Saunders et al. (2016) [7] there are four distinct types of reliability in maintenance activities: statistical, historical, event-oriented, and dispatch. Historical reliability is determined by analyzing system or component failure, removal, or repair rates.

Creswell (2014) [8] explains Event-oriented reliability is concerned with bird strikes and hard landings as well as in-flight engine shut-downs. Reliability in dispatching is a metric used to assess an airline's performance in terms of on time departures. A 4% delay rate would imply that eight flights would be delayed or cancelled out of every 200. Only 96 percent of deliveries would be on time if all deliveries were made on time. A reliability program's objective is to detect and correct problems, regardless of who or what is to blame.

Some airlines will investigate each delay but may not consider other similar failures that did not result in delays. While they may be related, rudder system malfunction is a distinct issue from the dispatch delay. A reliability programme is a set of rules and practices for managing and controlling a maintenance programme. Monitoring vehicle and equipment performance is the primary function of a reliability programme. Using the data collected, the reliability department can evaluate the maintenance program's performance. It's possible to remove items that are performing well from the programme based solely on the data. Reliability calculations are frequently based on failure rates and/or flight cycles. The rate at which aircraft components are removed varies significantly depending on the equipment or system in question. Unscheduled maintenance is a significant issue for the reliability programme. ETOPS operators are required to track IFSDs and respond to excessive rates.

ATA with two, four-, or six-digits is frequently used to facilitate tracking. If the flight crew discovers anything unusual, a discrepancy item is recorded in the maintenance logbook. This enables the source of a problem to be narrowed down to a specific system, subsystem, or component. System of alerts should be in place to rapidly identify areas were performance deviates significantly from normal. Event rates are determined through an analysis of previous performances and deviations from these standards. An additional calculation can be performed to eliminate "false alerts" and smooth the curve.

Wang et al. (2016)[9] suggest that combining operational data with regular and additional inspections of aircraft systems and components can effectively monitor the reliability of an aircraft. This approach relies on the accuracy of the collected data and the conclusions drawn from it to inform the reliability monitoring process. According to EASA Part M, item M.A.302(d) and AMC M.A.708 requirements (as stated by Ren et al. 2017)[5], air carriers are required to collect data in accordance with aviation regulations in order to continuously maintain aircraft airworthiness. Some of the parameters that can be used to monitor the operational reliability of an aircraft include:

i) flight hours,
ii) flight cycles,
iii) technical delays,
iv) technical cancellation,
v) pilot reports,
vi) technical staff reports,
vii) unscheduled component removals,
viii) component removals,
ix) in-flight shut down,
x) unscheduled engine removals and
xi) shop visits.

To facilitate comparisons between air carriers for the same type of aircraft the reliability indicators may be classified in four main groups:

i. general aircraft reliability indicators
ii. structure reliability indicators
iii. aircraft component's reliability indicators
iv. plant reliability indicators.

After collecting and analyzing data, aircraft availability and reliability data for a month is compiled statistically (Ren et al 2017)[5]. It is important to continually monitor the reliability program to ensure its effectiveness.Aircraft maintenance and reliability programs are designed to achieve the highest level of availability possible. However, these programs must be tailored to the specific needs of each operator's fleet, taking into account the range of operational conditions they encounter. The government has a strong incentive to ensure the proper maintenance of aircraft, as the safety of many lives is at stake. Maintenance reliability programs are a critical factor in optimizing operational performance, and although there is a standard set by the industry, each operator must tailor and optimize their own programs to meet their specific needs.

The larger the fleet, the more accurate and reliable the results of the maintenance and reliability program can be. It is common practice to establish minimum requirements for scheduled maintenance, and the MSG-3 process helps to determine these requirements for aircraft and power plants through a decision-making process that includes visual inspections of critical parameters such as the aircraft structure and engines. In 2015, there were only four fatalities on 37 million flights, making it the safest year in aviation history. However, efforts to improve aircraft reliability by both maintenance, repair, and overhaul (MRO) companies and airlines can help to further reduce the aircraft accident rate. Aviation maintenance reliability programs aim to ensure that planes operate as intended, providing safe and reliable travel. Operators should monitor deviations from this goal and evaluate the overall success of the program once the aircraft is in service. Factors such as operator organization, humidity, temperature, and load utilization can significantly impact aircraft reliability and safety.

V. METHODOLOGY AND DATA COLLECTION.

This section of the research outlines the methodology, sampling techniques, target populations, and data collection and analysis procedures and instruments used in the study. Both quantitative and qualitative data will be collected using a hybrid approach, and the research design is intended to systematically gather and analyze data in order to achieve the stated goals of the study. As Saunders et al. (2016)[7] note, exploratory research does not necessarily aim to provide definitive evidence, and surveys can be used to gather information about an organization's structure and culture. These authors also agree that exploratory research design is not necessarily aimed at providing definitive answers.

a) Data Collection

Both primary and secondary data were obtained for this study through the use of a field survey that included the use of questionnaires and personal interviews.

b) Primary Data

Primary data refers to first-hand information that is collected directly for the specific purpose of the research study. When secondary data is insufficient, inappropriate, or unavailable, researchers may need to gather primary data through methods such as interviews, questionnaires, and observations (Sekaran and Bougie, 2013.)[10] For this study, primary data was collected from target groups in the Lusaka district using interviews and questionnaires.

c) Secondary Data

Secondary data refers to information or data that has been previously collected by other researchers, typically for a different purpose. These data can provide context and depth to a research study, and in this case, were gathered through a review of literature and other sources such as books, journals, magazines, government papers, and prior studies. The questionnaire questions used in this study are included in the appendix and are discussed in more detail in the following chapter. To gather both quantitative and qualitative data, researchers used questionnaires and interviews in this study. An in-depth interview with a key informant was also conducted to gather insights into the "Performance Assessment of the Maintenance Reliability Program for Flight Safety in the Zambian Aviation Industry."

Table 1: asks respondents to list Zambian aviation industry maintenance reliability program implementation challenges.

	Maintenance challenges	Strongly agree%	Agree %	Not sure%	Strongly disagree%	Disagree%
1	Lack of basic machine operation skills affects maintenance activities	50	20	10	10	10
2	Lack of basic technical training skills affects proper maintenance and reliability activities	30	40	0	20	10
3	Lack of expertise training affects maintenance and reliability activities	20	50	0	10	20
4	Lack of adequate tools affect maintenance and reliability activities	40	20	10	20	10
5	Outdated technology affect maintenance and reliability activities	30	40	0	30	0
6	Financial aspects constraint maintenances and reliability activities	40	25	5	15	15
7	Uncontrolled maintenance costs affect maintenance programs	40	30	0	20	10
8	Inadequate maintenance and reliability budget affects maintenance and reliability activities	20	70	0	0	10
9	Unwillingness by management to commit resources affects maintenance activities	10	70	0	10	10
10	Management systems have no effective maintenance and reliability activities	20	60	5	5	10
11	Maintenance and reliability leadership fail maintenance activities/programs	30	40	10	10	10
12	Procurement of maintenance spares is a challenge in maintenance programs	40	35	5	10	10
13	Procurement of maintenance machines is a challenge in maintenance activities	30	40	10	10	10
14	Inability to repair machines in time has no effect in maintenance and reliability activities	45	25	10	10	10

Table 1 shows that respondents were asked how much lack of fundamental machine operation abilities affects maintenance. 50% of the majority respondent indicated strongly agrees, 20% of the respondent indicated agree, 10% of the respondent indicated not sure, strongly disagree and 10% of the respondent indicated degree.

Fig. 2, shows that the majority of 60% of the respondents were female while 40% were male an indication that most of the respondents were male. This is an indication that both genders were fairly involved in this research and thus the findings of this study did not suffer from gender biasness.

According to Fig. 3. Most of the respondents were well-educated, so they were able to understand the questions and provide thoughtful responses, 60% of respondents had a diploma, 20% had a postgraduate degree, 10% had a certificate and 10% had an undergraduate degree.

According to Fig. 4 The study requested the respondent to indicate their age category, from the findings, most of the respondents as shown by 40% of the respondents were aged between 31 to 40 years, 30% of the respondents indicated age between 41 to 50 years, 20% of the respondents indicated age above 50 years and 10% of the respondents indicated age between 20 to 30 years.

According to Fig. 5 the study request respondents to indicate marital status in which from the findings majority of 60% respondents indicated marital status married, 20% of the respondents indicated divorced, 10% of the respondent indicated widowed and 10% of the respondents indicated single.

The results from Fig. 6 majority of the respondents 40% between 6 to 10 years' experience, 30% of the respondents indicated between 11 to 15 years of work experience, 20% of the respondents indicated from 0 to 5 years of working experience and 10% of the respondents indicated 16 years and above working experience. The results indicate that large number of employees amounting 40% have worked long time with the organization for a duration ranging 6 and 10 years which implies that the air transport industry has capability to maintaining its work force.

According to Fig. 7 the study requested respondent to indicate department. 40% of the majority respondent indicated ground operations department, 20% of the respondent indicated fight operation department, 10% of the respondent indicated airworthiness department, 10% of the respondent indicated aviation security department, 10% of the respondent indicated personnel licensing department and 10% of the respondent indicated aircraft maintenance.

According to Fig. 8 the study requested respondent to indicate if do you have a Maintenance Reliability Program in your company. 99% of the majority respondent indicated that there do have Maintenance Reliability Program in company and 1% of the respondent indicated no.

According to Fig. 9 the study requested respondent to indicate If Yes to the above question, how effective is your Maintenance Reliability Program. 50% of the majority respondent indicated very effective, 40% of the respondent indicated effective, 5% of the respondent indicated less effective and 5% of the respondent indicated not effective. This is an indication that maintenance reliability program is very effective.

According to Fig. 10 the study requested respondent to indicate how do you administer the Maintenance Reliability Program in your company.40% of the majority respondent indicated allocate personnel resources and deploy tools, 30% of the respondent indicated develop a plan for improvement, 20% of the respondent indicated priorities company assets and 10% of the respondent indicated develop a plan for improvement.

According to Fig. 11 the study requested respondent to indicate if Maintenance activities are carried out by work orders. 40% of the majority respondent indicated very great extent that Maintenance activities are carried out by work orders, 30% of the respondent indicated great extent that Maintenance activities are carried out by work orders and 30% of the respondent indicated moderate extent that Maintenance activities are carried out by work orders.

According to Fig. 12 the study requested respondent to indicate large proportion of monthly maintenance hours available are used in reactive emergency maintenance. 40% of the majority respondent indicated great extent that large proportion of monthly maintenance hours available are used in reactive emergency maintenance, 30% of the respondent indicated very great extent and 30% of the respondent indicated moderate.

According to Fig. 13 the study requested respondent to indicate if Failures in machines are detected before the machine fails. 50% of the majority respondent indicated very great extent, 25% of the respondent indicated great extent and 25% of the respondent indicated moderate.

According to Fig. 14 the study requested respondent to indicate the Maintenance and reliability personnel spend free time on plant housekeeping. 70% of the majority respondent indicated great extent, 20% of the respondent indicated very great extent and 10% of the respondent indicated moderate.

According to Fig. 15 the study requested respondent to indicate if maintenance reliability programs have any effect on flight safety in Zambia. 60% of the majority respondent indicated yes and 40% of the respondent indicated no.

According to Fig. 16 the study requested respondent to indicate the effects of maintenance reliability programs on flight safety in Zambia. 100% of the majority respondent improves organization performance.

A. Presentation and Interpretation of Findings

1. Overview

The main objective of this study was to assess the maintenance reliability programs for flight safety in the Zambian Aviation Industry. Findings are mainly presented in form of frequency tables and pie charts. Data collection for this study was done basically through the usage of questionnaire. Given the size of staff member, the sample of 108. Out of the 108 questionnaires circulated, 108 were returned representing about 100% of response rate, which was regarded impressive considering the short time given to the respondents. Therefore, this study was informed by the following objective.

1. To investigate the existence of maintenance reliability Programs in the Zambian Aviation industry.
2. To establish the effect of maintenance reliability Programs on flight safety in Zambia.
3. To ascertain the challenges faced in the implementation of maintenance reliability programs in the Zambian Aviation industry.
4. To proffer strategies that can be used to effectively implement maintenance reliability programs in the Zambian Aviation industry.

2) Background characteristics of workers

Fig. 2 to 7 show background characteristics of respondents.

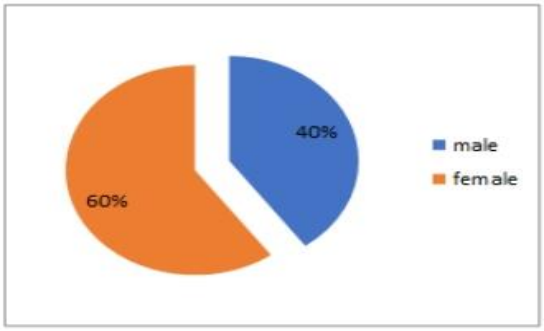

Fig. 2: Distribution of the respondent by gender

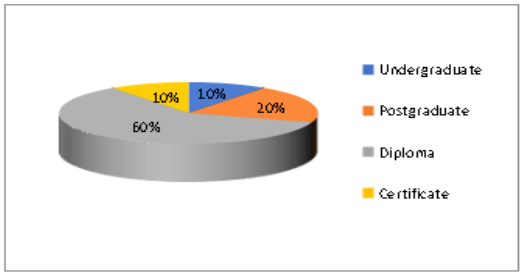

Fig. 3: Distribution of respondents by education levels

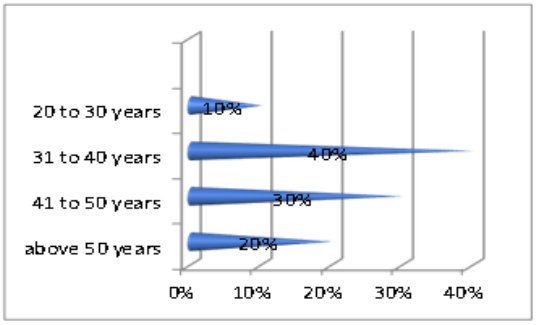

Fig. 4: Distribution of respondents by age

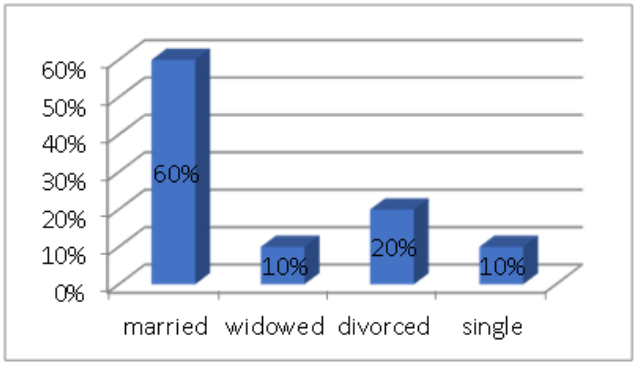

Fig 5: Marital status

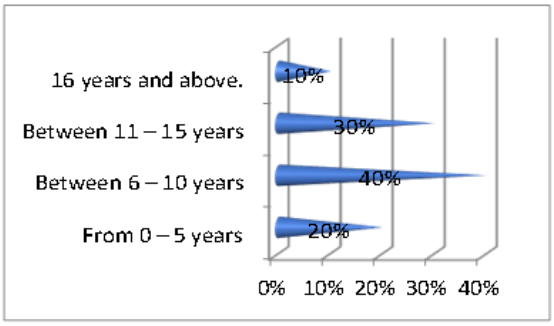

Fig. 6: For how long have you been working with air transport industry?

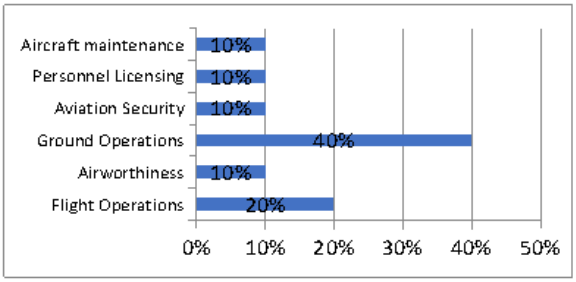

Fig. 7: Which of the following department do you belong to?

B. Existence of Maintenance Reliability Program

Fig. 8 to 10 show how respondents answered particular respective questions.

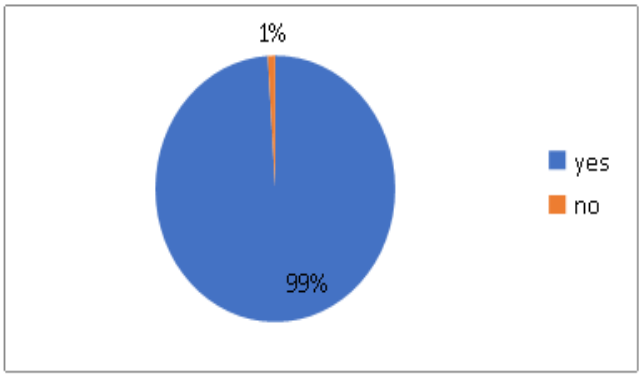

Fig 8: Do you have a Maintenance Reliability Program in your company?

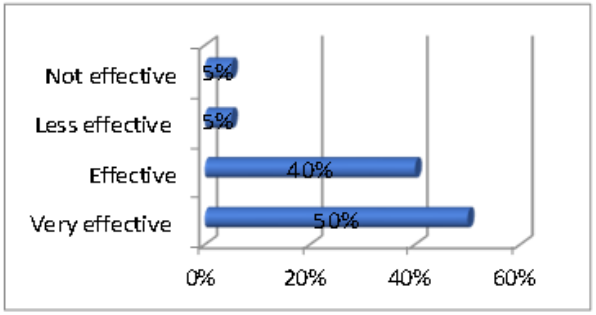

Fig 9: If Yes to the above question, how effective is your Maintenance Reliability Program?

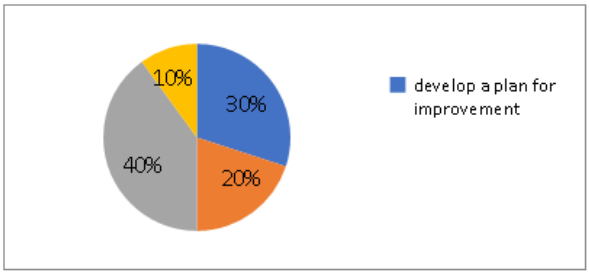

Fig. 10: How do you administer the Maintenance Reliability Program in your company?

Fig. 11 to 14 respondents' responses to strategies used to effectively implement maintenance reliability programs in the Zambian Aviation industry.

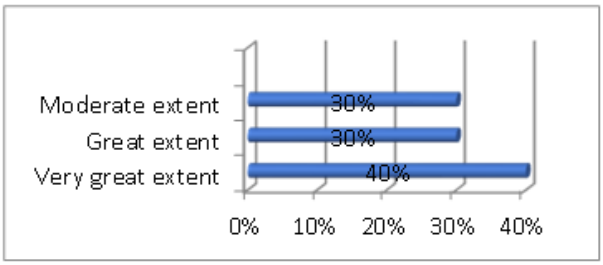

Fig. 11: Maintenance activities are carried out by work orders

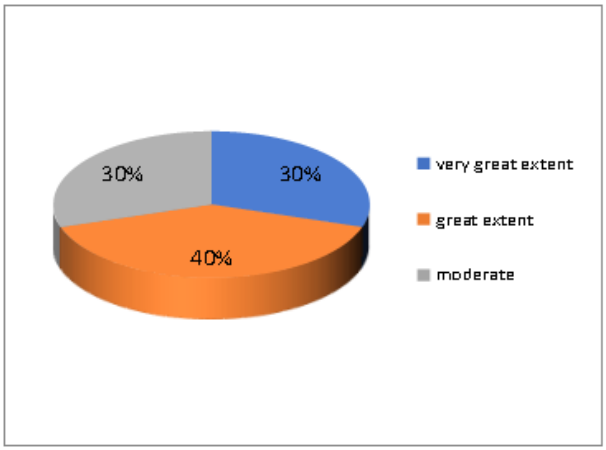

Fig. 12: Large proportion of monthly maintenance hours available are used in reactive emergency maintenance

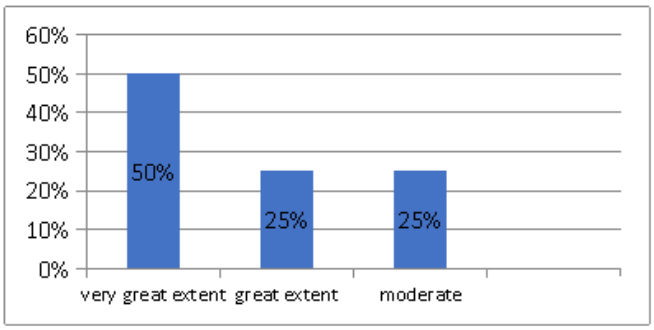

Fig 13: Failures in machines are detected before the machine fails

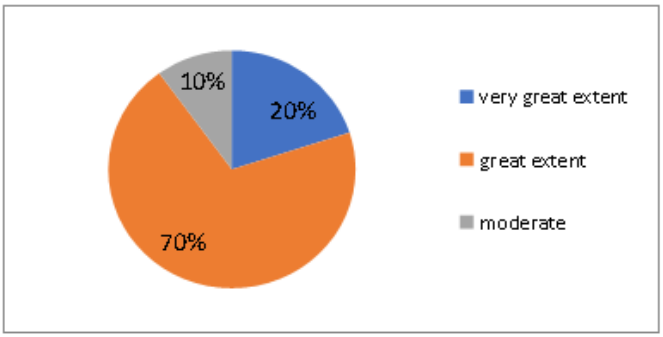

Fig. 14: Maintenance and reliability personnel spend free time on plant housekeeping

Fig. 15 and 16 show respondents' on the effect of maintenance reliability programs on flight safety in Zambia.

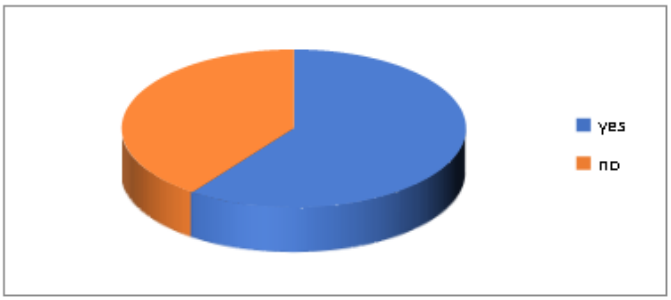

Fig. 15: Based on your practical experience, do maintenance reliability programs have any effect on flight safety in Zambia?

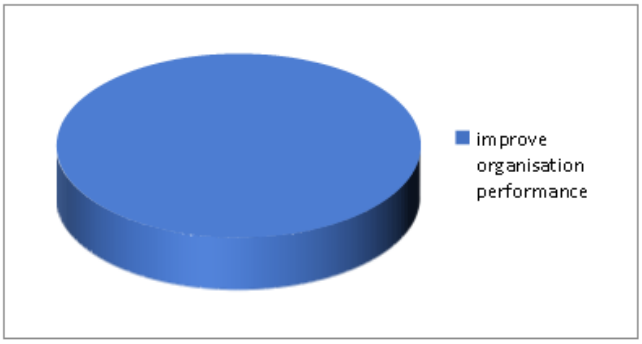

Fig. 16: If Yes to the above question, what are the effects of maintenance reliability programs on flight safety in Zambia

VI. DISCUSSION OF THE FINDINGS

i) Background characteristics of workers

According to the findings, 60% of participants were women, In this study, 60% of the respondents were women and 40% were men. The majority of respondents (60%) had a diploma education, while 20% had a postgraduate degree, 10% had a certificate, and 10% had an undergraduate degree. The respondents were well-educated and able to provide thoughtful responses to the questions.

The study found that further education on maintenance reliability programs can have a positive impact on flight safety in the Zambian aviation industry, regardless of age. Education can also increase awareness of the importance of financial management in this industry. Participants in focus groups expressed concern about the underdevelopment of human capital, particularly among the younger generation. Researchers believe that this may be due to the lack of post-secondary institutions in the area. According to the World Bank (2001), education is crucial for human development because it empowers people and improves their well-being, allowing them to participate in nation-building. It provides individuals with the skills and knowledge needed for better job opportunities and a better quality of life.

The survey included a question about the respondents' age range. The results showed that 40% of respondents were between the ages of 31 and 40, 30% were between 41 and 50, 20% were over 50, and 10% were between the ages of 20 and 30. This indicates that the age distribution of the respondents was evenly distributed. Respondents aged 26 to 36 were more open to aviation-related training opportunities. The study also asked about marital status, and the results showed that 60% of respondents were married, 20% were divorced, 10% were widowed, and 10% were single.

40% of employees had worked for the company for six to ten years, indicating that the air transportation industry is able to retain its workforce. The majority of respondents (40%) worked in the ground operations department, while 20% worked in the flight operations department, 10% worked in the airworthiness department, 10% worked in the aviation security department, 10% worked in the personnel licensing department, and 10% worked in the aircraft maintenance department.

ii) Existence of Maintenance Reliability Program

According to the findings of this study, 99% of respondents indicated that their company has a Maintenance Reliability Program in place. Among those who answered "Yes" to this question, 50% said their program is very effective, 40% said it is effective, 5% said it is less effective, and 5% said it is not effective at all. To implement their Maintenance Reliability Program, most respondents indicated that they allocate personnel resources and deploy tools, while 30% said they develop an improvement plan, 20% prioritize company assets, and 10% develop an improvement plan.

iii) Challenges faced in implementation of Maintenance Reliability Programs in Zambian Aviation Industry

Lack of Expertise Training: According to the study, 50 percent of the majority respondent indicated strongly agrees; 20% indicated agree; 10 percent indicated not sure; strongly disagreed; and 10 percent indicated degree, lack of basic technical training skills affects proper maintenance and reliability activities. To what extent do you think that lack of expertise training affects maintenance and reliability activities? The study asked respondents to indicate this. 40% of the majority respondents agreed, 30% indicated strongly agreed, and 20% indicated strongly agreed; 10% indicated degree, and 0% of the respondents indicated they were unsure. Lack of Adequate Tools: According to most respondents, maintenance and reliability activities are negatively impacted by a lack of expertise training. According to the survey, 20% of respondents said they strongly agreed, 20% said they agreed to some degree, 10% said they agreed to some degree strongly, and 0% said they weren't sure. Participants were asked to indicate the degree to which a lack of adequate tools affects maintenance and reliability activities. According to 40% of most respondents, maintenance and reliability activities are negatively impacted by a lack of adequate tools.

Financial Constraints: When asked how much financial constraints limit maintenance and reliability activities, 80% of the respondents said they agreed, 20% said they were strongly in agreement, 10% said they were unsure, and 10% said they disagreed. Financial constraints limit maintenance and reliability activities, according to 40% of those who responded, 30% of those who responded strongly agreed; 30% of those who responded strongly disagreed; 0% of those who responded indicated they were unsure; and 0% of those who responded disagreed; the study also asked respondents to indicate whether uncontrolled maintenance costs affect maintenance programme. Uncontrolled maintenance costs affect maintenance programme, as indicated by 40% of the majority respondent; by 25% of the respondent; by 15% of the respondent; by 15% of the respondent; by 5% of the respondent; by 5% of the respondent; by 5% of the respondent; More than half (40%) of the majority of respondents strongly agreed that a lack of maintenance and reliability budget negatively affects m&r activities; 30% agreed; 20% strongly disagreed; 10% disagreed; and 0% said they were not sure.

A lack of management commitment to m&r activities negatively affects the activities, according to most respondents (70 percent). To what extent do you think management systems lack effective maintenance and reliability y activities? The study asked respondents to indicate how much they agreed, how much they disagreed, and how much they strongly agreed or disagreed with this statement. Majority respondents agreed that management systems lack effective maintenance and reliability activities, with 70% of the majority indicating agreement; 10% indicated they were "strongly" or "strongly" agreed; 10% indicated they were "strongly" or "strongly" disagreed; 10% stated they were "disagreed"; 0% stated they were "not sure."

Leadership in the areas of maintenance and reliability fails to adequately oversee these activities and programmes, according to 40% of those who took the survey. More than two-thirds of respondents said they strongly agreed, while less than one-third said they strongly disagreed, and less than one percent said they were undecided. Procurement of maintenance spares is a challenge in maintenance activities, according to 40 percent of the majority respondent. Thirty percent of respondents strongly agreed, 10 percent of the respondent indicated not sure, and 10 percent of the strongly disagreed. The remaining 10% of the respondent indicated they were undecided.

iv) Strategies used to effectively implement maintenance reliability programs in the Zambian Aviation industry.

The study found that 40% of the majority respondent indicated a very great extent that Maintenance activities are carried out by work orders, 30% of the respondent indicated great extent that Maintenance activities are carried out by work orders, and 30% of the respondent indicated moderate extent that Maintenance activities are carried out by work orders. This suggests that a significant portion of maintenance activities are carried out through the use of work orders, with a slightly smaller portion being carried out to a lesser extent.

Respondents were asked in the study if failures in machines are detected prior to failure. More than 40% of those polled said that reactive emergency maintenance takes up a significant portion of their monthly maintenance time; 30% said this was true to a "very great" extent, while 30% said this was true to a "moderate" extent. This indicates that a significant portion of maintenance time is spent on reactive emergency maintenance, rather than being able to proactively prevent failures from occurring. Respondents were asked to indicate how much free time Maintenance and reliability personnel spend on plant housekeeping. Most respondents indicated very great extent, with 25 percent indicating great extent and 25 percent indicating moderate. This suggests that a significant portion of the maintenance and reliability personnel's free time is spent on plant housekeeping, likely indicating the importance of keeping the facility clean and organized.

v) Zambian flight safety and maintenance reliability programmes

In the study, 60% of respondents said that maintenance reliability programs have a positive impact on flight safety in Zambia, while 40% said they do not. When asked about the impact of maintenance reliability programs on the performance of their company, most respondents had a positive view. An effective reliability program can help operators track and improve the reliability of their fleet by optimizing maintenance programs and implementing other organizational measures. Reliability programs can also identify issues in an operator's system that can have significant impacts on the safety and profitability of an airline.

VII. CONCLUSION.

The results of this study indicate that the Zambian aviation industry places a strong emphasis on safety procedures. Many respondents strongly agreed that safety procedures are a top priority for their organization.

In terms of regulatory standards, respondents agreed that these should be set by the appropriate authority. However, they also noted that some operators in the Zambian airline market set higher standards than those required by the regulatory authority.

VIII. RECOMMENDATIONS.

To improve safety in the aviation industry in Zambia, the following recommendations are suggested:

i) Identify and address vulnerabilities in technology, including any design flaws or challenging maintenance procedures.

ii) Enhance the human and machine capabilities of the Air Force to ensure mission success while maintaining safety.

iii) Provide improved training for employees and address any equipment deficiencies.

iv) Ensure that the appropriate regulatory authority sets safety standards, and consider implementing higher standards than those mandated by the authority.

v) Consider establishing a reliability department within the Zambia Civil Aviation Authority to provide reliability programs for aviation operators in the industry. These programs can help to ensure that aircraft maintenance tasks are effective and provide appropriate techniques for monitoring the efficiency of the maintenance program.

REFERENCES.

[1] Zambia : Two ZAF officers die in plane crash. (2022, March 28). https://www.lusakatimes.com/2022/03/28/two-zaf-officers-die-in-plane-crash/

[2] Lumbe. (2020, January 11). One dies in light plane accident – Zambia Daily Mail. One Dies in Light Plane Accident – Zambia Daily Mail. http://www.daily-mail.co.zm/one-dies-in-light-plane-accident/

[3] Crash of an Avro 748-263-2A in Kasaba Bay | Bureau of Aircraft Accidents Archives. (1983, July 4). Crash of an Avro 748-263-2A in Kasaba Bay | Bureau of Aircraft Accidents Archives. https://www.baaa-acro.com/crash/crash-avro-748-263-2a-kasaba-bay

[4] Crash of a Britten Norman BN-2A Islander near Chirundu | Bureau of Aircraft Accidents Archives. (2014, July 6). Crash of a Britten Norman BN-2A Islander Near Chirundu | Bureau of Aircraft Accidents Archives. https://www.baaa-acro.com/crash/crash-britten-norman-bn-2a-islander-near-chirundu

[5] Ren, H., Chen, X., & Chen, Y. (2017). Reliability based aircraft maintenance optimization and applications. Academic Press.

[6] Vieira, D. R., & Loures, P. L. (2016). Maintenance, repair, and overhaul (MRO) fundamentals and strategies: An aeronautical industry overview. International Journal of Computer Applications, 135(12), 21-29.

[7] Saunders, M., Lewis, P. and Thornhill, A. (2016). Research methods for business students. Harlow: Pearson Education Limited.

[8] Creswell, J. W. (2014). Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). Thousand Oaks, CA: Sage

[9] Wang, X., Miao, Y., & Wang, S. (2016, October). Active fault-tolerant control of large commercial aircraft with asymmetric damaged horizontal stabilizer. In 2016 IEEE International Conference on Aircraft Utility Systems (AUS) (pp. 780-785). IEEE.

[10] Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. john wiley & sons