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Evaluation of Existing Measures of Safety Performance in Commercial Aviation Operators.

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ABSTRACT
This research is aimed at *evaluating the existing measures of safety performance in commercial aviation operatorsin Nigeria's airline-approved maintenance organizations. This would help to find a lasting solution to difficulties faced by the sector in determining safety management practices and compliance in line with global best practices for aircraft safety management requirement with emphasis on those outlined in the International Civil Aviation Organization framework. This consideration was established to help in enhancing standardized methods of application, enforcement of maintenance and repairs operations for commercial Airline carriers.This research adopted a quantitative research technique with cross-sectional survey as research approach. Semi-structured questionnaire was used for data collection while these data were analyzed using descriptive statistics (mean, standard deviation) and inferential statistics (principal component analysis (PCA) through Statistical package for social sciences (SPSS) version 23,for ease of computation.Finding showthat lack of collaboration and benchmarking with other airlines or industry stakeholders, complexity associated with integration of safety management systems into existing operational processes and procedures pose a challenge to adoption of safety management systems in aviation industry. This research therefore concludes/ recommends that regulatory authorities and industry associations can foster a culture of collaboration and provide platforms for knowledge dissemination.*

Keywords: *Evaluation, Safety Management system, Aviation, Maintenance, Organization.*

Background Information

Air transport is arguably essential to the globalization taking place in many other sectors, as it promotes economic development, commerce, foreign investment, and tourism (Kankaew, 2022). On average, over the years, travel for different uses has risen strongly globally with around 4.5 billion people using air transport in 2022 and the annual number of passengers has increased by 8.9% since 2019 (ICAO, 2022), reflecting the domination of the industry and a need for its productive operations and profitability as this trigger the need for airline safety.
Early in the new millennium, the Safety Management System (SMS), a key method to safety management, was introduced with the goal of enhancing the safety of air transport operations and maintaining these operations at acceptable levels of risk (Zimmermann & Duffy, 2023). Even though flying is currently the safest form of transportation, there have nevertheless been incidents and fatalities in the industry (Hook, Sizoo & Fuller, 2022). Aviation accidents have

not yet been prevented, as evidenced by Nepal in January 15. 2023 with Yeti Airlines Flight 691, an ATR 72-500 operating a domestic flight from Tribhuvan International Airport to Pokhara International Airport, which crashes into the gorge of the Seti Gandaki River in Pokhara, Nepal where all 72 people aboard are killed (Aviation report, 2023); in August 23, 2023 where an Embraer Legacy 600 crashes in Oblast, Russia killing all of the 10 people on board, including Wagner Group leader Yevgeny Prigozhin (Aviation Report, 2023).
Coming to Nigeria there have not been recent commercial plane crash in last seven years, however **on November 14, 2023, at least 62 passengers escaped death on Tuesday as an aircraft belonging to Nigerian airline, Value Jet skidded, off the runway at the Port Harcourt International Airport in Rivers State (Channels News, 2023). Also** on the evening of 21 May 2021, a Nigerian Air Force Beechcraft King Air 350i with Ibrahim Attahiru and ten other occupants were on a visit to the northern state of Kaduna to attend a Nigerian Army recruit passing out parade the following day (The Guardian Nigeria, 2021). During the flight the aircraft crashed killing all on board including Attahiru. Thus the last major commercial plane crash was withDana Air Flight 0992. Dana Air Flight 0992 was a scheduled Nigerian domestic passenger flight from Abuja to Lagos, Nigeria. On 3 June 2012, the McDonnell Douglas MD-83 aircraft serving the route suffered a dual-engine failure during its approach to Lagos. It failed to reach its intended destination and crashed onto buildings, killing all 153 people on board and six on the ground (Seeger & Auer, 2016). With 159 deaths, it remains as the deadliest commercial airliner crash in Nigerian history since the Kano air disaster in 1973 (Gambrell, 2012).

Consequently, according to Yang, Chang and Lin (2023), SMS is an approach to safety management that has been placed in order to increase safety of aviation operations and to sustain these activities at appropriate standards of risk. Early in the new millennium, aviation authorities realized that only adhering to laws and regulations was insufficient to ensure safety. As a result, they adopted SMS, which was the outcome of an approach to safety management that was considerably different from previous method (Malakis, Kontogiannis & Smoker, 2023). The first manual pertaining to aviation safety was published by the International Civil Aviation Authority (ICAO) in 2006 with the title Safety Control Manual (ICAO, 2022). SMS is the outcome of a paradigm shift that admits that people and organizations can make mistakes and observes the environment as it is. SMS speaks to the need for a proactive culture of protection by attempting to identify the underlying causes of accidents, refraining from taking a denouncing stance (Şimşek & Ünal, 2022). SMS's main objective is to make people safer in everyday situations. SMS encourages all workers to view safety as a priority and to take all actions in flight operations that are focused on this priority, which is substantially different from old-school safety procedures (Malakis, Kontogiannis & Smoker, 2023). In order to boost safety in aviation operations, it is thus possible to anticipate hazards that are likely to harm one another and produce unwelcome accidents, assess the effects of those hazards, and eradicate them before they result in injuries.

According Shneiderman (2022), aviation safety monitoring is moving away from being an industry best practice and toward becoming a regulatory requirement. Identifying and handling risks before accidents or events occur is a critical aspect of maintaining protection. Regulatory organizations are also quite interested in how SMS contributes to ensuring safety. For instance, the Civil Aviation Authority of the United Kingdom (2020) recognizes the value of SMS as the organized management of the risks involved in achieving a high level of safety effectiveness in flight operations, aircraft maintenance, and related ground activities. Similarly, several countries' civil aviation authorities (New Zealand, Nigeria, China, etc.) are taking steps to improve the industry's safety because of past incidents and incident-related problems (Kaspers et. al., 2019).

This study aims to evaluate safety management systems (SMS) and their implementation in airline approved maintenance organizations (AMO) in Nigeria

Problem Statement

The adoption of SMSs transformed aviation safety management from an industry best practice to a legislative mandate (Stolzer, Sumwalt & Goglia, 2023). As a result, aviation authorities are expected to create new ways to describe the sector's safety management operations, and the industry must establish means to certify compliance with the requirements (Stolzer, Sumwalt & Goglia, 2023). Several countries have gone from conventional modes of safety surveillance carried out by a vast number of product checks to safety surveillance based on SMS tracking using safety efficiency metrics (Leib & Lu, 2013; Shekari, 2020; Bugayko & Ierkovska, 2021; Kešeľová et al., 2021; Korkmaz, Filazoglu & Ates, 2023). The transition in safety management in the late 1970s from a strategy emphasizing compliance with prescriptive legislation to a strategy emphasizing an organization in charge of managing its own unique risk profile ushered in the era of result-based legislation and self-regulation (Şimşek & Ünal, 2022.

The organizational responsibilities and duties outlined in the ICAO Framework that form the foundation for SMS's successful functioning are not well understood in Nigeria's aviation industry (Aruwa, 2019).In order to address the inadequacies of the present SMS demand, the prevailing impression is one of dependence on the robustness of the quality control system and on the adaptability of the maintenance operations (Adjekum & Tous, 2020)

Consequently, aviation safety in Nigeria would suffer if the SMS, which is intended to lower accident rates and improve aviation safety, does not function properly (Chukwuka & Amahi, 2024). Previous studies by Chinonso and Ejem (2020) shows that even airport service quality (ASQ) in Nigerian airports is now low, suggesting that the service quality expectations of the airlines and passengers are not being effectively met. Thus if the airport service quality is low that tells of the nature of the SMS quality in use among airlines. However, identifying the problems in the SMS implementation process is critical to improving SMS performance. Appropriate solutions should be created to ensure SMS success. For example, the Nigerian aviation sector has not yet fully transitioned to SMS (Tyagi, Tripathi & Bouarfa, 2023), and the danger is that passenger traffic rose by more than 40% in 2021, from 9,069,295 to 14.2 million (National Bureau of Statistics, 2021). In 2022, passenger traffic climbed to 16,173,361 from 14.2 million passengers, representing a 13% increase over the previous year (Ayodele, 2023). Also in 2022, 37 airlines flew over Nigeria, with 26 airlines running 13,003 foreign flights and 11 airlines operating 80,328 domestic flights (Okeke-Korieocha, 2023). This is a cause for concern, as safety hazards are anticipated to rise in tandem with the dramatic increases in passenger volume. It was not until 2020 that the Accident Investigation Bureau Nigeria (AIB-N) has affirmed readiness with partners to implement Safety Management System (SMS) to enhance aviation safety. Hence a comprehensive review of the implementation of the SMS and it interfaces with current maintenance and quality control activities are necessary (Kešeľová et. al., 2021).

Objectives of the Study

The specific objective is:

1. To evaluate existing measures of safety performance in commercial aviation operators.

Research Questions

The following research questions will guide the study:

1. What are the measures of safety performance adapted by commercial aviation operators in Nigeria?

Research Hypotheses

HO_1: The measures of safety performance adapted by commercial aviation operators in Nigeria do not yield the expected global best practices and outcome.

Justification of the study

Understanding the benefits of SMS and implementing it inside an Approved Maintenance Organization (AMO) in any country would be beneficial to airline operators in that country as well as the global aviation sector.

The findings of the study might give significant information that aviation stakeholders can use to enhance Nigeria's aviation safety record. The findings may be used by the Ministry of Aviation to evaluate aviation rules and policies in order to instill an aviation safety culture. Donors and international aviation authorities may be able to utilize the study's findings to identify and implement programs suited to specific issues in Nigerian aviation safety. The findings and suggestions of this study might be used as a reference for researchers, academia, and aviation stakeholders.

Scope of the Study

This research as an assessment study will have wide coverage spanning major approved maintenance organizations (AMOs) in Nigeria Aviation Industry. Twenty-one airline operators having AMOs are now listed by the Nigerian Civil Aviation Authority (NCAA), and ten (10) major AMOs will be considered in this study. The study will be delimited by concept to all the principles, objectives, forms, definitionsof SMS in Nigeria Aviation Industry, with more emphasis on maintenance intricacies of the study. Relevant theories and models will be captured in the study and an empirical review of literature will help direct the study in the area of statistical approach reduced to descriptive statistics, predictive tests and relationship-based analysis.

Conceptual Review

Concept of Aviation Safety

While aviation is one of the world's safest modes of transport today, accidents are still happening (Zhang & Mahadevan, 2021). It is necessary for one to see that they nevertheless exist no matter how often someone attempts to avoid an accident. In order to stop as many as possible, what is necessary is attempting to formulate a plan of action. "The simplest definition of safety, according to Merriam-Federal Highway Administration (2012), is "the state of being protected from damage, injury, or failure" or "a system (like a firearm or a machine) designed to avoid inadvertent or unsafe activity.

According to Roland and Moriarty's paper submitted to the Aeronautical Science Institute entitled 'Engineering for Safety' came in 1947 as a first form of safety idea, which states that "Safety must as well be planned and implemented in aircrafts as is performance, and that it is the first form of safety principle, as indicated by Zhang and Mahadevan (2021). A

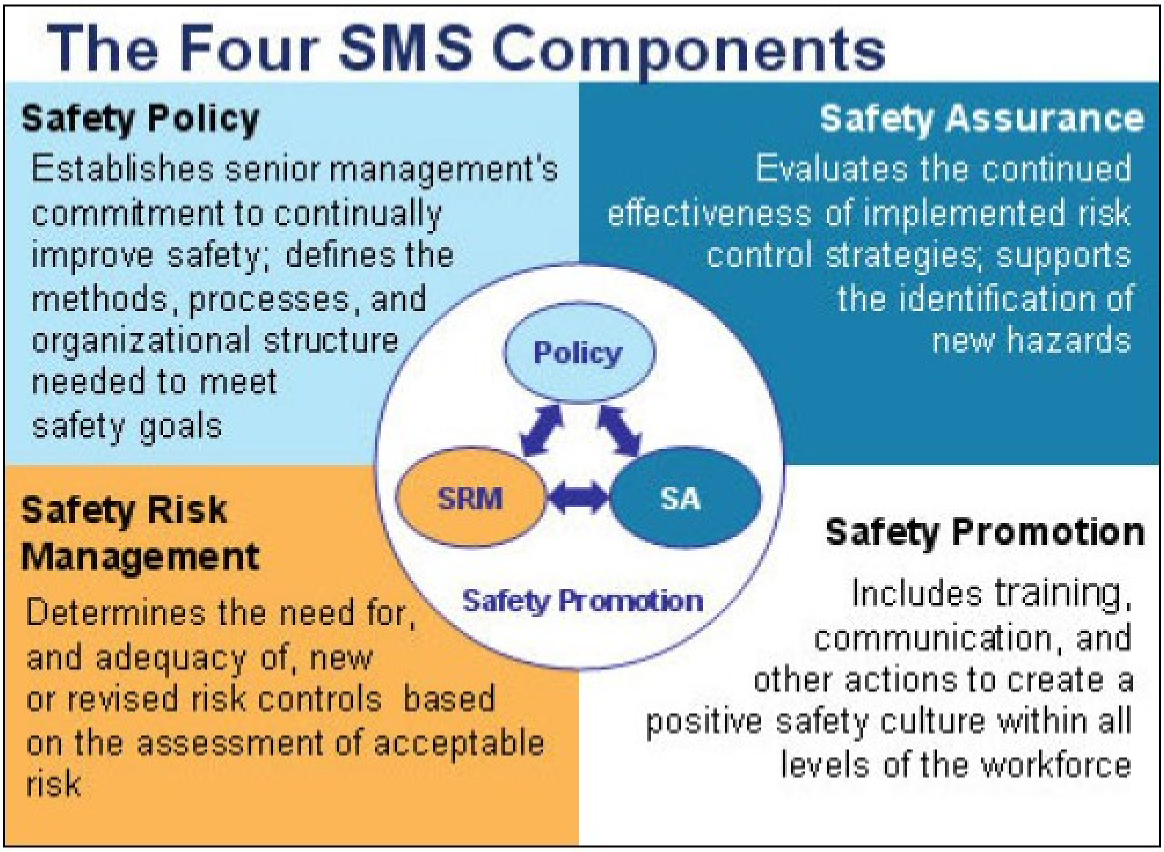
manufacturer's organizational structure must prioritize safety just as much as tension, aerodynamics, or a set of weights.
It is also new to have safety as a specialty, in contrast to other disciplines that have been established for some time Zhang and Mahadevan (2021). Many safety professionals who are currently pursuing careers in safety and accident prevention initially planned to pursue certification in prevention. Years ago, anyone could work in accident prevention, but today it is a more rigorous profession that calls for people to be trained in specific disciplinesZhang and Mahadevan (2021). In this country, accidents occur everyday. Some are fatal, like an airline crash, and others are non-fatal, like a broken leg. By actually introducing a Safety Management System, more accidentscan be avoided.
The fly-crash-fix-fly method—a reactive safety system in which people react to accidents by devising preventative measures—has given way to a proactive safety approach in aviation over time.

Brief Overview of Safety Management Systems in Aviation Industry
Safety Management System in aviation safety originated as a result of aviation safety being reactive rather than proactive, as was previously indicated (Transportation Research Board, 2007). Owing to a particular incident, injuries seldom occur. Typically, it involves a string of incidents that take place before an injury actually happens, which is also known as the snowball effect or an error chain. The FAA acknowledges that there will still be risks via this program, SMS, but "SMS provides a systemic, explicit, and comprehensive risk management process" (Transportation Research Board, 2007). SMS aims to improve safety and decrease the number of incidents that occur.

Safety Management Systems are founded on four basic principles:
• The dedication of management to protection
• Constructive hazard recognition
Action taken in the management of risks.
• Assessment of safety controls (Transportation Research Board, 2007).
To deliver an effective SMS service, it is crucial for everyone to participate, including high management (Transportation Research Board, 2007). The success of the business and the company's safety culture, which will be thoroughly discussed later, depend on it. This guarantees a proactive safety policy and strengthens the corporate safety culture even further. SMS is not meant to be a burden, even though it is meant to be helpful for the entire company. SMS can be incorporated into everyday operations, just like runway inspections are. The four pillars that make up Safety Management Systems are its constituent parts.
Those pillars include:

a) Safety Policy
b) Safety Risk Management
c) Safety Assurance
d) Safety Promotion (Transportation Research Board, 2009)

As briefly seen in Figure 2.3, these components reflect the broad reach of aviation safety management, which should be part of every airport safety management scheme in place.



The Four Components of SMS. (Federal Aviation Administration, 2009)

Safety Policy

Three components form the safety Policy pillar: policy declaration, corporate framework and procedures (Zonnevylle, 2020). The Policy Statement, to begin with, is a statement by senior management and incorporates the following commitment to SMS deployment:

i. Ensuring that administrators monitor safety efficiency only as closely as financial performance.
ii. Encouragement to report possible safety issues to all staff without fear of reprisal.
iii. Establishment of specific safety-related criteria of reasonable behaviour.
iv. Commitment to supplying the services required (Transportation Research Board, 2007).

The policy statement outlines the functioning of the whole organisation in depth and includes the duties, obligations and interactions of all persons participating in the organization (Transportation Research Board, 2007). It explicitly requires the engagement of top management in SMS. It is a core component of SMS performance to have top management involved. The policy statement also lays out a procedural structure that details the responsibilities of all organizations, including planning, procedure evaluation, and system modification, should it be necessary.

The operational framework is the second pillar of the Safety Policy foundation.To begin implementing the SMS at each airport and to guarantee effective implementation, at least one person must be assigned to supervise the project depending on the size of the airport (Transportation Research Board, 2009). The organizational structure makes it easier for the business to understand the functions of other employees. The organizational structure, which is a component of the SMS, is crucial for ensuring that employees follow the organization's correct procedures. The procedure part of the Safety Policy pillar describes how risks are found and reduced. Changes may be made, including adding a new way to monitor water damage in the terminal, if such changes fall under this area. As changes are achieved, it is crucial that they are adequately shared across the entire organization and are available to everyone (Transportation Research Board, 2007). This section addresses the appropriate course of action at that precise moment, regardless of the accident or event. In addition, the process factor dictates who to call, who to call first, and who is easily reachable by either entity.

Safety Promotion

The second pillar of SMS is safety promotion (Transportation Research Board, 2009). The Federal Aviation Administration (2007) defines an SMS as "a combination of safety culture, training, and data sharing activities that support the organization's adoption and operation of an SMS." History, contact, and preparedness are the three pillars of safety promotion. SMS should not be the primary area of concentration for management; all employees should be focused on SMS (Transportation Research Board, 2007). Therefore, top management must not only remind the organization of its commitment to safety through a compliance statement but also take an active role in it (Transportation Research Board, 2007). The safety culture of the company is significantly impacted. For top management, maintaining and displaying a positive view about SMS is crucial. They must remain committed since they are a necessary and vital pre-requisite for developing a good safety culture, in addition to being on board from the beginning. The organization's internal community analysis, which may be challenging to assess, is the following step (Transportation Research Board, 2007). This involves assessing the current business culture to determine the necessary course for possible development.

Promoting the safety culture is the focus of the Safety Promotion cornerstone, which has proven to be one of the most demanding and challenging aspects of the entire SMS process (Stolzer et al., 2018). The first feature under the safety promotion pillar is safety culture (Transportation Research Board, 2007). It's a challenging job to get individuals to change their ways or get on board with something entirely different. When something different arrives in and affects things, people are fixed in their ways and hatred; the SMS adaptation process will assist with this. Employees want to believe that they are an aspect of things. You first need to get the upper management in the company involved to trust in the program in order for any program to succeed (Stolzer et al, 2018). The key term is confidence. No one wants to work for a boss who doesn't believe in the present rules or has faith in a plan to obey them. The presence of management provides workers with the assurance they want and seek (Stolzer et al, 2018). This is where connection, a further tenet of safety promotion that will be covered later, comes into play.

The second Safety Promoting aspect is training. This part is so important because it helps the company to correctly demonstrate SMS (Transportation Research Board, 2007). After promoting a positive safety culture, the next step is to comprehensively teach all staff members on the organization's protocols, the procedures for how to adjust to such events and to address their roles and obligations, and how it pertains to SMS. It is important to keep in mind that preparedness involves ongoing training in addition to the deployment training (Transportation Research Board, 2007).

Under Safety Promotion, communication is the last part. The secret to any effective organisation or initiative is cooperation. Written modes of correspondence should not be the only means of communication, such as policy documents. In addition to textual material, it's imperative that employees see proof of senior management's dedication to safety (Transportation Research Board, 2007). Identifying what went wrong, how to fix problems, and what lessons each team member can use to ensure that the lessons learned do not recur are some examples of progress that may be made through communication (Transportation

Research Board, 2007). Employees must feel that they are contributing to the business and that communication is open; otherwise, information, whether it is useful to the company or the employees, is of little value.

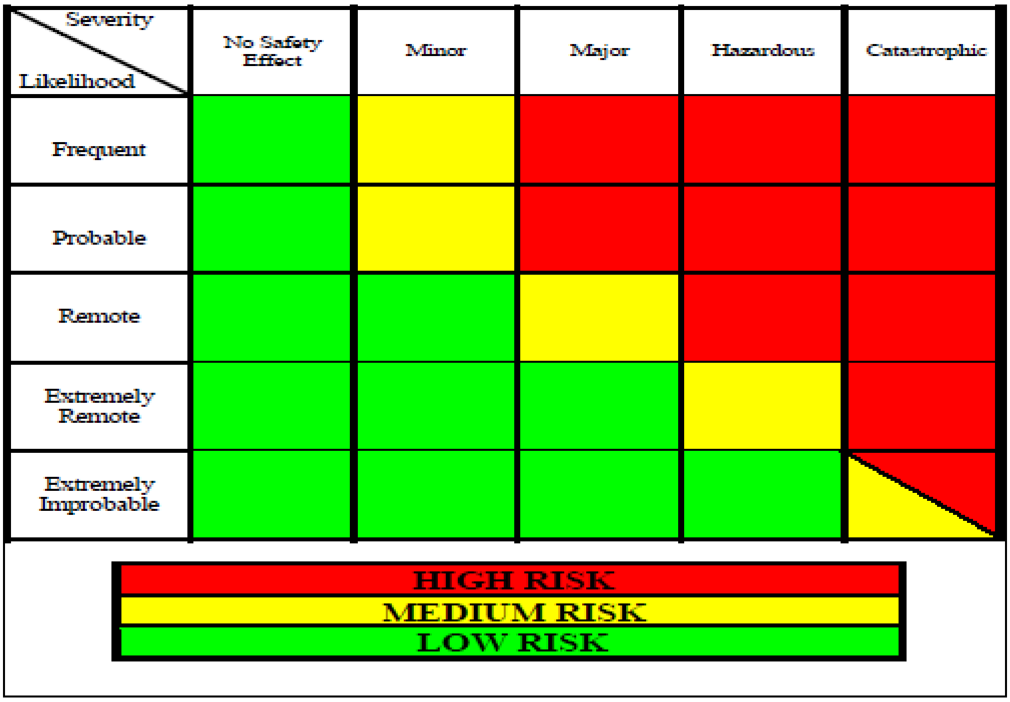
SMS must have a solid foundation in order to be effective since every component has a significant impact on the others. Companies already have internal structures, processes, and procedures; what is needed is for them to be updated and centralized, along with a safety handbook. Yet it will actually be difficult to train and communicate with all staff properly. The performance of SMS in that company is jeopardized if this foundation is not the best it can be. A business must have the best safety handbook, planning, and communication before moving on with the final two pillars of SMS.

Safety Risk Management (SRM)

Safety Risk Management (SRM) is the third component of SMS. The SRM pillar describes operating procedures for all agencies and agency borders, establishes and regularly examines key performance indicators, carefully analyses risk, and applies controls to reduce risk. Understanding operational procedures is central to the risk assessment tenet (Transportation Research Board, 2007). The SRM pillar conducts risk reviews and assessments, examines processes, and defines risks. It also needs risk acceptance, cause interpretation, risk monitoring, and system execution. The basic structures in place at the airport are specified in the SRM pillar and include the following elements:

- Identification of the risks,
- Evaluating and assessing the threats,
- Monitoring of the risk (Federal Aviation Administration, 2007).

The Safety Risk Management Pillar's initial feature is hazard identification. This basis enables us to examine the hazards facing the airport in depth and with a critical eye (Transportation Research Board, 2007). It might be difficult for people to accomplish this without bias at times. If this is discovered, the airport may request an audit from a third party. A risk assessment is the following step once all dangers have been found. To determine what action is required to eliminate or reduce the hazard-related safety risk assessment, both discovered hazards are reported and analyzed in an SMS (Transportation Research Board, 2007). The Risk Assessment Matrix, which can be seen in Figure 2.4, is used to determine the hazard's severity. The probability of recurrence and the seriousness of the effects are included in the risk estimate. For instance, the state of the runway would make it dangerous if an aircraft were to abandon it. If this threat is defined as likely to occur regularly and the severity is severe, it will be Appropriate to minimize the risk.



Risk Management Matrix. (Federal Aviation Administration, 2007)

Risk reduction and monitoring are the last aspects of the third pillar of SRM. After a danger has been discovered and mitigated, it should be thoroughly examined to confirm that the rationale for mitigation was, in fact, the source of the hazard. This step is completed by a system that allows us to neutralize any hazards and maintain a steady operation. SMS isn't only about detecting and mitigating errors; it's also about keeping track of the problem. As a result, once a system is in place, it must be examined on a regular basis to verify that the danger does not return and that risk reduction continues to be successful (Transportation Research Board, 2007).

Safety Assurance

According to the Federal Aviation Administration (FAA), "process management tasks that consistently give trust that organizational products/services meet or exceed safety requirements" (Safety Assurance) are the fourth and final component of Safety Management Systems. Fundamentally, it is the cornerstone that boosts morale and gives the organization assurance that what they are doing actually works to identify, reduce, and keep an eye on threats (Transportation Research Board, 2007).

Once policies, procedures, audits, and controls (the Safety Risk Management pillar) are established, it is necessary to conduct yearly management reviews to ensure that safety goals are being fulfilled. Safety assurance includes the collaboration between safety risk control and safety assurance, as well as knowledge for decision-making, internal evaluations, external audits, internal reviews, regulatory and voluntary system alignment, review and evaluation, and environmental monitoring. Internal audits, external audits, and disciplinary procedures are the three components of safety assurance (Transportation Research Board, 2007).

The first component of the Safety Assurance pillar is internal audits. It is important to keep in mind that external audits, which will be covered later, should be conducted in addition to internal audits (Transportation Research Board, 2007). The airport safety inspector has the ability to conduct both official and informal audits in both departments. These audits, which include both planned and impromptu audits, have to be carried out every day (Transportation

Research Board, 2007). Internal audits provide the airport the opportunity to conduct an audit using its own personnel. This might have both good and bad implications. One of the advantages is familiarity with airport regulations and procedures, which allows the user to quickly recognize potential dangers. A negative effect is that, because it has the potential to get the airport into trouble, or just be used to observe the threat but not recognize it as such, the user may be prejudiced and overlook issues. External audits, the second factor of the Safety Assurance pillar, should then be done.

With the exception of the need that external audits be carried out by an impartial third party, internal audits are similar to external audits (Transportation Research Board, 2007). This provides an objective way for risk assessment, although it typically costs the airport money (Transportation Research Board, 2007). Outside organizations may observe things that the airport was not aware of earlier, therefore airports are hesitant to employ this option.

The third and last component of the Safety Assurance pillar is Corrective Intervention, which is the part that bears the effect. This feature is the pillar's checks and balances. These pillars guarantee that the necessary sanctions are imposed if anyone does not obey the appropriate procedures after an injury or event happens. To make sure that dangers are really addressed, the corrective action component is frequently utilized (Transportation Research Board, 2007).

METHODOLOGY

RESEARCH DESIGN

In this study, a survey research design will be used. According to Gupta and Gupta (2022), this approach involves interviewing a sample of people or giving them a questionnaire to collect information. The primary purpose of the survey research design is to use questionnaires to determine the fundamental characteristics of a large number of people, objects, or things. The design would also be utilized to help the researcher collect information from sample participants in order to calculate population parameters because to its descriptive character. When a researcher wishes to establish specific facts regarding the issue, Siedlecki (2020) advises using a descriptive research approach.

SAMPLING SIZE

Sampling design and sample size are highly important in order to determine the representativeness of the sample for generalizability (Lakens, 2022).

There are presently twenty-one AMO airline operators on the Nigerian Civil Aviation Authority's (NCAA) register. The sample for this study will be selected using a non-probabilistic, subjective method based on operators with a minimum of five aircraft in their fleet. Among the operators are aero contractors Bristow Helicopters (Nigeria) Limited, Peace Air, Arik Air, and Wing Aviation Limited. Based on judgment/purposive selection criteria, a sample size of 201 professionals was selected as respondents

SAMPLING TECHNIQUE

Non-probability design will be used in this analysis and will be used as a particular purpose sample technique.

This survey analysis will be made public, providing each respondent a fair chance to express views and guaranteeing the authenticity of the information collected and the randomization sampling method used to collect information from the sample, which aims to remove any bias elements for a specific segment of the population.

SOURCES OF DATA COLLECTION

The topic of this study makes clear that the necessary data were gathered from primary and secondary sources.

INSTRUMENTS OF DATA COLLECTION AND MEASUREMENT

Questionnaires and interviews will be utilized as the instruments for data collection and measurement.

QUESTIONNAIRE DESIGN AND ADMINISTRATION

The Likert five-point scale will be used to develop the questionnaire. The respondent's scale's structure reveals which of the following statements they believe to be true:

Strongly disagree = I point

Disagree = 2 points

Neutral = 3 points

Agree = 4 points

Strongly agree = 5 points

It will be created and given to professionals. As more people were contacted and more comments were gathered, the main goal of this questionnaire is to guarantee that accurate information will be provided. All 201 questionnaires will be designed and conducted on a stand-alone basis.

DATA ANALYSIS METHOD

The methods to be used are simple percentage, factor analysis, t-test and canonical correlation (Mishra & Alok,2022) The simple percentage approach will help to evaluate the profiles of respondents and other related issues that have addressed study objectives.

Factor Analysis (Principal Component Analysis)
The criticality, ranking, and qualities of the elements to be evaluated are determined using the renowned dimensional reduction method known as exploratory factor analysis (Schreiber,2021).
Principal Component Analysis, or PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set (Schreiber,2021).
So to sum up, the idea of PCA is simple — reduce the number of variables of a data set, while preserving as much information as possible.(https://medium.com)

Identified Factors to be Tested.

ID	Factors
EC	Expertise Constraint
RF	**Regulatory Framework**

FC	Financial Constraints
ICB	**Industry Collaboration and Benchmarking .**
OC	**Organizational Culture**
PA	Poor Awareness
CI	**Complexity of Integration.**
DCA	**Data Collection and Analysis**
CR	**Communication and Reporting**
LSC	**Lack of Senior Management Commitment**
HTP	**High Turnover of Personnel**
HIR	**High Interest Rate**
HOP	High Operating Cost and Multiple Charges
MF	MRO Facilities.
PSR	**Perception of SMS as a Regulatory Burden.**

Existing Measures of Safety Performance in Commercial Aviation Operators

ID	**Measures**
SOCA	Commercial aviation operators in Nigeria sets clear safety objectives and targets that are aligned with the organization's overall safety goals and derived from industry standards and regulatory requirements to create a framework for measuring safety performance.
FSMS	There is a formalized SMS approach to managing safety within the aviation organization which includes processes, policies, and procedures to identify, assess, and mitigate safety risks.
KPI	Commercial aviation operators use Key Performance Indicators (KPIs) to measure specific aspects of safety performance. These KPIs include metrics the number of incidents, accidents, and near-misses, as well as safety-related trends and patterns.
DSE,M	Data related to safety events, maintenance activities, flight operations, and other relevant aspects are collected and analyzed to identify trends, patterns, and potential safety risks.
RPM	There is incident reporting system within maintenance organization of commercial aviation operators in Nigeria, which have a feedback process in place to notify contributors on action taken.
SAIC	There are regular safety audits and inspections conducted to assess compliance with safety regulations, internal policies, and industry best practices to help identify areas for improvement and ensure that safety standards are being met.
SSCA	Commercial aviation operators use surveys and assessments to gauge the safety culture

	among employees and identify opportunities for fostering a positive safety culture.
BSP	There is a monthly benchmarking of the safety performance against industry peers or best-in-class organizations to identify areas where aviation operators can improve and learn from others' best practices
CII	Based on the safety performance data and analysis, commercial aviation operators implement continuous improvement initiatives to enhance safety practices and mitigate potential risks.
STP	Aviation operators in Nigeria ensure that employees receive adequate and relevant safety training where they track the effectiveness of training programs to evaluate their impact on safety performance.

Decision Rule

The measurement will take place at a significance level of 0.05. The data analysis will make use of a computer tool called SPSS version 23, which stands for Social Science Statistical Software. The decision rule would therefore be as follows: if the text's effect (p-value) or meaning is less than 0.05, the null hypothesis will be accepted and the alternative hypothesis disregarded; however, if the result is the opposite, the result is deemed to be relevant.

RESULTS AND DISCUSSION

Results

The field data obtained from the 201 respondents are presented in this section. With the expectation of collecting data with high accuracy, the researcher carefully followed ethics and principles associated with data collection.This section presents statistical analyses of the field data with varying statistical tests conducted to proffer solution to the outlined objectives of the study, and to aid valid inferences.

Reliability Results

Scale: All Variables

Table.A. Case Processing Summary

		N	%
Cases	Valid	20	100.0
	Excluded[a]	0	.0
	Total	20	100.0

a. Listwise deletion based on all variables in the procedure.(https://cdn)

Table B.Reliability Statistics

Cronbach's Alpha	N of Items
.896	2

A test-retest method was adapted in establishing the reliability of the instrument. Twenty (20) copies of the questionnaire were administered online to twenty (20) aviation maintenance experts in Nigeria found in Linkedin. This is not part of the study population but share similar characteristics. After 20 days, the same instrument was re-administered to the same respondents through Google Form. The results of the two tests were analyzed using Alpha Cronbach reliability test. Nunally (2015) affirmed that result of 0.7 and above is reliable; however our result revealed an alpha cronbach value of 0.896 which means that the instrument is reliable by 89.6%.

Existing measures of safety performance in commercial aviation operators

The study set out to obtain the existing measures of safety performance in the various aviation operations. However, as almost is the case with most research, there are just too many variables to work with amongst which some might not be that relevant to the study. Using the dimensionality reduction approach known as Principal Component Analysis (PCA) is one of the finest ways to handle this challenge. By converting a big collection of variables into a smaller one that still includes the majority of the information in the collected large set from the field, this dimension reduction approach was used to reduce the dimensionality of the comparatively large data set (Ray et al., 2021).Building on the already established suggestions of Cao, et al. (2017), the result was evaluated under three parts namely: communality test, explained variation for principal components, and rotated principal component matrix as seen in the following sections. The study used the KMO scores of Excellent (KMO > 0.9), Good (KMO > 0.8), Acceptable (KMO > 0.7), Questionable (KMO > 0.6), and Unacceptable (KMO 0.5). The results in Table 4.1.4a show that the data were suitable for PCA with a KMO value of 0.748 and significance (Sig.) of 0.000. To embed rationality also, the study adopted communalities benchmark of 0.40 and above (Lee Seung, 2017) a shown in table 4.1.4b.

Table C: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.401
Bartlett's Test of Sphericity	Approx. Chi-Square	431.098
	Df	45
	Sig.	.000

Result in Table 4.1.4a is the Bartlett's Test of sphericity applied to ascertain the adequacy of the correlation matrix. A chi-sqr. value of 431.098 and a KMO value of 0.401 with significance of 0.000 were obtained, implying that the matrix has significant correlations among at least some of the variables, hence the data are appropriate for PCA. A communalities threshold of 0.35 and above was adopted (Lee-Seung, 2017) for rationality.

Table D.Communalities of existing measures of safety performance in commercial aviation operators

	Initial	Extraction
EMSM16	1.000	.700
EMSM17	1.000	.770
EMSM18	1.000	.852
EMSM19	1.000	.839
EMSM20	1.000	.418
EMSM21	1.000	.749
EMSM22	1.000	.647
EMSM23	1.000	.739
EMSM24	1.000	.881
EMSM25	1.000	.928

Extraction Method: Principal Component Analysis.

The extracted values for the ten variables are shown in Table 4.1.4b as a consequence. The scree plot (Figure 4.7) and subsequent PCA are used to identify the variables' hidden significant representatives. The first five variables in Table 4.1.4c were kept for rotation by maintaining only those with eigen values of 1 or above. These 5 factors were found to account for the 20.27%, 16.61%, 13.61%, 12.68% and 11.84% of the total variance, respectively. The remaining 5 factors together account for 24.77% of the variance. However, communalities of the existing measures of safety performance in commercial aviation operators in the industry garnered a total of 75.23%, which comprises: EMS17, EMS18, EMS19, EMS22, and EMS24.

Table E: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.090	20.899	20.899	2.090	20.899	20.899	2.027	20.272	20.272
2	1.787	17.870	38.768	1.787	17.870	38.768	1.662	16.615	36.887
3	1.445	14.453	53.222	1.445	14.453	53.222	1.381	13.812	50.699

4	1.149	11.489	64.711	1.149	11.489	64.711	1.269	12.686	63.385
5	1.052	10.518	75.229	1.052	10.518	75.229	1.184	11.844	75.229

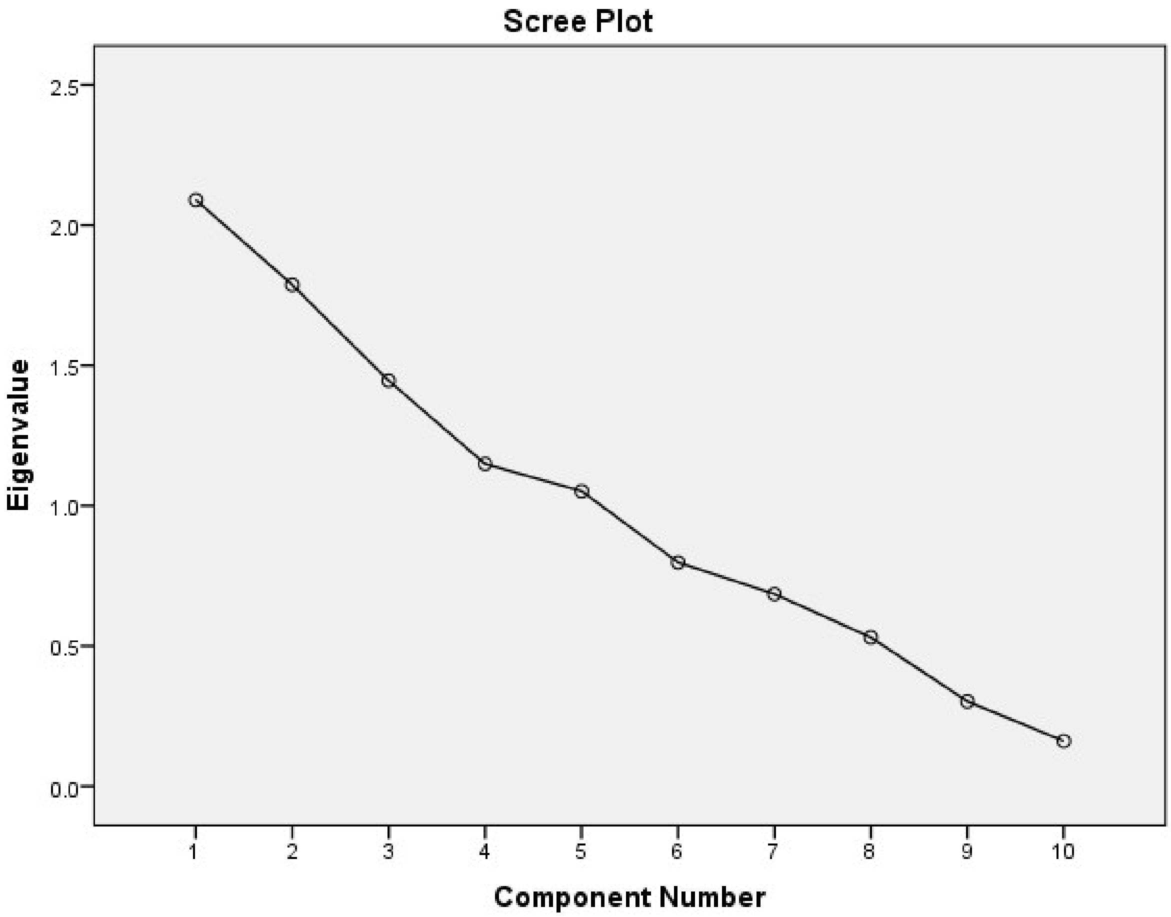


Figure : scree plot of existing measures of safety performance

TableF: Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
There is a formalized SMS approach to managing safety within the aviation	.862				
Data related to safety events, maintenance activities are collected and analyzed		.861			
Commercial aviation operators use Key Performance Indicators (KPIs) to measure specific aspects of safety performance.			.888		
Commercial aviation operators use surveys and assessments to gauge the safety culture				.706	
Commercial aviation operators implement continuous improvement initiatives to enhance safety practices based on safety performance data analysis.					.929

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Table 4.1.4d is the factor rotation result which shows the suppressed loadings less than 0.35 to arrive at the principal factors for existing measures of safety performance in commercial aviation operators. The study used Varimax rotation because the factors are believed to be related. 5 factors are therefore loaded unto rotated component matrix (Table 4.1.4d). The result shows most significant loading in factor one has a score 0.862, which relates to the existence of is a formalized SMS approach to managing safety within the aviation organization which includes processes, policies, and procedures to identify, assess, and mitigate safety risks. Under the second factor, the most significant loading has the value 0.861 (the identification of trends, patterns, potential safety risks are based on the collected and analyzed data relating to safety events, maintenance activities, flight operations, and other relevant aspects). The use of Key Performance Indicators (KPIs)which includesthe number of incidents, accidents, and near-misses, as well as safety-related trends and patterns by commercial aviation operators to measure specific aspects of safety performance, was noted to have a significant loading of 0.888. For factor three, the use of surveys and assessments by commercial aviation operators, to gauge the safety culture among employees and identify opportunities for fostering a positive safety culture, was the most significant loading of score 0.706, and lastly, Factor four has a significant loading of 0.929 which concerns the implementation of continuous improvement initiatives by commercial aviation operators to enhance safety practices and to mitigate potential risks, based on safety performance data analysis.

- **Safety Incident Analysis**
- **Safety Checklists Management:** Admins use this screen to create, assign, and monitor safety checklists, ensuring that safety checks are performed and reported effectively.
- **Safety Policy Management:** This screen allows admins to upload, manage, and track safety policies and staff/passengers' acknowledgments, ensuring that all they are aware of and compliant with safety procedures.
- **Safety Reports and Analytics**
- **Safety Training Management:** Admins can schedule, track, and manage safety training programs through this screen, ensuring staff members complete required training modules.
- **Safety Regulation Compliance**
- **User Management/User Roles and Permissions:**
  Admins create and manage user accounts, including staff and passenger accounts. They can assign roles and permissions to staff members and ensure that passengers have access to essential safety information.
- **Audit Logs and Security:** Admins can monitor user activities and system security. Any suspicious or unauthorized activities are recorded in audit logs, allowing admins to take appropriate action.
- **Aircraft Information Management:** Admins can track aircraft maintenance schedules, schedule maintenance tasks, and ensure that maintenance activities are completed according to regulatory requirements.
- **Data Backup and Recovery:** Admins can configure automated data backup settings to protect critical safety data. In case of data loss, they can initiate data recovery procedures to ensure data integrity and availability.

Results Discussion

This section presents a comprehensive and detailed discussion of the results in the previous section.

Existing measures of safety performance in commercial aviation operators

Findings of safety performance indicators in the Nigerian aviation sector indicated the existence of a structured SMS strategy to managing safety within the sector. It consists of methods, rules, and processes for identifying, evaluating, and mitigating safety hazards that are crucial to the efficient operation and success of commercial aviation enterprises. In fact, it cannot be over emphasized that the implementation of a formalized SMS as a systemic approach within an aviation organization is crucial to ensure the safety of operations, compliance with regulations, and a continuous improvement of safety performance. This result is consistent with Amber (2012) observation that safety management systems (SMS) are an effective, codified method of risk management and safety improvement.

The identification of trends, patterns, potential safety risks are based on the collected and analyzed data relating to safety events, maintenance activities, flight operations, and other relevant aspects. Apparently, incorporating data-driven analysis into the SMS allows aviation organizations to move from a reactive to a proactive approach in safety management (Seah et al., 2021). By identifying potential risks and taking timely corrective actions, the industry aims to prevent accidents and incidents, protect personnel, and enhance overall aviation safety.

Another finding indicates the use of Key Performance Indicators (KPIs)which includes the number of incidents, accidents, and near-misses, as well as safety-related trends and patterns by commercial aviation operators to measure specific aspects of safety performance. The identified KPIs are known to provide quantifiable metrics that help aviation organizations assess their safety practices, identify areas for improvement, and track progress over time (De Vecchi, 2021). The use of key performance indicators (KPIs) in the Nigerian aviation sector aligns with worldwide safety standards and supports the Safety Management System (SMS) framework. These indicators support the development of a safety-conscious culture, the identification of possible safety hazards, and ultimately the improvement of aviation safety throughout the nation.

The use of surveys and evaluations by commercial aviation operators to analyze employee safety cultures and find ways to promote a healthy safety culture.

Findings revealed that by forging a culture of continuous improvement, commercial aviation operators in Nigeria can create an environment that fosters safety, efficiency, innovation, and collaboration. This culture becomes a cornerstone of the organization's identity and contributes to its sustainable growth and success. It can further enhance safety practices, mitigate risks, and contribute to the overall safety and success of the aviation industry in the country.

CONCLUSION AND RECOMMENDATIONS

CONCLUSIONS

Since the surge of SMSsasa regulatory necessity foraircraft safety management, the aviation industry has staggered over new ways of identifying the safety management practices and compliance with the regulations, especially that stipulated in the ICAO framework (Malakis et al., 2021). The current study identified the inhibiting factors that limits the adoption of SMS and proffers solutions to the challenges associated with SMS implementation in the Nigeria aviation industry. Below are the conclusions derived from the findings in the study:

1. The implementation of a formalized SMS as a systemic approach within an aviation organization is one of the existing measures of safety performance in commercial aviation operators to ensure the safety of operations, compliance with regulations, and a continuous improvement of safety performance.
2. Safety management consultancy, alongside training and awareness programs, investment in modern data collection and analysis, and comprehensive regulatory framework are country-based solutions to curb the challenges associated with the adoption of SMS in aviation industry.

RECOMMENDATIONS FOR PRACTICE

The outlined conclusions clearly spur the following recommendations for the aviation stakeholders, regulatory authorities and organizations at large.

Aviation organizations should actively seek out opportunities for collaboration and benchmarking, since participating in industry forums, conferences, working groups, and safety-sharing initiatives can provide platforms for knowledge exchange. Organizations can also establish partnerships with other airlines or stakeholders to facilitate the sharing of information and experiences related to SMS implementation.

Regulatory authorities and industry associations can play a role by fostering a culture of collaboration and providing platforms for knowledge dissemination. Overall, a collaborative approach enhances the effectiveness of SMS adoption and contributes to safer aviation operations across the industry.

Organizations need a well-structured implementation plan that considers the specific needs and context of their operations. Key strategies include effective change management, comprehensive training programs, clear communication of the benefits of SMS, and gradual implementation to minimize disruptions. Additionally, involving employees in the design and decision-making process can foster ownership and enthusiasm for the new SMS.

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