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Research Article

Assessment of Safety Management System Implementation in an Approved Maintenance Organization: A Case Study of Nigeria Operators

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Abstract: In this study survey data was used to assess employees' perceptions of Safety Management System (SMS) implementation in an Approved Maintenance Organization (AMO) in the aviation industry. AMOs in Nigeria were used as a case study. Results show that over 80% of the population used for this study accord to the existence of plans to implement SMS. However, results indicated a lack of safety management education, training and motivation, which are key concepts that influence all the safety management implementation process. Furthermore, results reveal the lack of skills to analyze risk associated with identified hazard. Internal audit and safety investigation are the main means of safety performance monitoring within the AMO. Hypothetical test was conducted using Chi-square statistic. The results show that there is no significant relationship between the appointment of key personnel and management commitment within an AMO safety management system. Overall, the findings suggest that AMO need to do more to improve the implementation and understanding of SMS within the AMO.

Keywords: Approved maintenance organization, aviation, implementation, Nigeria, safety management system

INTRODUCTION

According to Roelen and Klompstra (2012), aviation safety management is becoming a regulatory requirement rather than an industry best practice. This is based on the perception that there will always be threats to safety. A vital component of ensuring safety is about identifying and managing threats before incidents or accidents occur. Gill and Shergill (2004) stated that the effectiveness of a Safety Management System (SMS) depends on how well it penetrates through the organization.

Regulatory authorities are also taking a keen interest in the role played by SMS in ensuring safety. For example Civil Aviation Authority, United Kingdom (2002), recognizes the value of SMS as the systematic management of the risks associated with flight operations, aircraft maintenance activities and related ground operations to achieve high level of safety performance. Similarly, Civil Aviation Authorities of many nations (New Zealand, Nigeria, China etc.) are taking steps to enhance safety in the industry, as a result of past accidents and incident related issues see Gill and Shergill (2004).

Understanding the benefits and implementation of SMS within an Approved Maintenance Organisation (AMO) in any nation would certainly be to the advantage of airline operators in those nations and the aviation industry all over the world. According to ICAO (2009b) and ICAO (2010a), the organizational roles and responsibilities, which provides the framework for effective implementation of SMS as set in the ICAO framework may not be adequately understood. The process of harmonization of existing maintenance legislative framework in the context of safety management system must be considered due to the existing culture, practice and operational style. Uhuegho (2010) noted that the general picture is one of reliance on the flexibility of quality management system and that of adaptability of the maintenance operation to cope with the deficiencies that exist in the new demand emerging from the SMS. There is the need for a systematic assessment of SMS implementation and it interfaces with existing maintenance and quality management practices.

This study reports the findings of an industry wide study carried out to assess on a broad view, the level of SMS implementation within an AMO. It does not provide a detailed description of activities pertaining to

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technical aspect of safety, but presents an overview of areas that needs to be considered in order to assess the level of SMS implementation within an Approved Maintenance Organization in any nation.

SAFETY MANAGEMENT SYSTEMS IN AVIATION

Safety management is defined by ICAO as a management process, with responsibility at two levels: the state level and the level of the individual service providers. States are responsible to establish a safety program, which is an integrated set of regulations and activities aimed at enhancing safety. According to ICAO (2009b), ICAO (2010a) and ICAO (2010b) it is noted that as part of such program, individual service providers such as aircraft operators, AMOs, airport operators and air traffic providers are required to implement SMS see acceptable to the state that as a minimum satisfy the followings:

- Identifies safety hazards
- Ensures the implementation of action necessary to maintain agreed safety performance
- Aims at a continuous improvement of the overall performance of the SMS
- Provides for continuous monitoring and regular assessment of the safety performance

A framework for representing the minimum requirement for the implementation and maintenance of SMS by an organization is provided by ICAO (2009b), which includes the four major components and twelve elements shown in Fig. 1. These four major components of an SMS are generally accepted as a means of compliance to satisfy SMS requirements see European Commission (2011a), FAA AC (2010) and Lu *et al*. (2007).

SMS for Maintenance Repair Organization (MRO) although new; is now required for all airline operators to plan towards its implementation in their AMOs from 1st January, 2009, as required by the Nigerian Civil Aviation Authority (2009). Within the context of AMO, an airline management needs to understand the complexities associated with its aircraft maintenance operational environment, develop a safety programme, as well as implement and monitor systems within the maintenance outfit that will ensure compliance with safety standards. Hence, the objective of this study is to assess the implementation of SMS within the AMO in Nigeria, which on a broad view provides guidance on SMS implementation assessment within AMO all over the world.

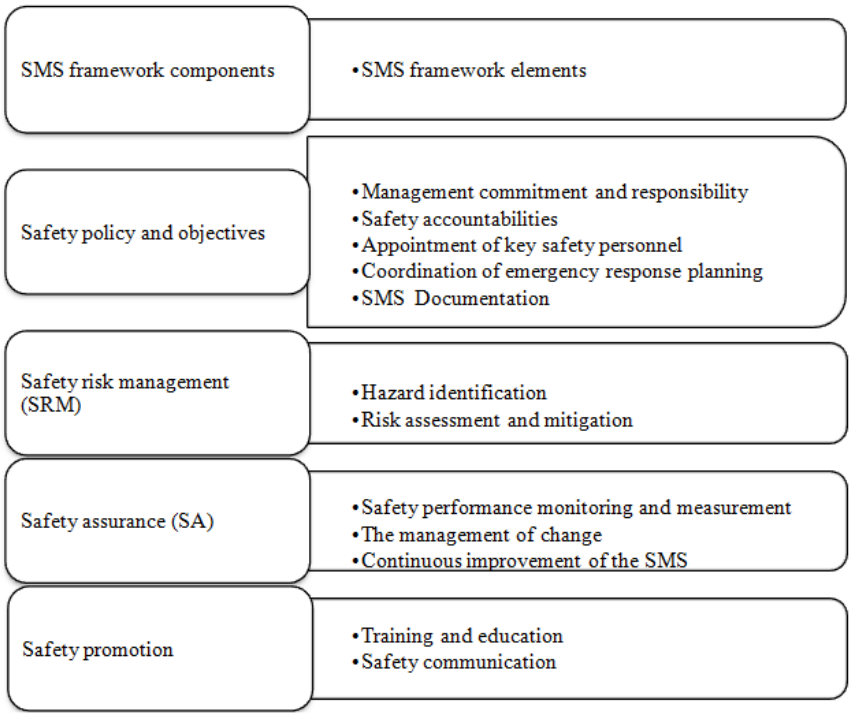

Fig. 1: ICAO SMS framework components and elements

RESEARCH METHODOLOGY

The questionnaire was the major instrument for data collection. The data were collected with a view of establishing the implementation level of SMS within the MRO in the Nigerian airline operators.

Sample selection: Nigerian Civil Aviation Authority (NCAA) currently has twenty-one airlines operators with AMO on its list. The sample for this study was chosen using a non probabilistic but judgmental decision based on operators with not less than five aircraft in their fleet. These operators include Aero-contractors, Bristow Helicopters (Nig.) Limited, Associated Aviation Limited, Arik Air Limited, PAN African Airlines Nigeria Limited, Virgin Nigeria and Wing Aviation Limited.

Sample population: The Population (P) of interest in this study was the AMO of airline operators in Nigeria, operating domestic and international flight on the register of the Nigerian Civil Aviation Authority (NCAA). The same set of questionnaires was administered to each of the seven airlines selected. Out of 267 questionnaires distributed, 179 questionnaires were returned representing 67% response which is considered satisfactory for statistical application in a sample population. The hence $P = 179$ was used in the study.

Data collection: Questionnaires were the primary data collection instrument. To establish the level of implementation of the SMS within the MRO a questionnaire (Table 1) was designed to ascertain the following information:

- Establish if there is an awareness of the existence of safety management in place.
- Establish if the main components of safety management system as stated in the ICAO frame work exist within the MRO.
- Establish if the airlines have safety information reporting and management system, how they are

Table 1: Safety management system questionnaires

S/N	Questions
Q1	What is your designation? senior management, middle management, supervisor, maintenance staff
Q2	What is your role within the maintenance unit?
Q3	Are you aware of safety management system regulation in aviation industry?
Q4	If yes, has SMS been implemented in your organization?
Q5	If no to Q4, is there a plan to implement it?
Q6	Is your SMS structured with all the defined components of the ICAO frame work?
Q7	Do you have a written safety policy with reference to maintenance activity in place?
Q8	If yes to Q7, how is it publicized and communicated within the organization?
Q9	Do you have a designated focal person in charge of your SMS in the maintenance department to manage and oversee the day to day operation of SMS?
Q10	Has the person had formal training in SMS?
Q11	As a member of the maintenance team, do you have safety authorities, responsibilities and accountabilities?
Q12	Do you have an SMS implementation plan in your organization?
Q13	Do you have an emergency response plan in place in your organization?
Q14	Are you always informed of any development that affects safety?
Q15	Are all your safety management information documented (i.e., procedures and performance requirements)?
Q16	Is your SMS incorporated into the approved organisational document such as the AOC or AMO approval?
Q17	Do you have a records system that ensures generation and retention of maintenance record support operational requirements?
Q18	Do you have a formal safety data collection and processing system?
Q19	If yes, what date collection and processing method do you have. Mention actual type.
Q20	What tools for safety management are in use in your organization?
Q21	Are you actively involved in data collection and processing in your organization?
Q22	If yes to Q21, what type of training have you undertaken?
Q23	Do you have the knowledge to analysis any form of safety data?
Q24	If yes, have you had training in data analysis?
Q25	Do you have an incident reporting system within your maintenance organization?
Q26	If yes, does it have a feedback process in place to notify contributors on action taken?
Q27	Do you have a system for analysis of the risk associated with identified hazards?
Q28	If yes to Q27, are risks expressed in terms of probability and severity?
Q29	How are corrective actions decided in response to event analysis?
Q30	How do your monitor safety performance within your maintenance organization?
Q31	Do you have a process in place for the generation of corrective and preventive action in response to hazard identified?
Q32	If yes, are you required to conduct an internal investigation?
Q33	If yes to Q32, what is the purpose of internal investigation?
Q34	Do you have a procedure for reporting audit results and maintaining records?
Q35	Do you have a procedure to record and report verification of action (s) taken?
Q36	Do you have a process in place for managing change?
Q37	Does the process of management of change analyze changes to risk?
Q38	Do you have in place a mechanism to ensure continuous improvement of the SMS in your organization?
Q39	If you don't have safety management system in your maintenance organization, would you please explain why it is so?

communicated and how safety information is shared within the organization.

- Establish if the non punitive policy was in place on reporting safety issues.

Data analysis technique: The data were analysed using charts and Chi-square statistical distribution. This method was used to ensure adequate and comprehensive data presentation. In applying this method, the responses to the questions in table 1 were collected according to the option given ('Yes', 'No' and 'Don't know'). The data collected were presented using tables, bar charts and pie charts. Hypothetical test was conducted using chi-square statistical techniques at five percent confidence level for Q9 and Q11 (Table 1). If the computed value of the chi-square is found to be higher than the critical table value, then, it will lead to the rejection of the null hypothesis; otherwise, it will not be rejected.

DATA PRESENTATION AND ANALYSIS

Determination and analysis of SMS implementation: The relevant data obtained through the questionnaires were accordingly presented and analysed in this section. Simple charts were used to ensure adequate and comprehensible data presentation as shown in Fig. 1 through Fig. 2.

From Fig. 3 and 4, 61.5% of the respondents are maintenance staff and approximately 65% are engineers. This shows that the questionnaires were given to those actively involved in maintenance activity

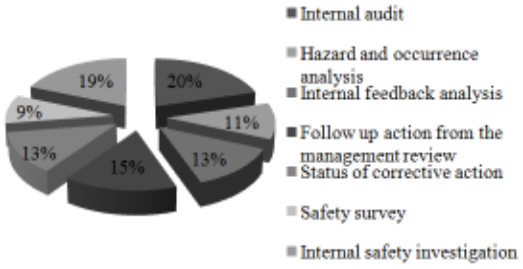

Fig. 2: Responses on the monitoring of safety performance (Q 30)

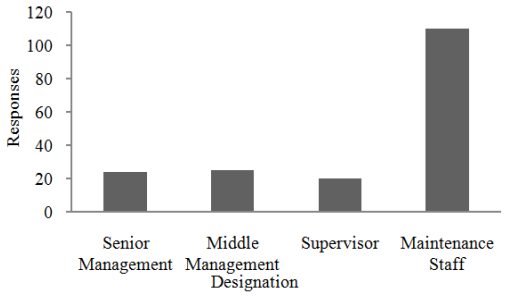

Fig. 3: Designation of the staff used in the study

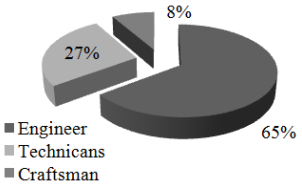

Fig. 4: Professional roles of research respondents

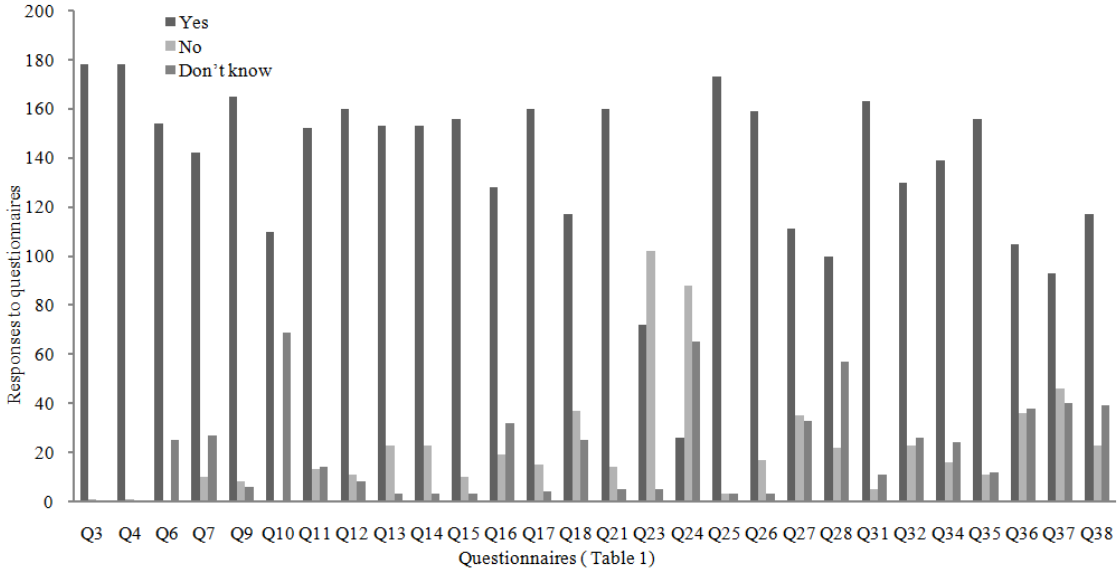

Fig. 5: Responses to questionnaires against study questionnaires

in an AMO and have initiative for SMS implementation.

Figure 5 shows that, 99% of the respondents have heard of SMS in the aviation industry and the same percentage acknowledged that it has been implemented within their organization. Eighty six percent of the respondents agreed to the fact that the SMS within their organization is defined according to the components of the ICAO frame work. However, 14% are unaware if SMS implementation within their organization is in accordance with ICAO frame work. It was observed that 33% of the questionnaires were unreturned and some percentage had questions unanswered, which indicates that there is a lack of in depth awareness of the SMS within the MRO.

About 79% of the respondents indicated that their organization has a written safety policy with reference to maintenance activities in place. Approximately 6% indicated that there is no written safety policy with reference to maintenance activities in place, which means that the authority has not formally enforced the implementation nor have they provided a guidance material for the implementation of SMS within the AMO.

Fifteen percent of the respondents do not know about it which shows the level of unawareness of the implementation within the AMO. Ninety two percent of the respondents indicated that their organization have a designated focal person in-charge of their SMS in the maintenance department. This implies that the management of the airlines are devoted to ensuring that SMS is implemented within its AMO since there is a person in-charge to plan, monitor and ensure that safety activities are coordinated. The person in-charge of the SMS in the maintenance unit should have the required training that will drive the implementation and success of the SMS. Sixty one percent of the respondents agreed that the focal person has the formal training required for the job function while 39% do not know. It can therefore be concluded that safety activities within AMO may not be adequately communicated.

An approximate 14% of the respondents do not agree that they have safety authorities, responsibility and accountability with an SMS environment, which is an indication of the low awareness of what role they have to play in the maintenance unit. In order to determine the SMS pro-activeness of all organizations used in this work, question 12 (Q12) tries to verify the SMS implementation plan. Eighty nine percent of the respondent accord, that within the Nigerian airline operators there is plan in place to implement the SMS within its maintenance organization and lack of which would have been an indication of lack of commitment to safety management. The purpose of the statements presented in Q13 Q14 and Q15 was to determine the existence of three components of SMS according to the ICAO frame work. That is, emergency response plan, communication of safety issues and documentation of safety information. About 85% of the respondents indicated that these components does exist, which indicates that SMS is in place within the AMO.

The incorporation of SMS into the AMO document was the bases of Q16, in order to ascertain if the organization's employees are aware of the regulatory requirement of SMS and to know if the SMS is actually functional. Over 28% of the respondents were not sure of whether it is incorporated by their organization. The inclusion of it will ensure effective oversight from the state and this will enhance effective implementation, thus, improve safety.

Q17, Q18 and Q21 were to determine the existence of a safety information gathering tool. Well crafted SMS requires that data collection system should be in place to help the proactive safety nature of SMS which is used to initiate process improvement. Eighty nine percent of respondents confirmed the existence of a record system that ensures retention of the maintenance records while 65% of respondents acknowledge the existence of a formal data collecting and processing system. This is required as a major component of the ICAO frame work and ensures continuous improvement of the SMS. Eighty nine percent of respondents show that the understanding of data collection which is the responsibility of all within the work unit is lacking.

The difficulty of respondents encountered in mentioning specific data collection and processing methods in use or their inability to mention any tool of safety management show a lack of safety management education, training and motivation which are key concepts that influence all the safety management implementation process. Q23 and Q24 were aimed at verifying if the organization has the capability to analysis safety data. Fifty six percent of the observed group responded with a "No" while 44% responded positively. This indicates the treatment of data collected the level of report that can be derived from such data and its impact on safety will not be significant.

From Q24, over 96% of the respondents were of the opinion that an incident reporting system within their maintenance organization existed, which is mainly aimed at gathering information on mandatory occurrences reports for the CAA. It is not an integral part of the safety management system, which may be an indication that a safety culture is yet to take root within

the AMO. Q25 sought to establish the awareness of the existence of a feedback process on actions taken on identified hazard, which is aimed assisting management in its pursue for continuous improvement in safety. Over 88% of the respondent acknowledged the awareness of this mechanism and about 10% are not actually aware of this, which shows that some of the concepts of SMS are not clear to the workforce of the AMO.

Q 27 and Q 28 sought to assess if the staff within the maintenance unit is aware of a mechanism used to analyse risk associated with identified hazard and determine the measure of which the identified risks are expressed since assessing and mitigating the risk associated with hazard will ensure safer operations and a proactive safety management system. About 62% of the respondents were of the opinion that a system of risk analysis and identified hazard exist and over 55% of the respondent expressed their opinion on the measure of risk in terms of probability and severity which is in accordance with ICAO doc. 8956. About 32% are not sure of the way the risk is expressed. These shows that there is still a lot of awareness/training that needs to be carried out within the maintenance unit to expose the workforce to what SMS hazard identification and analysis entails.

The responses on safety performance monitoring (Q30) within a maintenance organization shown in Fig. 2 were used to determine the available methods used to monitor safety performance within the maintenance organization within the Nigerian Airline Operators. Figure 2 showed that about 20% of the respondents chose the use of internal audit followed by 19% that suggested the use of internal safety investigation and 15% choose follow up action from management review.

Q31 was used to access the way in which hazards identified are treated. Ninety one percent of respondents indicated that identified hazards are treated through a process that is documented in a standard operating procedure which is an indication that within the Nigerian airline operators AMO, there is proper hazard identification process that is documented and carried out according to approved procedures.

Q32 and Q33, seek to assess the purpose of internal safety investigation within the maintenance organization (Fig. 6). 78% of respondents agreed that the purpose of safety investigation is to determine safety lessons, while about 9% certifying that it is for both punishment and lesson learnt. This is an indication that the non punitive policy required within SMS culture is not really understood by all and if it is implemented, it will encourage a lot of reporting and data gathering that will be used for safety improvement.

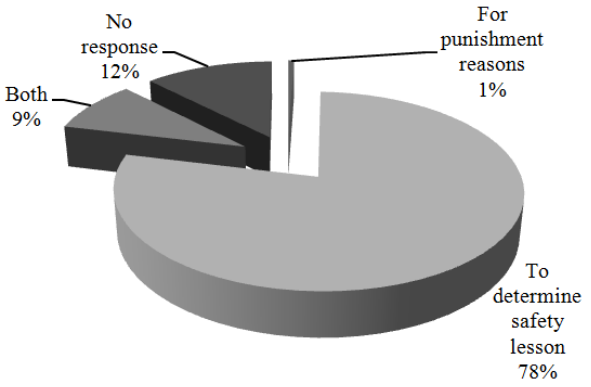

Fig. 6: Responses to the purpose of internal investigation (Q33)

From Q34, the questionnaire sought to know whether the organizations within their maintenance unit carryout safety audits. Seventy seven percent indicated that safety audits are carried out, such audit records are maintained and they are used for safety improvement. From Q35, 87% of the respondents indicated that procedures are in place for verification of action (s) taken after a safety audit has been conducted. This indicates that there is a form of continued evaluation of the safety management process within the MRO. The purpose of Q36 was to determine the existence of another component of the SMS according to the ICAO framework that stipulates that a change management mechanism should be incorporated in the SMS for an approved maintenance organization. About 58% of respondents ascertain to this fact which is an indication of SMS implementation within the AMO in accordance to the ICAO frame work. Q37 aimed at ascertaining how management of change is carried out. Since a safety change management process is one that takes into consideration risk levels that are involved in changes in work areas to ensure that management reviews tasked are assured of successful action. About 51% of respondents are in agreement that risk considerations are there while about 24% did not know. 25% indicated that risk levels are not considered. Q38 determines if the implementation of SMS with the AMO of the Nigerian Airline Operators have the mechanism of continuous improvement which is an important aspect of safety management system. About 65% of the respondents responded to its existence while 21% did not respond and 14% indicated that it does not exist. This leaves a lot to be desired in terms of the effectiveness of the SMS if the continuous improvement mechanism is not properly positioned.

Table 2: Shows responses to question 9 (Q9 Table 1)

Response	Frequency	(%)
Yes	165	92.18
No	8	4.47
Do not know	6	3.36
Total	179	100

Table 3: Shows responses to question 11 (Q11 Table 1)

Response	Frequency	(%)
Yes	152	84.92
No	13	7.26
No response	14	7.82
Total	179	100

Hypothetical test: The null hypothesis represented by Eq. (1), states that 'there is no significant relationship between the appointment of key personnel and management commitment and responsibility within an AMO's safety management system':

$$H_o: W = W_o \tag{1}$$

where, W and W_o represents the chi-square statistic and the hypothesized value of the chi-square statistic respectively. Equation (2) defines W:

$$W = \chi^2 = \sum_{i=1}^{n} {(o_i - e_i)^2}/{e_i} \tag{2}$$

where,

n : The number of interval i $(i = 1, 2, \dots, n)$

o_i & e_i : The observed and expected frequency for each interval i

The test was conducted as follows:

Step 1: Select a hypothesized distribution for the given sample. Table 2 and 3 depicts the sample space used.

Step 2: Select a specified significant level α. α = 0.05 was used in this study.

Step 3: The rejection region was set as $R \geq \chi^2_{1-\alpha}(n - m - 1)$, where $\chi^2_{1-\alpha}(n - m - 1)$ is the (1 - α) 100 percentile of the chi-square distribution with $n - m - 1$ degrees of freedom. M is the number of parameters estimated from the sample. If the parameter of the distribution were estimated without using the given sample, then $m = 0$. $m = 3$ and $n = 6$ was used.

Step 4: The chi-square statistic W was calculated using Eq. (2).

Step 5: The null hypothesis is rejected if $W > R$; otherwise it is not rejected.

Table 4: Observed frequency table

		Columns (c)		
	Response	Designation of focal person	Safety authority responsibility	Sum of rows
Rows (r)	Yes	165	152	317
	No	8	13	21
	Don't know	6	14	20
	Sum of columns	179	179	358

Table 5: Chi-square distribution test table ($n = 6$)

o_i	e_i	$(o_i - e_i)^2$	$(o_i - e_i)^2 / e_i$
165	158.5	42.25	0.2666
8	10.5	6.25	0.5960
6	10.0	16.00	1.6000
152	158.5	42.25	0.2666
13	10.5	6.25	0.5950
14	10.0	16.00	1.6000
W			4.9232

The study observed frequency values are shown in Table 4. The expected frequency values were computed using Eq. (3):

$$e_{jl} = \left({\sum_{l=1}^{c} o_{jl}}\Big/{\sum_{j=1}^{r}\sum_{l=1}^{c} o_{jl}} \right).P \tag{3}$$

where, o_{jl} and e_{jl} are the observed and expected frequency values in row j and column$l$ of Table 4. From Table 4 the number of rows (r) and columns (c) are 3 and 2, respectively. Setting $jl = i$, then $o_{jl} = o_i$ and $e_{jl} = e_i$. The perception, that the appointment of key personnel to take care of SMS can be associated with management commitment and responsibility of the SMS implementation within the AMO is evaluated.

The value $R = \chi^2_{.95}(2)$ from the standard chi-square distribution table is 5.9915 while the calculated chi-square statistic value W is 4.9232 as shown in Table 5. Since $W < R$, the null hypothesis which states that 'there is no significant relationship between the appointment of key personnel and management commitment and responsibility within an AMO safety management system' is not rejected. Hence it can be concluded that the appointment of key person does not imply that the SMS is being implemented by the Nigerian airline operators in accordance to the approved frame work within the Approved Maintenance Organization and it also does not indicate management commitment to SMS implementation.

DISCUSSION

It was observed in the course of this study that Airline Operators in Nigeria needs to understand and believe in the benefits of the implementation of SMS

within the AMO to the overall operation of airlines and the aviation industry all over the world. From the results, the organizational roles and responsibilities, which provide the framework for effective implementation of an SMS as set in the ICAO framework, are not properly understood.

There is the claim of the existence of data bank but problems of hazard identification appropriate to AMO were observed in the reporting system available. These could not be grouped as contributory factors to safety within the MRO. In the MRO, most common contributory factors to aircraft damage or accident can be failure to follow standard operating procedures, failure to follow safety regulatory procedures, lack of appropriate procedures, defects, equipment damage, use of inappropriate tools/equipment, faulty design, or deficiencies as a result of maintenance work and inspection carried out. The Civil Aviation Authority United Kingdom (2008), listed eight maintenance problems which are frequently occurring. They are incorrect installation of components, the fitting of wrong parts, electrical wiring discrepancies, loose object or tool left in aircraft after maintenance work, inadequate lubrication, cowlings access panels and fairings not secured, fuel/oil cap and refuel panels not secured and landing gear ground lock pins not removed before departure.

These items can form the basis for categories of incident/occurrence data that can help to put up a good hazard identification which can be used to improve the overall safety within the MRO. Since accident within the MRO are relatively infrequent, the understanding of these factors and organizational factors can enable the AMO to learn from its occurrence and incidences by a system of reporting, investigation and analysis, then feeding this information back into the organization. The regulatory body and the airline operators should make a move towards the development of effective data collection, detailed safety investigation and build a comprehensive analysis of the consequences of incidence/occurrences which presently poses problems for many of the AMO. A systematic safety management strategy will require a range of right information collected, which will enable appropriate countermeasure to be formulated in order to maintain the required level of safety.

CONCLUSION

The study shows that airline operators in Nigeria lack a coordinated approach to safety implementation. Lack of country wide data base for maintenance activities is a major challenge to the implementation of the SMS in Nigeria. Furthermore, it is revealed that most of the individuals within AMO are highly skilled professionals, but lack safety management system training. This is thus, seen as a challenge in a system which requires a good understanding of safety management principles.

This study also revealed that airline operators in Nigeria within their AMO are aware of the safety management system, but the demand of safety management system which is proactive and systematic is beyond just nomination of a Safety Manager (SM) or appointing a focal person to be in-charge of safety issues as shown by statistical analysis (Chi-square statistic) conducted in this study. It requires the development of a safety culture or an operational environment that is proactive in terms of data collection, hazard identification and risk elimination, mitigation, reduction and management of threats to safety within the AMO which can be enhanced by the provision of guidance material by the state CAA.

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