

IMPACT OF HUMAN FACTORS ON AIRLINE OVERALL MAINTENANCE EFFECTIVENESS: AN ANALYSIS OF MAJOR AIRCRAFT OPERATORS IN SRI LANKA

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Abstract - Skill based error and mistakes form a significant part of the effect of aviation human factors as far as maintenance is concerned. Many air and ground incidents have been traced back to have occurred due to lapses that occurred during handling and maintenance of aircraft, which resulted in such human errors. Proper identification of the possibility of such mistakes and errors to occur in a given maintenance environment and finding steps to mitigate the same is crucial in order to increase the effectiveness of the airline's maintenance programme. This research focused on the maintenance environments of two of Sri Lanka's leading aircraft operators. For diversity, a civil and military maintenance organization was selected. Information was gathered by means of structured questionnaire and existing records of aircraft related incidents and occurrences. Quantitative and qualitative analysis of data was conducted. Quantitative analysis was done using SPSS software and comparisons were made between different indicators such workplace design, fatigue, routine violations etc.

It was found that mistakes amount to a higher percentage of errors caused, whilst skill-based errors have a significant contribution as well. Identification of the probable causes and prevailing condition of human factor contributions to maintenance effectiveness will provide insight to the respective organization to find better solutions to overcome existing shortcomings.

Keywords - Human factors, Mistakes, Maintenance effectiveness, Skill Based errors.

I. INTRODUCTION

Smooth functioning of an airline requires arranged contribution from every level starting from pilots to maintenance crews. In order to ensure effective maintenance, manageability and accountability every level is designated with specified task and held responsible for their own deliverables. This research emphasizes on reducing the effects of aviation human factors to enhance airline overall maintenance effectiveness.

Human factors is simply human performance in the working environment. The role of 'Human Factors' include Information about human abilities, human's limitations, flaws along with other characteristics of human and applying it to machines, systems, tasks, equipment, jobs, tools as well as the working environments to produce and also to ensure harmless, comfortable, and effective use of human in aviation.(Graeber, 2017).

The role of human factors in aviation safety cannot be underestimated. One small error caused by poor procedures, maintenance technicians, pilot, air traffic controller or else line manager can result in catastrophic events including the loss of life. In aviation, human factors is dedicated for better understanding on how humans can most carefully and skilfully be integrated with the present and updated technology. That understanding can be put into design, training, policies, or procedures to help human's performance better. An aircraft is just a

machine, and machines sometimes malfunction. Flight attendants and pilots may even fly several times per week even though the airlines companies take all possible precautions to avoid any accidents or incidences. This research will mainly focus on the impact of errors done by the maintenance engineers and technicians in the aircraft maintenance environment.

A. Research Question

The research questions around which this research is based are presented below:

Primary Question: Does airline's overall maintenance effectiveness depend on mitigation of skill-based error rather than mistakes?

Secondary Questions

- a. Is 'skill-based error' the main cause of human error present in airline maintenance organizations?
- b. What is the present procedure followed in civil and military airline operating organizations in Sri Lanka to mitigate human errors?
- c. What are the recommended procedures for ensuring the expected performance from the maintenance crews for overcoming human errors, mostly skill-based errors?

B. Research Objectives

The main objectives of this paper is to recommend ways for mitigating the adverse effects of aviation human factors of aircraft maintenance crews of maintenance organizations by reducing skill-based errors.

The specific objectives are to find whether the effects of skill-based error affect the maintenance effectiveness of the two main civil and military airline operating organizations in Sri Lanka. Identifying common errors and mistakes done by the maintenance engineers and technicians in the two selected organizations. Finding whether skill-based errors of maintenance engineers and technicians vary due to the age and gender difference and measures could be taken to mitigate effects of human errors to enhance maintenance effectiveness.

C. Research Hypothesis

The research hypotheses are as follows:

Hypothesis 1 : Most of the human errors are occurring due to skill-based errors by maintenance crews in civil and military airline operating organizations in Sri Lanka.

Hypothesis 2 : Human errors due to mistakes have been mitigated to an acceptable level by civil and military airline operating organizations in Sri Lanka.

II. METHODOLOGY

The scope of this research was limited to focus only on skill-based errors and mistakes. There are many elements of skill-based errors that can remain latent for a considerable amount of time and result in a catastrophic form afterwards. The data which has been collected through a series of interviews by the aviation personnel and questionnaire has helped to sort out the common indicators of Skill Based Error.

A. Rationale for Adopting the Method of Research:

The research has been conducted by a detailed survey from military operator and civil operator of Sri Lanka to ascertain the hypotheses. It is a descriptive and causal research and followed the mixed methodology. The sample included aviation maintenance crews, including the engineers and technicians from both organizations. The subjects have been selected on random sampling method and both qualitative as well as quantitative data has collected in the form of survey. Interview of maintenance crews has been taken and used for qualitative subjective analysis. Relevant literatures on the subject is the main sources of secondary data.

B. Conceptual Framework:

The conceptual framework which connects the dependent variables (DV): "Skill-based error" to the independent variables (IV): "Slip of action" and "Memory lapse" and "Mistakes" to independent variables "Knowledge based

errors” and “Rule based errors”. The independent variables have different indicators. Sorting out these indicators of each independent variable is necessary for the research. The indicators of slip of actions are shown below:

- Workplace design
- Fatigue
- Distraction
- Interruption
- Supervision
- Independent checking
- Over confidence

The memory lapses that can occur amongst the maintenance crews can be found out by the indicators’ interruption and distraction of the independent variable slip of actions. Besides age and gender also have their role on memory lapse. It can be faced by the people of almost all ages, but the severity differs from age to age. Though mistakes have not emphasized much in the research; yet, through the questionnaire and interviews it has sorted out whether it contributes more than the skill-based errors. So, to know about the indicators of mistakes is necessary. The indicators of mistakes are given below:

Knowledge based errors and Rule based errors

- Improper application of good rule
- Bad rule

C. Data Collection:

Primary data was collected through a structured questionnaire which was distributed to engineers and technicians of the two organizations. Further, interviews were conducted where areas such as total strength of the maintenance crews, number of qualified personnel, most common incidents that occur day to day, way of mitigation of those incidents, fatigue management, critical situation management and memory lapse occurred amongst the crews were touched upon. Besides, secondary data has also been collected from books, journals, and articles and by brainstorming with the persons related to aviation.

D. Methods of Data Analysis

The responses were obtained on a 5-point Likert scale to ascertain level of agreement to measure each of the indicators. Skill-based errors there were represented by 07 indicators which determine both the slip of actions and memory lapses, while 03 indicators represented mistakes. In skill-based errors, the indicator fatigue had been divided to two categories.

- **Fatigue1** was based on the workplace comfort ability, number of working hours, number of breaks and how often they go on leave.
- **Fatigue2** was based on their health issues and their general lifestyle.

Data was then analysed using SPSS.

III. DATA CALCULATION AND ANALYSIS

The percentage of each indicator of a particular dependent variable (IV) was found using the equation below:

$$\frac{\% \text{ of an indicator}}{\Sigma \% \text{ of all indicators of a IV}} \times 100 = \% \text{ of an indicator in a IV}$$

The results yielded are depicted in table 1.

IV. RESEARCH FINDINGS AND RESULTS

Through data analysis it was found that the majority of skill-based errors of the military operators comes from the indicator Supervision, which is 29.39%. There is a clear difference between what SLAF technicians have stated and what engineers have stated and that is because even though technicians feel that they are always supervised, engineers do not supervise them always unless it is required. In the responses some engineers have said that they rarely supervise, and this is because some of these engineers are quality managers who does not do supervision always anyway. In the civil operator, the mean value of Supervision is 2.4 whereas in the military operator it is 2.8.

Table 1. Summary of Errors

| Human Errors | | % of errors in military operator | | % of errors in civil operator | |
|--------------------|-----------------|----------------------------------|-------|-------------------------------|-------|
| Skill based errors | | 47.47 | | 33.13 | |
| Mistakes | Rule Based | 57.24 | 52.53 | 71.29 | 66.87 |
| | Knowledge Based | 42.76 | | 28.71 | |

The second highest percentage of errors was found in independent checking which was 22.91%. The main reason for this is the over confidence of experienced technicians, who tend to have an inertia to refer to maintenance manuals and work instructions while performing work. This finding is further supported through interviews carried with technicians of different levels. It was found that certain engineers are quality managers and do not refer to such documents unless there is a strict need to do so. It was also found that fatigue 1 has added up to a percentage of 17.55% and this is due to excessive working hours and a smaller number of leave the maintenance crew get on a weekly basis.

In case of the civil operators, interestingly the highest percentage of errors found was from the indicator Independent Checking which was 25.34%. Unlike the military crews most of the civilian engineers work in the same department for a longer period of time and they have the tendency of not referring the maintenance manual or perform a check on technicians' work every time they carry out any maintenance activity on an aircraft. The second highest percentage is from the supervision indicator for the same reasons mentioned above. Fatigue 1 also takes a majority part in skill-based errors because of the excessive working hours inside hangars.

Through interviews it was found that the military technicians switched their job roles within the same hangar as well as other technical and even non-technical jobs during their service tenure. Further, since they were not bound by international civil aviation legislation, it was found that the percentage of skill-based error is more in military operators in comparison to the civil operators. Taking all the indicators of skill-based errors into account, the comparison between these two operators is shown in Figure 1.

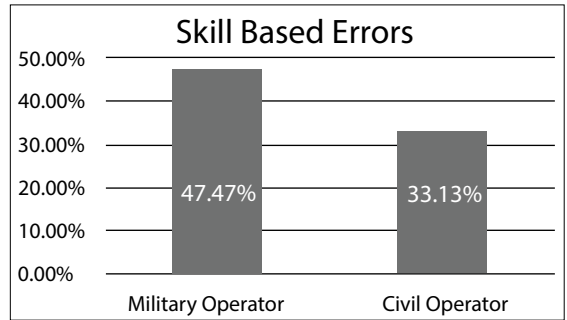


Figure 1. Comparison of skill-based errors between two organisations

Another reason for this result maybe the nature of the aircraft fleet operated by the two organizations. Since the aircraft fleet of the civil operator was frequently upgraded and the maintenance crew need continuous training on new upgrades. The military operator, on the other hand maintains a rather aging fleet of aircraft with little or no upgrades which resulted in comparatively lesser training for the technical crew.

While analysing the data it was also found that, the highest percentage of mistakes in military operator consists of bad rule as depicted in figure 2.

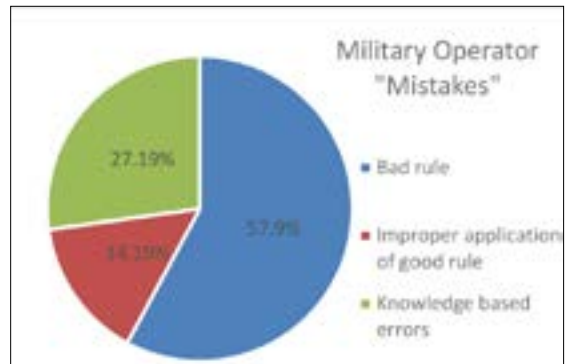


Figure 2. Presence of mistakes in military operator

The reason for this was found out through interviews, to be the presence of redundant rules. Second highest is from the knowledge-based errors which can due to the lack of consistent and higher training. Like military operator, in civil operator also the highest percentage of mistake is from the indicator Bad Rule, followed by improper application of good rule. The reason for this is seen as the

flexibility in application of rules, commonly seen with the civilian technicians.

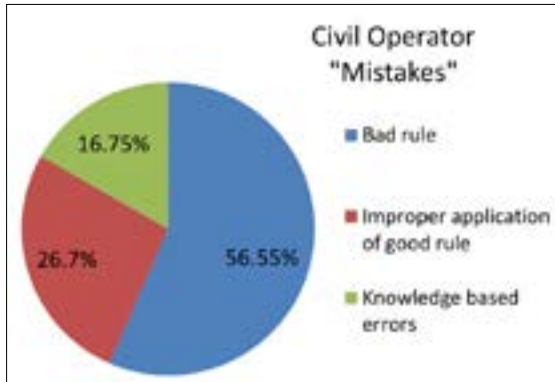


Figure 3. Presence of mistakes in civil operator

A comparison of the mistakes between military and civil operators are shown in figure 4.

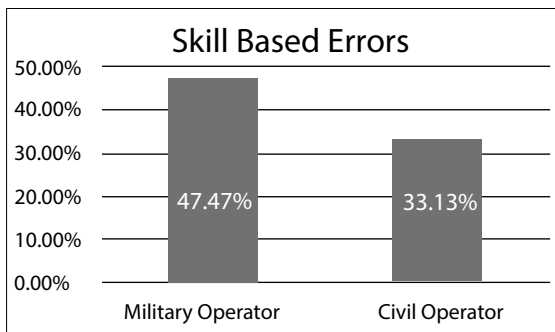


Figure 4. Comparison of mistakes between two organisations

Both rule and knowledge-based errors lead to mistakes and it is found that the civil maintenance crews are more prone to break rules or less effective to adapt with the new rules when applied in case of any emergency or critical situations. On the other hand, as the military personnel undergo through a tough and strict disciplined life, the tendency of breaking rules is less with them in comparison to the civil personnel.

The highest standard deviation is 1.54 amongst the responses for the indicator Fatigue 2 (Based on health issue and general life style) of the civil airline operator. Apart from workplace design and fatigue which are two of the ten indicators, all have their standard deviation under

1.00 which gave the idea that the variation of the responses around the mean response is very less.

The inter-item correlation matrix was generated to depict the relationship among the indicators. For skill-based error taking workplace design as 1.00 and for mistakes, taking knowledge-based errors as 1.00 the correlations of other indicators were found. All the values found were positive which indicates that all the indicators are related to each other in the similar fashion; not reversibly.

Cronbach's alpha reliability test was done to measure the internal consistency of the responses of the participants. When there are less than 10 items and the value of alpha comes greater than 0.5, then the responses are considered to be consistent. (Pallant, 2005). In the research, only the Cronbach's alpha of mistakes of civil operators came below 0.5 (0.496), which was a limitation of the research.

IV. CONCLUSION AND RECOMMENDATION

This research analysed the maintenance environments of two aircraft operating organizations in Sri Lanka. The aviation maintenance crews are the lynchpin in the airline industries. They are the most important personnel who are maintaining the aircrafts and help to fly on time it by hard works. For the better maintenance of the aircrafts they should not commit any human error. As maintenance crews are doing the most important and complex job in a wide variety of ways thus, they must be aware of human factors associated in aviation.

Out of several causes of human errors of maintenance crews, it is found that rule-based error is more common. The first research hypothesis was, "Most of the human errors are occurring due to skill-based errors". However, it was found that the percentage of mistakes is higher than that of the skill-based errors. On the hand, second hypothesis was, "Human errors due to mistakes have been mitigated to an acceptable level by the civil operator and the military operator". But if 50% is considered as the average level, in both the cases the percentages found were higher. Thus, it cannot be concluded that the mistakes have been mitigated at an acceptable level. Within mistakes, the percentage of rule-based errors is more than that of the knowledge-based errors. In the military operator the rule-based errors are comparatively lesser in comparison to the civil operator.

Based on the findings of this research, the researchers have found that despite the immense contribution made by both organizations towards the aviation industry in Sri Lanka, proper utilization of available human and technical resources are not utilized to the fullest potential to achieve better productivity. Improvements to overall maintenance effectiveness can be achieved by inculcating a more disciplined work environment where rules and regulations with regard to technical work are more stringently imposed and facilitating cross training between two organizations to enable mutual development and resource sharing.

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