The contributions of human factors on human error in Malaysia aviation maintenance industries

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Abstract. Aviation maintenance is a multitasking activity in which individuals perform varied tasks under constant pressure to meet deadlines as well as challenging work conditions. These situational characteristics combined with human factors can lead to various types of human related errors. The primary objective of this research is to develop a structural relationship model that incorporates human factors, organizational factors, and their impact on human errors in aviation maintenance. Towards that end, a questionnaire was developed which was administered to Malaysian aviation maintenance professionals. Structural Equation Modelling (SEM) approach was used in this study utilizing AMOS software. Results showed that there were a significant relationship of human factors on human errors and were tested in the model. Human factors had a partial effect on organizational factors while organizational factors had a direct and positive impact on human errors. It was also revealed that organizational factors contributed to human errors when coupled with human factors construct. This study has contributed to the advancement of knowledge on human factors effecting safety and has provided guidelines for improving human factors performance relating to aviation maintenance activities and could be used as a reference for improving safety performance in the Malaysian aviation maintenance companies.

1. Introduction

Aviation is one of the transport industries where the change of technology is eminent. However one must understand that maintenance of aircraft does not entirely depend on technology alone. In fact the main contributor to aircraft maintenance is human who the aircraft maintenance personnel are. The work of aircraft maintenance personnel obviously is vital to the safety and economic viability of airlines operations[1]. Aviation safety must not be compromised by inadequate maintenance. To ensure that maintenance is carried out properly, the aircraft maintenance personnel must be properly trained [2]. Aviation maintenance has changed over the years; new aircraft manufactured with new materials and systems operated with the latest technology. However, one aspect of aviation maintenance that has not changed is that most maintenance task is done by human. As the tasks are performed by human, errors will somehow surface and if not properly contained, can cause accidents where lives are lost. Currently, there are numerous hurdles in the human factors pertaining to aviation maintenance. This research is a fundamental proactive study to understand issues relating to human errors in aviation and also to ensure safe and effective maintenance processes so that aircrafts released from maintenance are safe and timely. Emphasis and study on this subject will provide confidence to the aviation authorities and on those aviation industries that has shown commitment in battling human
error contribution to aircraft maintenance within Malaysia. Although the human factors are highly emphasized in the human factors management literature, human factors alone may not only be the factors contribute to the human error in aviation industry[3]. The result shows that, if the human factors are coupled with the organization, then the strategy for reducing human error will be better in aviation maintenance industries. This implies that the following constructs of human factors (software, hardware, environment, liveware(I) and liveware(O) and also efforts of organization (quality of support, company policy, workforce, finance strategy, and safety culture) must be managed and controlled within aviation maintenance companies in order to reduce human error. Therefore, managers in aviation maintenance industry should consider human factors and organization as a facilitating initiative for reducing human error in aviation environment.

2. Methodology

2.1. Development of Questionnaire

A survey was conducted to find out the perception of the maintenance personnel on the significant human factors that would contribute to human error in aircraft maintenance environment. The most efficient and productive way to formulate effective questions as well as set meaningful framework for the research is to involve at least some of the respondents in the construction of the questionnaire[4]. Basing on the comments above, the final draft of the questionnaire was sent to the aviation maintenance experts and practitioners from the industries and academician the objectives to evaluate the feasibility of carrying out the research in this environment, to acclimatize with the organizational environment, especially in areas that are not familiar to the researcher, to identify which category of maintenance personnel in aviation industries that would have the greatest impact on human error in aviation maintenance and to communicate with the potential survey respondents so that the research is well supported and can be conducted smoothly with minimum hassle.

2.2. Data Collection

Data are simple facts or recorded measures of certain phenomena, while information refers to a body of facts in a format suitable for decision making or in a context that defies relationship between pieces of data collection and procedure. Collecting data using survey questionnaires methods could be administrated using mail, or delivered personally. Initially, a survey questionnaire has been distributed to the selected 18 aviation maintenance industries in Malaysia. Respondent were selected from the several categories of aviation maintenance personnel such as Supervisor, License Aircraft Engineer (LAE), Instructor and Technician. Some of the questionnaires were personally handed directly to the respondent, but a major portion of the questionnaire was mailed to the leader for distribution. The estimated times taken by respondents to answer the questionnaires are taking about three month. A total of 500 questionnaires distributed on the first stage, however only 146 responded have returned to the researcher within 2 to 5 weeks from the day of the questionnaires being dispatched. The follow up process was carried out with telephone calls, fax transmission, and re-mail the questionnaire to the respective aviation industries with the same amount of questions, and the total of 315 respondents were recorded after the second follow up process. In the research of assessing human factors variables in aviation maintenance, the data will be used to provide quantitative data for the purpose of analysis. The data will be used as the research on assessing human factors is more of cognitive science where by the perception of the people involved in the maintenance environment towards the casual factors of human errors must be considered. Survey conducted on the aviation maintenance personnel by using questionnaire covering elements that normally contributes to human errors in aircraft maintenance industry in Malaysia.

2.3. Structural Equation Modelling

The Structural Equation Modelling (SEM) was used to test and analyse the relationship of the research model. SEM aims to examine the inter-related relationships simultaneously between a set of posited constructs, each of which is measured by one or more observed items,SEM involves the analysis of two models; a measurement or factor analysis model and a structural model[5]. The measurement
model specifies the relationships between the observe measures and their underlying constructs, with the constructs allowed to inter-correlate. The structural model specifies the posited causal relationships among the constructs. To study the research model with the measurement model, the structural model with a path diagram is constructed. Single headed arrows represent causal relationships between variables. Goodness of fit tests is conducted with the survey data to examine the efficiency of the structural model. To assess the overall model fit without being affected by sample size, alternative standalone fit indices less sensitive to sample size are use.

3. Results

From the path analysis, it is observed that Human Factors and Organization were significant towards dependent variable Human Error. With reference to the significant importance, independent Organization factors (0.405) were more significant compared to independent Human Error (0.324) which was referring to the estimate value stated in the Table 1.

Table 1. Regression Weight on Human Factor, Human Error and Organization

|                | Unstandardized Estimate | P-value | Standardized Estimate |
|----------------|-------------------------|---------|-----------------------|
| HE < -------- HF | .569                    | ***     | .324                  |
| ORG < -------- HF | .501                    | .008    | .252                  |
| HE < -------- ORG | .632                    | ***     | .405                  |

Note: *** indicate that the p-value is <0.001

Table 2. Standard Regression Weight of Factors in the Conceptual Model

|                | Unstandardized Estimate | P-value | Standardized Estimate |
|----------------|-------------------------|---------|-----------------------|
| SW < -------- HF | 1.000                   | ***     | .754                  |
| HW < -------- HF | 1.214                   | ***     | .871                  |
| ENVT < -------- HF | 1.069                  | ***     | .714                  |
| LW(I) < -------- HF | 1.110               | ***     | .818                  |
| LW(O) < -------- HF | 1.120                | ***     | .768                  |
| QS < -------- ORG | 1.000                   | ***     | .803                  |
| CP < -------- ORG | .920                    | ***     | .836                  |
| WF < -------- ORG | .908                    | ***     | .818                  |
| FS < -------- ORG | .878                    | ***     | .883                  |
| SC < -------- ORG | .867                    | ***     | .741                  |
| INST < -------- HE | 1.000                  | ***     | .781                  |
| SR < -------- HE  | .901                    | ***     | .848                  |

Note: *** indicate that the p-value is < 0.001

Based on weight and ranking, the order of significance of the five dimensions studied, the result is presented in Table 2 with Human Error as dependent variable and Software, Hardware, Environment, Liveware (I) and Liveware (O) as independent variables, it indicated that variable Software, Hardware, Environment, Liveware (I) and Liveware (O) were significant at 95% confidence level (p-value > 0.001) with variable Software taken as reference group. In this model, variable Hardware (0.871) is the most significant factors, followed by variable Liveware (I) (0.818), Liveware (O) (0.768), Software (0.754) and Environment (0.714).

Furthermore, when independent variable Quality Support is taken as reference factor, it is found that independent variables Quality Support, Company Policy, Workforce, Finance Strategy and Safety
Culture were significant in 95% confidence level ($p$-value > 0.001). Finance Strategy (0.883) is the most significant factor influencing organization. It continues with other independent variables Company Policy (0.836), Workforce (0.818), Quality Support (0.803) and Safety Culture (0.741).

4. Discussion

This study has shown the significant relationship between human factor based on SHELL model and human error in aviation maintenance[6]. Based on the hypothesis the human factors contribute to human error in aviation maintenance. In the Organization dimension, three items are first in the weight order of significant factors: Finance Strategy, Company Policy and Workforce [7][8]. With respect to Finance Strategy, aviation maintenance personnel perceive that recognition for their professional performance is reflected in the level of their salary and company incentive. Decision makers may need to be reminded that salary and incentive issue directly affect employee mood and indirectly affect employee involvement in an organization, and that they create a potential aviation safety risk factor if the staff feels that they are being underpaid and underappreciated. The factor of company policy refers to the need to establish a policy which encourages all staff to actively report any mistakes or improper condition professionally to avoid creating a blaming culture. In the first dimensions of Human Factors, concerning on aviation personnel and their interactions with hardware such as correct equipment, tools and parts available, is first in the weight order of the Hardware dimension. Confucius stated that it is necessary to have effective tools, equipment, and proper aircraft parts to do a good job[9]. However, in many first-line maintenance units, such as line maintenance or maintenance stations, aviation personnel cannot use or obtain the appropriate tools for their job due to equipment or parts shortages, unfinished checkups, or workplace limitations. On the second dimensions, almost all experts focus on the risks concerning Liveware, confirming that humans are still the major source of risk in aviation maintenance operations[10][11][12]. The research findings indicate that aviation personnel rank second in the survey, in the middle of the five dimensions in Human Factors. Professional personnel with a positive attitude believe that safety standards make the company more competitive, "safety works until we are busy"[12][13] while employees with a negative attitude feel that such rules impede operations and reduce efficiency in this highly competitive business environment. Ahlstrom and Hartman[14] identified a lack of communication and coordination breakdowns, a significant factor generally agreed upon by the maintenance experts is in the weight order of the Liveware dimension. As is true in many other professions, aircraft maintenance involves time pressure and professional competition; therefore, it is easy for aviation maintenance personnel not to freely and frequently communicate with each other about their maintenance failures and successes, and to make unclear statements and practice poor listening skills. While aviation maintenance personnel may listen to supervisors' orders and instructions when doing their jobs, they often refuse outside suggestions for improvement because of feelings of professional superiority and stubbornness. Consequently, it is easy for aviation maintenance personnel to develop blind spots that cause maintenance error. Insufficient details in maintenance manual and poor illustrations are the two factors in the weight order of the Software dimension. A maintenance manual refers to the manual references ensuring that the newest aviation standards, rules, regulations, and skills descriptions are contained in aviation maintenance manuals. Certain workplace norms of inappropriate practices are accepted by company employees, such as when aviation maintenance personnel make no use of their manuals in their routine work schedule. These norms usually violate the standards for maintenance procedures, but they are tolerated and have been in use within companies for a long time. Long term exposure to hazardous environment
comes first in the weight order of the Environment dimension. Therefore, aviation maintenance personnel should be informed and trained to handle hazardous materials. In addition to providing aviation maintenance personnel protective gears such as protective clothing, rubber gloves, ear muffs and safety glasses, airline companies should also hold regularly scheduled health and safety seminars. In terms of Workforce, aircraft maintenance operations require professional certificates and rotations. Frequent changes in management team or leadership in organization will disturb also the maintenance team performance. The importance of management attitudes justifying the important attached by other researchers[15]. It is difficult to train aviation personnel. The number of qualified personnel available for job vacancies is usually far less than required by the scheduled flight increases of airline companies. Aircraft deterioration and the additional work hours needed to maintain newly purchased airplanes also present problems on the job. In a situation without sufficient manpower, aviation maintenance personnel must improve their efficiency in response to the increased work load. Therefore this study suggests that human factor alone may not only be the factors contribute to the human error in industry.

5. Conclusion

The results from the study provide an empirical support on the impact of human factors and organization to human error. Results showed that there were significant relationships of human factors on human errors. Human factors had a partial effect on organizational factors while organizational factors had a direct and positive impact on human errors. It was also revealed that organizational factors contributed to human errors when coupled with human factors construct. This study has contributed to the advancement of knowledge on human factors effecting safety and has provided guidelines for improving human factors performance relating to aviation maintenance activities and could be used as a reference for improving safety performance in the Malaysian aviation maintenance companies.

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