Human Factors in Training for aircraft maintenance Technicians

A. Shanmugam \textsuperscript{a}, T. Paul Robert \textsuperscript{b}

\textsuperscript{a} Directorate of Airworthiness, DGCA India, Chennai, India; \textsuperscript{b} Department of Industrial Engineering, College of Engineering Guindy, Anna University, Chennai, India

Abstract

Aircraft Maintenance training is a primary intervention to overcome human limitations and to enhance individual and team performance. Maintenance training increases the competency and situation awareness, thereby technicians are likely to commit a fewer error during maintenance. Although, technicians attain over 90\% of the critical skills through on-the-job training, it is a costly approach of the airlines to make them learn through experience. There is a need for scientific approach or new model to impart training to the aircraft maintenance technicians. Exhaustive study of maintenance training system in South Asian Countries revealed interesting facts of limitations. The training system is of score board approach rather than a skill and competency based. The paper proposes a cognitive model based approach to increase the efficiency of the maintenance training. The heuristic model transforms aircraft maintenance training from a compliance based system to the performance based approach. The data collected from seventy two trainings covering 6 countries highlight that the model of occurrence (accident and incident) based training has greater impact compared to the conventional method of course curriculum. The proposed innovative method of training is being proved empirically as an effective model of aircraft maintenance training.

1. Introduction

Aircraft Maintenance training is a primary intervention to overcome human limitations and to enhance individual and team performance. Maintenance training increases the competency and situation awareness, whereby technicians are likely to commit fewer errors during maintenance. Even though, mechanics attain over 90\% of the critical skills through on-the-job training, it is a very costly approach for the airlines to make the technicians learn through experience. There is a need for scientific approach or new models to impart training to the aircraft maintenance technicians. Exhaustive study on aircraft maintenance training systems in South Asian Countries reveal interesting facts on limitations of the available training systems, are of score-board rather than skill and competency based. This paper proposes a cognitive model based approach to increase the efficiency of aircraft maintenance training. The model transforms from a compliance based system to a performance based approach. The data collected from seventy two trainings covering six countries highlight that the model of occurrence (accident and incident) based training has greater impact on trainees, compared to the conventional method of course curriculum in use. This proposed innovative method of training is being proved empirically as an effective model of aircraft maintenance training.
2. Research Motivation

Aircraft maintenance is one of the key functions in airlines. The field has attracted much of public attention due to increase in incidents due to human error in aircraft maintenance (Reason & Maddox, 1998); human error in maintenance attributes to 30 - 90% of aircraft incidents (Marx, 1998). Aircraft maintenance organisation must sensitize this issue and creates strategies to reduce human errors (Gramopadhye, Ivaturi, Blackmon, & Krause, 1994). Maintenance training is one of the primarily interventions to overcome human limitations and to improve an individual's and the team’s performance (Harris, et al., 1998). Effective training and competency development is one of the key spotlights of error reduction goal (Mannan, 2014). Study on aircraft maintenance training in South Asian countries highlighted that most of the maintenance training methods are ineffective and not performance based, with exception to specific aircraft type training. This study is an exploration of all the existing methods of class room training in aircraft maintenance, and to develop an improved method.

3. Methodology

The study comprised of primary and secondary data collection through explorative research. The primary data sources are 72 trainings of 24 scheduled airlines, covering six South Asian countries. Five airlines are operating fleet size of more than 50 aircraft of Boeing, Airbus, ATR, bombardier and Embraer series. Secondary data sources are annual surveillance report of the Civil Aviation Authority from airlines training data and literature survey from digital libraries through internet searches. For the purpose of collecting primary data, six set of experiments; one set at each country has been conducted. Study group of 12 batches of trainees consisting of 30 – 45 trainees in each group have been chosen. Average age of the group is 47 years with similar profile and experience. One group has been taught with conventional method and other group was tested with new methodology of training. Recall appraisal test was conducted with all groups of six conventional training groups and other six with new methodology using data analysis tools both qualitative and quantitative methods. Simple regression analysis is used to validate the results of qualitative analysis. The analysis results are pictorially depicted for better understanding. Cognitive based human performance model has been developed to enhance the understanding of the theory of aircraft maintenances.

4. Aircraft Maintenance Training

4.1 Literature Survey

Organizational structure must support choosing job-aids and training system in aviation maintenance organization (Shepherd, Johnson, Drury, Taylor, & Berninger, 1991). Sadasivan et. al. (2004, 9 - 10 March) have described that computer-based training and virtual reality are also effective means of training. Endsley and Robertson (2000) highlighted that well trained maintainers gain high situational awareness that led them to commit fewer errors and to achieve higher
maintenance performance. Training in Safety Management System (SMS) and aircraft maintenance is effective only if the objectives, design and delivery of curriculum system are matched with training requirements (Taylor, 2000). Computer based on-the-job Training (OJT) system to impart training of aviation regulations is a popular tool to meet training needs of government inspectors and maintenance crews (Chandler, 2000). Walter (2000) cited that more than 90% of the critical skills of aviation maintenance technician are acquired through OJT. Walter proposed that the Task Analytic Training System, a model of team-driven OJT is an efficient training method. A SMS Training system must be an integral part of organizational design (Salas & Cannon-Bowers, 2001) and is a powerful enabler to identify hazards at the maintenance workplace, to assess maintenance risks and to correct the safety deficiencies (Allen, 2001, March). Mattson, Petrin, & Young (2001) cited that cross-disciplinary training among flight crews, cabin crews and maintenance engineers is important to minimize communication gap and to improve safety performance among crew members. Human physical limitations impede visual inspection capabilities (Gramophadheya, et al., 2002 April), but relevant training and providing them with appropriate tools to intervene most of the limitations. Vora et al. (2002) demonstrated that Virtual Reality trainings have an advantage over conventional computer based training tools. Dekker’s (2003) study revealed that investment made on training accrues into greater tangible and intangible benefits. For superior maintenance performance, it is recognised that the organisation must recruit wisely (Terpstra & Rozell, 1993) and make employees competent and skillful through training and development (Tharenou, Saks, & Moore, 2007) and it must hold them with distinct structure and hierarchy (Pettersen & Aase, 2008).

4.2 Types of Training

The training requirements for aircraft maintenance technicians are mandated and standardized as per International Civil Aviation Organization requirements. The types of training for aircraft maintenance engineers are: (a) Initial basic technical training for basic certificate, (b) specific aircraft type maintenance training for Licence, (c) Human factor Training; (d) Safety Management Training; (e) Organizational Policy and Procedural Training, (f) Fuel Tank safety Training. Besides, aircraft maintenance related special operation training which includes, Reduced Vertical Separation Minimum (RVSM) training, Extended Twin Engine Operation Training (ETOPS) and Performance Based Navigation (PBN) Training. Most of the training requires to be refreshed once in two years to update the revisions and latest development in the field.

4.3 Methods of Training

Maintenance Organization operating and maintaining larger fleet of more 25 aircraft have established their own training organization whereas other organization operating and maintaining smaller fleet of aircraft have outsourced their training needs. Majority of the organization use class room training, on-the-job training and computer based training, whereas distance learning and internet and intranet based training are also adopted at times by the organization. Computer based specific aircraft type trainings have better efficacy. Trainees acquire the knowledge and skill
at ease. The classroom trainings using non-standard Microsoft power point presentation, especially, training on regulatory subjects is more of routine slides without figures or visual attraction. The efficacy of the training and recall rate is observed to be less.

5. Trends in training needs

Advances in aircraft technology and the advent of fly-by-wire technology and automation increased the complexity of aircraft maintenance. The business model of maintenance and repair organizations (MRO) has increased third party maintenance responsibility, which reinforces the competitive pressure and accountability of the technicians. MRO are on competitive pressure in terms of timely delivery at higher quality of maintenance. Contracting of certified maintenances technicians are under constant pressure of professional survival of maintenances technicians. The growing popularity of licensing regulations of European Aviation safety Admiration (EASA) Part 66 concepts and Federal Aviation Admiration Licensing has simplified hiring of technicians from global market. Highly demanding civil aviation regulatory needs of skill and competency of maintenance technicians keeps the constant pressure on manpower resources in organization. All these scenarios need well trained technicians. The efficiency of the training, in other words, acquiring more skill and competency during training is of great importance. It is determined by the relevant content, format, and delivery of the training materials. Efficient training delivers the appropriate types of information in the correct amounts which will have cognitive impact on trainees for better retention and recollection. Henderson and Feiner (2007) published a detailed research report on Augmented Reality (AR), which is an emerging technology in the field of aircraft maintenance focusing on reducing human error and increasing maintenance performance. Application of AR is finding its place in aircraft daily inspection (Crescenzio and Fantini, 2010), maintenance training (Crescenzio, et al., 2011) and components’ removal, repair and replacement (Jo, et al., 2014).

6. Issues in conventional methods of presentation

Training materials without pictorial description of the points, attracts less attention of the participants. Studies confirmed that especially while teaching theoretical subject such as (a) Regulation on aircraft Maintenance Organization approval (EASA / FAA Part 145), (b) Continuing Airworthiness Management (EASA / FAA Part M), Maintenance Training organization (EASA / FAA Part 147) and other regulatory subject that are theoretical and descriptive without much scope for pictorial depiction. Participant’s acquiring of knowledge, retention and recall ability varies between 67 – 92%., even for skillful delivery.
Compressing the subject matter in each slide makes it difficult to absorb more materials. Slides with lesser visual appeal – Variation of font size, mismatch of slide background and font color, clutter of information – creates less cognitive impact and recall, compared to visually attractive slides. Poorly designed slides often fail to link the subject matter with cases, incidents or accidents making the whole subject matter dry and cognitively less appealing to the trainees.

7. Cognitive model of human Performance

The classical model of hierarchy of effect model (Ray. 1973) which describes sensory system ultimately influences the decision making. Based on the literature review, a new model namely Human Physical and Cognitive Performance Model shown in Fig. 1 has been proposed. Physical environment affects the short-term and long-term memory, which in turn has a strong influence on the level of knowledge and awareness, leading to action or inaction, which ultimately affects human performance. Visual presentation has greater impact on understanding of the subject matter. This model is a culmination of the detailed survey of the literatures, where ample evidences are available to support that stimulus affects the human action or inaction and quality of task performance in aircraft maintenance.

8. Visual Presentation of Training Materials

The new method of presentation adopted picture and block diagrams linking to the subject matter of each key point. Pictures and block diagrams supported the trainees for cognitively relating the subject point and easy recall. In the proposed new method of training, more number of actual accidents and incidents cases are linked to the specific subject point so as to sensitize the matter and have higher cognitive impact and higher recall rate. In the new cognitive approach, training has been administered with questions to self-assess their level of understanding of the subject prior to the training and subsequently taught afterwards. As the trainees realize that they lack some knowledge, their attention level increases and learning level and recall rate also improves. The experiment was conducted in six countries. Each country was deployed with two experimental groups, one that was subjected to conventional training methods and the other that was subjected to the new cognitive method. It was inferred that the conventional method of training resulted in a recall rate varying between 71 – 87%, whereas the new cognitive method of training resulted in a recall rate of 90 – 96%.
9. Conclusion

Aircraft Maintenance training requires a radically new approach in delivery. Although, the design of course outline, notes, delivery methods are matched with requirements, the attractive visual presentation, inclusion of accident and incidents case studies and inclusion of pre-training examination that creates an awareness that the trainee lacks the subject knowledge, will bring about a higher learning output, which increases the competency level to contain the tendency of committing maintenances errors.

References


Steven J. Henderson and Steven K. Feiner. 2007. "Augmented Reality for Maintenance and Repair (ARMAR)". Air Force Research Laboratory, Wright-Patterson AFB OH.


