Influence of the human factor in the aircraft and its components continuing airworthiness system

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Abstract. Continuing the airworthiness of an aircraft requires well-coordinated interaction between the participants in this process, especially the engineering and technical staff performing maintenance. Human impact on all areas of aviation activity is recognized by ICAO as a “human factor” and is worthy of special attention. In the process of work the personnel can make obvious and hidden mistakes, the combination of which can negatively affect flight safety. This is often due to a combination of conditions affecting the ergonomics of the workplace and the time frame for performing the maintenance work. The ability to ensure the implementation of the required list of works is also influenced by the complex structure of aviation personnel, which is also subject to change. The article deals with the models of working environment assessment and personnel management systems in maintenance organizations. Each of the models under consideration allows you to achieve certain success in the study of erroneous actions, since it allows you to obtain an analytical basis for making decisions aimed **at reducing the impact of the human factor on the quality of aircraft and its components maintenance. 184**

1. Introduction

In order to reduce the negative impact of the human factor in the aviation industry, the constant introduction of new technical solutions and technologies is carried out, which requires careful theoretical and practical personnel training and the development of measures to prevent errors from their side. Today, the automation of data processing of the aircraft maintenance process, an increase in the volume of specific information in conditions of intensive work significantly exceed the capabilities of an individual. Since the consequences of incorrect actions of personnel can appear suddenly and have serious consequences, ICAO has issued Doc 9683-AN/950 [1], Doc 9859 [2] and there have been introduced the requirements for training and continuing knowledge in the field of Human Factors in EASA standards and recommended practices.

The specifics of personnel activity in maintenance organizations can cause hidden errors, the manifestations of which are possible both under certain operating conditions and in time [3]. Today, measures are being elaborated to minimize the negative impact of the human factor on the quality of maintenance. It is the person who is the connecting link between the assigned task, the conditions for fulfilling the duties, and the accompanying factors. The efficiency of work and the final result depend on the decisions he/she makes [4]. Therefore, in addition to existing documents, ICAO issued Doc 9806 AN/763 [5] and Doc 9824 AN/450 [6] which clarify the specifics of maintenance processes.

Unfortunately, the content of work on the maintenance of new types of aircraft and those that have been discontinued is significantly different, despite the fact that they are regulated by the same documents [7]. Therefore, in order to reduce the manifestations of the human factor in this area of aviation activity, the development and improvement of workflow and information processing methods, personnel management techniques, approaches to assessing the capabilities of personnel in the professional environment remain relevant.

2. State of the problem

The efficiency of aircraft maintenance depends on the quantitative and qualitative composition of the brigade, as well as on the material, technical, methodological and organizational support of the process. Unlike flight crews, engineering and technical personnel do not receive direct feedback on the results of their work [8]. Minimizing the number of hidden errors is dictated by a number of protective measures to reduce the risks of human factor manifestations. These include certification of maintenance organizations, licensing of personnel, verification of work and related documentation, registration and transfer of information between process participants, interaction with the developer and operator, integration into safety management and quality management systems [8]. The practical implementation of such measures consists in the introduction of mathematical risk assessment methods, the effectiveness of maintenance programs and continuing the airworthiness of the aircraft and its components [7, 8].

The commissioning and maintenance of aircrafts of various types entail the development of mechanisms for interaction between services and take some time. Modern types of aircraft are characterized by an increase in the periods between long forms of maintenance, but at the same time there is limited operational information, the need for improvements in operating procedures for individual elements of the vessel. When servicing an aging fleet, engineering and technical personnel have a certain information base, experience, but at the same time it is necessary to assess the prospects for possible retraining which may cause discomfort among young specialists [7, 9]. If it is necessary to change the composition of the aircraft fleet, the airline’s management should assess financial, technical, personnel and other types of risks. If the level of technology of an aircraft type planned for operation differs significantly from the existing ones, this will require significant investments in personnel training, mastering new logistics schemes or attracting external specialists [9], making responsible decisions individually or in a group. In this case, the personnel resource management system plays an important role, in particular, Maintenance Resource Management (MRM).

The basic principles of MRM are borrowed from the KLM human factor management company Cockpit Resource Management (CRM) [10]. There are several generations of CRM in which crew management techniques with an emphasis on specialized skills and behaviors, error management and human empowerment have been implemented. The system continues to develop towards preventing the very possibility of errors and introducing a risk management system [10].

Aviation staff is a complex structure that is subject to change. Based on the situational analysis, attempts were made to improve the efficiency of decisions made in the field of management through qualimetric assessments of its state. At the same time, it was proposed to introduce quantitative assessments of the situation in order to automate the adoption of managerial decisions [11]. Unfortunately, the accuracy of such decisions can be questioned due to the variety of difficult situations in aviation activity, including maintenance.

The characteristics of the aircraft, assumed at the design stage, give it high resistance to various kinds of failures. If some single errors or failures occur, then it is possible to reduce the consequences of the general impact on the system due to their timely detection [12]. Most accidents are often caused by a combination of multiple failures; the so-called critical combination of events [12]. Therefore, even if equipment failures that are not on the MEL are detected, the cumulative impact on flight safety is considered. This solves the problem of preventing the occurrence of critical events. In the work of

Bogomolov A.S. [12] the construction of a tree of events individually for each situation, the use of probability theory and the Markov model for the mathematical justification of decisions are offered. This technique allows us to estimate the relationship of the impact of possible failures on flight safety, but it is based on a specific database about the type and instance of an aircraft. In the conditions of limited information the correctness of decisions can be doubtful. In addition, accounting for latent errors is difficult both in quantitative and qualitative terms.

Along with the material and technical support of the process, an important role is played by providing the necessary documents

Aircraft maintenance is most often performed by a team of workers of different ages and skill levels. It is necessary to take into account the influence of time of day, weather conditions and time limits, which are available to complete the list of work. Along with the material and technical support of the process, the provision of the necessary documents plays an important role [13]. The level of ergonomics of the workplace influences the risk-taking decisions of the staff. A number of external stimuli, provoking conditions, the moral, psychological attitude of the individual form an attitude towards defensive behavior [14]. At the same time, the attitude depends on the degree of the perceived risk, the prevailing motivation and experience (personal, acquired). In this case, the installation can be strengthened or weakened by examples of obtaining the desired result, the facts of negative consequences, and influence from the outside [14]. Thus, it becomes advisable to test engineering and technical personnel not only in terms of knowledge, but also risk inclinations and violations of work rules. It should be remembered that readiness for risk in the group is stronger [14].

From the human factors management work mentioned above, the MRM system has been widely used in practice since the early 1990s for aircraft maintenance processes. It allows considering the working conditions of a specific group of engineering and technical personnel, to estimate the factors of greatest influence on the number of errors made, to raise awareness of these factors and evaluate the effect of training programs [15]. MRM programs focus on improving staff capabilities to improve the efficiency and safety of the work performed.

Typical MRM programs are based on training in the following aspects: awareness of the elements of the “dirty dozen”, analysis of failures and accidents, study and correction of acute problems in a specific organization or department, trainings on improving the communication between employees. Depending on the resources available, the desired outcomes of the new experience in the company, the program may be revised. At the same time, a systematic approach to the analysis of the processes of the organization activity is preserved [15]. Five generations have been identified in the development of the MRM program. All of them, with more or less success, have been used to train managers and engineers. As we know, achieving and maintaining the expected effect in organizations with a complex structure requires the involvement of a wide range of employees. Thus, some programs began to be applied to technicians. Let’s consider the features of these programs.

The first generation of MRM programs were aimed at developing leadership styles, awareness and stress management, problem solving and decision making skills, improving interpersonal communication, procedures and the value of coaching, increasing the general level of awareness of organizational measures and their impact on safety [15].

The second generation of programs is determined by the level of awareness of employees, as a result of its influence on changes in their attitude to the work performed, at the same time, the basis for changing the style of corporate behavior was created. For this purpose, an unspoken agreement was concluded between the management of the organization and the union to encourage employees to learn and voluntarily report their mistakes publicly. Thus, it became possible to identify, effectively solve systemic problems, as well as reduce the number of suppressed facts of violations and errors. The participation of the staff in the discussion of incidents allowed the repetition of mistakes to be minimized. Another important result of the implementation of the program was a decrease in the number of violations when filling out the relevant documentation [15]

The shift of focus from individual guilt to systemic responsibility allowed the implementation of the third generation of MRM programs [15]. This type of software is also known as Human

Performance in Maintenance (HPIM). The program is more focused on the individual than the team, focused on security measures. A distinctive feature of the program is the introduction of teaching materials on the “Dirty Dozen” topic [15]. Gordon Dupont highlighted twelve common problems in aviation maintenance processes, which we now call the "Dirty Dozen" in 1994. Problems include:

- lack of communication;
- complacency;
- lack of knowledge;
- distraction from the performed actions;
- lack of teamwork;
- fatigue;
- ack of resources;
- lack of time;
- lack of confidence;
- stress;
- ignorance;
- norms [16].

Training using this system has increased the overall level of discipline in the team, self-control of engineering and technical personnel and mutual control between colleagues. Opportunities to classify negative impacts on performance were not only discussed in training workshops. The design of information stands and posters made it possible to maintain and develop a certain line of behavior aimed at countering the “Dirty Dozen” [16].

The third generation MRM program has produced good results, but isolating problems and dealing with difficulties on an individual basis has led to bridge-to-nowhere scenarios due to a lack of a certain level of trust and support among employees. Also, without leadership involvement, the standards adopted during the program deteriorated [15].

Issues identified in the course of the analysis of changes in maintenance organizations have led to differentiation of fourth generation MRM programs: systemic change throughout the organization; building trust between employees and management. Thus, significant changes in the culture in the team, the possibility of adjustments and better perception of internal organizational procedures were achieved [15].

The fifth generation of MRM includes a safety action program (ASAP) in services. By the beginning of the 21st century, the level of awareness about the principles of the human factor and the culture in organizations allowed talking about uniting in professional communities to exchange information and make systematic decisions to prevent critical combinations of events that threaten flight safety. This indicates the transition of the error response system in maintenance organizations from blame to fairness [15].

Advances in MRM and the interdependence of aviation stakeholders have been the driving force behind the Linear Oriented Safety Audit (LOSA) program [17]. The implementation of the LOSA program is aimed at centralizing security programs of individual departments, collecting processing and storing data in order to raise awareness of errors and correct actions in organizations, and manage training programs [17].

Since the MRM and LOSA programs used in maintenance organizations do not completely eliminate the influence of the human factor on the performance and flight safety in general, and the process of equipment turnover and the overall workload on personnel are quite intensive, the development of new models for building causal relationships between errors and accidents does not lose its validity. Therefore, Reason’s models, SHEL (L), risk assessment and risk management methods are widely used in aviation standards and recommended practices at all levels without exception.

In the field of aviation services, the PEAR model deserves special attention [18]. It is aimed at analyzing and developing measures to maintain a balance between components in the aviation service system such as “Personnel”, “Environment”, “Actions” and “Resources”.

Figure 1 shows the features that must be taken into account when evaluating personnel [18].

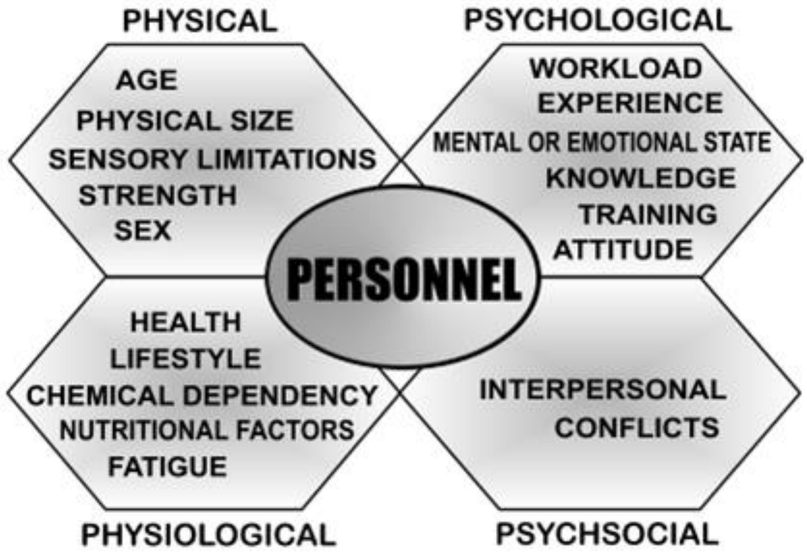

Figure 1. Personnel doing their job.

As a result of personnel assessment, it is necessary to take into account the characteristics of each employee and his ability to perform job and functional duties.

The environment (Figure 2) in the PEAR model is assessed from a physical and organizational point of view [18].

Figure 2. The environment in which they work.

To ensure a safe working environment, both are important. This requires corporate interaction and the cost of certain resources [18].

The principle of evaluating actions is presented in Figure 3 [18].

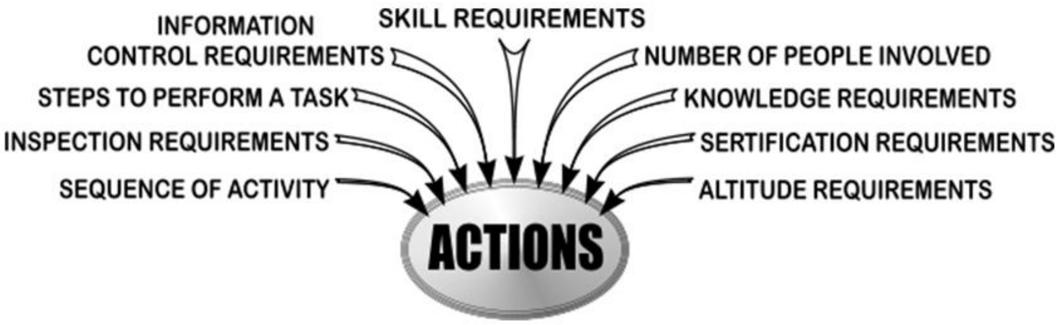

Figure 3. Actions that she performs.

The actions of the personnel are carefully analyzed to comply with safety standards when performing work. It is also expected to conduct appropriate training, material, technical and methodological support at workplaces [18].

Figure 4. Resources required to get the job done.

The resources required (Figure 4) can be tangible or intangible. They can be used directly at the workplace or in the training process, accompanying actions of the main or auxiliary personnel [18].

The PEAR model allows for the assessment of the maintenance process at a local and more general level, but there is still the possibility of erroneous actions on the part of the engineering staff.

To investigate errors, understand their causes and take preventive measures, Boeing has developed and successfully implemented the Maintenance Error Decision Aid (MEDA) system [15].

The purpose of using this system is to investigate errors, determine the factors contributing to their occurrence, find ways to understand the root causes and prevent accidents during work. In this case, the emphasis from the search for the culprit of the event is shifted to countering the causes of its occurrence. At the same time, personnel are less likely to find themselves in an uncomfortable situation from a moral point of view, and malicious violations are detected more quickly. Making transparent and fair decisions fosters positive relationships in the organization.

The MEDA philosophy is based on unintentional error actions on the part of the employee, following positive patterns in the process of identifying and preventing errors, recognizing the combination of several factors, and active participation of a group of people in the error correction process [19, 20]. The MEDA process consists of five steps:

– recognition of the event fact;
– deciding if there are links to maintenance operations after the problem has been resolved;
– investigation of the causes of the event;
– error prevention strategies;
– receiving feedback [19, 20].

Implementation of the MEDA system takes time, management decisions in the area of events requiring investigation, the involvement of appropriate personnel, and the cost of implementing proactive action. This requires a special manager who will develop a plan for conducting and tracking investigations, timely gather a commission of competent specialists, present solutions and a strategy for further actions, and carry out explanatory work with staff.

Organizations that decided to implement MEDA initially investigated major incidents. The cost-effectiveness of the system soon meant that even small disruptions were considered before they could develop into a larger damaging chain of events. More than 60 organizations that have implemented MEDA have reported significant positive impacts in terms of improved team performance, discipline and fewer accidents.

Conclusions

Methods for reducing the influence of the human factor in the field of aircraft maintenance require mutual cooperation between employees in the team, the team and management, organizations participating in the processes among themselves.

Despite the generally accepted principles and values set out in the control programs discussed in the article, the methods are developed individually for each type of aircraft and for a particular organization. This takes into account the local characteristics of the organization location, current economic conditions, priority areas of activity, mentality and many other factors.

The specifics of maintenance workflows is inextricably linked to the prior art of the aircraft being serviced. Adoption of a new type of aircraft into the fleet requires the operator to resolve issues to maintain its airworthiness. The staff involved in this process (an EASA Part-145 approved organization) will also make mistakes that require investigation and response. As a rule, most often, erroneous actions will refer to recently introduced deeply modernized components and assemblies. Due to the principle of nesting the structure, the development of accompanying documentary support for a new type of aircraft is significantly accelerated, and the development of maintenance methods will also be more comfortable for personnel.

Unfortunately, the consciousness and attitude to the work of an individual person is difficult to control. Maintaining a balance between the interests of the individual and the team as a whole is a complex process, subject to the influence of factors that are not always amenable to adjustment (weather conditions, for example). Therefore, teams should be formed taking into account the comfortable interaction of workers. In cases of malicious violations, it is sometimes permissible to take harsh action against unscrupulous workers.

For young professionals with limited experience it is important and useful to have a mentor who can share practical experience and monitor the results. The formation of a team of mentors should be done only with the consent of the employees. The workload should be adjusted; additional training and a system of incentives should be provided for them. Thus, a significant reduction in the number of mistakes made by new employees is assumed. At the same time, the team’s performance and the quality of work will remain at an acceptable level.

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