EJONS International Journal on Mathematic, Engineering and Natural Sciences | ISSN 2602 - 4136

Article Arrival Date: 26.04.2021 | Article Type: Research Article | Article Published Date: 20.06.2021

Doi Number: http://dx.doi.org/10.38063/ejons.420

EVALUATION OF AIRCRAFT MAINTENANCE DOCUMENTS IN TERMS OF FLIGHT SAFETY AND HUMAN FACTORS

Res. Asst. Tarık GÜNEŞ

Eskisehir Technical University, Faculty of Aeronautics and Astronautics, Department of Airframe and Powerplant, Eskisehir/TURKEY. 0000-0003-3098-7654

Assist. Prof. Dr. Uğur TURHAN

Eskisehir Technical University, Faculty of Aeronautics and Astronautics, Department of Air Traffic Control, Eskisehir/TURKEY. 0000-0002-0653-0630

Assist. Prof. Dr. Birsen AÇIKEL

Eskisehir Technical University, Porsuk Vocational School, Department of Electronics and Automation, Eskisehir/TURKEY. 0000-0002-6067-5697

Abstract

Aircraft maintenance activities are one of the most essential factors in maintaining flight operations safely and effectively. Properly maintained maintenance activities help ensure the safety of people and aircrafts, as well as control costs. Maintenance activities are carried out by maintenance technicians with the necessary competence and training in areas such as hangars, aprons and workshops. The maintenance system is responsible for ensuring the safety and reliability of the transportation system along with the human-machine interaction. It is also a system that contains multiple interactive components. Considering its contribution to flight safety, aircraft maintenance technicians are considered as one of the most critical stakeholders of the system. Maintenance technicians must also use maintenance documents and necessary operational procedures when performing maintenance activities with human factors such as stress and workload, time pressure, and the need for improved situational awareness, in all weather conditions, before, during and after flight operations. While maintenance technicians are performing their duties, they have to act according to the maintenance documents created in accordance with international standards. The design of maintenance documents and errors in implementing the maintenance tasks of maintenance technicians have the potential to adversely affect flight operations. Based on this importance, in the study, the extent to which the current structure of aircraft maintenance documents is appropriate to the working conditions of maintenance technicians and its effects on aviation safety, qualitative research methods and stakeholder views were tried to be examined. Individual interviews and focus group practices were held with 74 participants, consisting of maintenance technicians, technical trainers and students with maintenance training. By analyzing the contributions provided by the participants, it was tried to identify the negative aspects of aircraft maintenance documents in terms of human factors, safety, suitability for maintenance operations and cost, and to propose solutions on the subject. As stated in the analysis of the study, the participants answered that by improving and interacting with maintenance documents considering human factors, maintenance technicians, especially aviation safety, can provide significant benefits to the working conditions and thus to organizations and authorities.

Keywords: Aircraft maintenance, Aircraft maintenance documents, Aircraft maintenance technicians, Human factors.

1. Introduction

The most important task that operators and aviation authorities must fulfill in order to achieve the planned targets in the aviation sector is to work together by considering all stakeholders in order to realize safe and reliable flights. In order to fulfill this task, all stakeholders, especially maintenance technicians, should be well managed in relation to aircraft maintenance activities. Aircraft maintenance activities have an important place in accidents and incidents that have occurred until today. Effective and sustainable maintenance activities will contribute to ensuring the safety of people and aircraft and effectively managing the operational costs of organizations.

In addition to problems such as densities in the air traffic system and adverse weather conditions, problems that may occur in the aircraft maintenance system can cause delays and even cancellations in flights (Toufexis, 2012). Maintenance-related errors are one of the primary causes of aircraft accidents, according to research results (Hobbs, 2008). Since the possibility of intervention to maintenance errors is relatively higher, solving maintenance problems will provide serious benefits to aviation companies in terms of cost and safety.

Maintenance activities constitute one of the basic conditions for effective and safe flight operations. In cases where maintenance activities are not carried out effectively, there may be malfunctions in the systems and performance may decrease due to this situation (Bao & Ding, 2013). Airline companies and aviation authorities carry out maintenance activities in order to prevent incidents such as accidents and crimes, and to minimize delays and cancellations that may occur in operations. In addition, they continue to work on improving the functioning of maintenance activities in order to reduce maintenance-related costs and maintain people's sense of trust in the aviation industry. In this context, it may be a solution to make the technical trainings received by maintenance technicians more efficient and to improve the technological possibilities used in aircraft maintenance environments.

Global problems are observed in the competence of maintenance technicians and the quality of training of technicians, and the lack of approving technician (C/S) is observed in maintenance companies (Güneş, 2016). Although it is known that maintenance activities are so important in terms of flight safety, the structure of maintenance documents, which are the basis of maintenance tasks, is open to improvement especially in human factors and should be evaluated in terms of the performance of maintenance technicians. Inadequate observation of the technology used during the performance of maintenance tasks compared to the technology used in aircraft operating today, and the performance of maintenance tasks with hardcopy documents are among the negative situations observed in the field of aircraft maintenance.

In this study, the maintenance documents used in aircraft maintenance activities were evaluated within the scope of safety, compliance with operations, cost and human factors, and the deficiencies related to the subject were tried to be determined. Aircraft maintenance technicians, technical instructors and students receiving maintenance training are the participants of the study. Through individual interviews and focus group interviews with the participants, it was tried to collect information on the subject and to identify the deficiencies anticipated by the participants. In this way, it was tried to provide information to stakeholders about the general status of the documents currently in use and to create data that would contribute to future studies.

2. Aircraft Maintenance

Efficient maintenance activities are necessary for the systems to fulfill their functions fully and to carry out safe flight operations that meet the airworthiness requirements. Aircrafts are delivered from the relevant manufacturer to the organization operating the aircraft under conditions that the systems are fully operational and the airworthiness criteria are met. As of the date of operation, aircraft can be exposed to technical loads such as pressure and temperature, aerodynamic loads caused by vibration and loads caused by engine thrust. In

addition, liquids caused by environmental conditions can cause corrosion on the aircraft. In addition to these, natural events such as sandstorms and lightning strikes can cause physical damage to aircraft surfaces. These situations can adversely affect aircraft performance (Garris, 2003). In order to prevent these problems, maintenance operations are carried out in order to maintain and/or improve the reliability and performance of the aircraft. These maintenance operations; It includes tasks such as repair, repair, visual inspection, and parts replacement (Hessburg, 2001). Maintenance activities are carried out by technicians who have been trained and competent in the relevant subjects, applying the standards, methods and instructions described in the relevant regulations and regulations, using the specified tools and equipment, and in areas or facilities deemed appropriate within the scope of environmental limits (SHGM, 2003). Considering that flight operations can be carried out at all hours of the day, maintenance activities can also be carried out in all periods and weather conditions under the specified conditions.

Aircraft maintenance operations; It is a process in which quality and safety standards are strictly applied. Aircraft maintenance activities are determined by the manufacturers and authorities and are supervised by the relevant aviation authorities during the operation of the aircraft. Maintenance activities are standardized in directives such as EASA-145 (European Aviation Safety Agency) and MSG-3 (Maintenance Guidance Manual) (Yu & Gulliver, 2011). Organizations are obliged to create the necessary organizational structure to protect aircraft under flight operations and to perform maintenance duties. One of the important objectives of maintenance activities, which is the most critical stage of airworthiness conditions, is to prepare the aircraft for flight at the most affordable costs for the operator, within the high safety standards (Knotts, 1999). All employees, especially the aircraft operators, are responsible for meeting these conditions.

Maintenance activities are beneficial in keeping the aircraft within design limits in terms of reliability and performance issues in the post-production operating processes (Friend, 1997). Maintenance activities carried out under appropriate conditions will make significant contributions to organizations in terms of cost by reducing delays, flight cancellations (Van den Bergh et al., 2013). Maintenance activities are implemented in line with the maintenance programs prepared within these objectives. The goals of care programs can be listed as follows (Shanmugam & Paul Robert, 2015);

- Ensuring that the system and components work in appropriate safety and reliability standards,
- Returning the system/component to safe and reliable working conditions in case of a possible problem,
- Providing the necessary information for the improvement and optimization of the program when the safety level of the maintenance program changes,
- Providing information in order to identify and develop situations where duties are insufficient when changes occur in the safety level of maintenance programs,
- To achieve the objectives given above at the lowest possible costs.

The maintenance organization, which is planned, established and managed with an efficient and appropriate method, will achieve success in safety, reliability and cost, which are the main objectives of its maintenance. In addition, it will contribute to the achievement of the business goals. Therefore, the goals of maintenance activities should be considered and planned during the establishment process of the organization (Paluszek, 2014) (Figure 1).

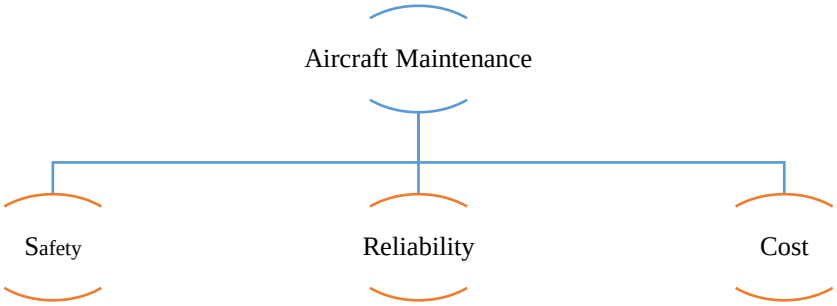


Figure 1. Purposes of maintenance activities

3. Aircraft Maintenance Documents

The documentation process is used in all aircraft maintenance activities. These documents explaining the maintenance requirements may differ depending on the aircraft types. Airline operators need to use only the most current version of their maintenance documentation. Maintenance documents are created by aircraft and component manufacturers, evaluated by regulatory authorities, and arranged and implemented by airline operators according to maintenance programs (Kinnison, 2007). These documents used when performing maintenance tasks are created from different sources. These; It includes the information required to prepare the job, warning and attention messages, procedures in the implementation of maintenance and the actions to be taken after the maintenance tasks are completed. In order to increase safety and to set a standard by eliminating the differences of opinion between technicians, the documents need to be prepared and applied properly. Up-to-date studies are also being carried out to make the documents more convenient, considering the cost issue (Zafiharimalala et al., 2014). For example, physical, cognitive and social contributions will be provided to maintenance technicians by using documents prepared in the digital environment in maintenance areas.

Aircraft maintenance document is a resource created by aircraft manufacturers for all aircraft types and contains information that meets the airworthiness requirements (Aviationglossary, 2020). The writing and expression formats used in the creation of documents are mostly prepared in a way that every user can understand and use. This simple structure, which is seen in my narration and writing, makes it easier to understand the transactions on the one hand, and also creates some disadvantages. Considering the complex structures in the systems and components, the descriptions in the documents are sometimes not efficient in terms of usage. The current structure of documents increases the number of pages used and creates difficulties in accessing and using the documents. The maintenance technician must have access to the information in the most accurate way in order to prepare the aircraft for which he carries out his maintenance task in the safest and shortest time possible. These requirements cannot be fulfilled at the desired levels with the current structure of the documents (Güneş, 2016). Aircraft maintenance documents can be examined under three different headings: documents created by manufacturers, regulatory documents created by certain authorities, and operator documents.

3.1. Manufacturer Documents

These documents created by aircraft manufacturers can be created in different ways according to aircraft types. Manufacturer documents can be prepared and updated in line with the requests of the operators in some cases, while in some cases the manufacturer documents are created completely by the producer decisions (Kinnison, 2007). Manufacturer documents are listed in Table 1.

Table 1. Manufacturer documents (Sirat ve Harun, 2006)

Document	Abbreviation
Airplanes maintenance manual	AMM
Component maintenance manual	CMM
Vendor manuals	VM
Fault isolation manual	FIM
Fault reporting manual	FRM
Illustrated parts catalog	IPC
Storage and recovery document	SRD
Structural repair manual	SRM
Maintenance planning data document	MPD
Schematic diagram manual	SDM
Wiring diagram manual	WDM
Master minimum equipment list	MMEL
Configuration deviation list	CDL
Task cards	TC
Services bulletins	SBs

2.1.1. Aircraft Maintenance Manual (AMM)

Aircraft Maintenance Manual (AMM) is a document that contains information about maintenance activities and flight operation procedures and explains how the maintenance should be carried out. This document begins with how systems will work, explains maintenance activities and replacement processes and adjustments such as system, equipment tests and functional tests (Kinnison, 2007). The maintenance manual describes the structures of all systems and components on the aircraft. Some of the transactions in the document are given below (FAA, 2016);

- Identification of systems (electrical, hydraulic, fuel and control systems, ...),
- Lubrication processes applied on components,
- Identification of primary and secondary structures and systems,
- Special repair methods,
- Special examination methods (x-ray, ultrasonic),
- Tolerance and adjustments required for effective operation of aircraft,
- Balancing of control surfaces,
- List of all tools.

The deficiencies in the logic of creating aircraft maintenance documents and the application errors of maintenance technicians seriously affect flight operations. Maintenance activities performed by maintenance technicians without depending on the relevant documents also constitute approximately %64 of maintenance errors (FAA, 2004). Considering these data together, it becomes evident that the maintenance technician's ability to access documents, the ability to read and understand documents, and the ability to use documents are critical factors for aviation safety.

3.2. Regulatory Documents

Regulatory documents are documents covering the modifications, changes and updates that occur during the operating period for the maintenance activities to be performed for the aircraft that continues flight operations within the relevant organization after the production process of the aircraft. Regulatory documents are listed in Table 2.

Table 2. Regulatory documents (Sirat ve Harun, 2006)

Document	Abbreviation
Aviation regulations	FARs, JAR, EASA, BCAR
Advisory circulars	ACs
Airworthiness Directives	ADs

Regulatory documents consist of aviation regulations, advisory circulars and airworthiness guidelines established by aviation authorities such as the European Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA).

3.3. Operator Documents

Operator documents are documents prepared by aircraft maintenance organizations in order to perform maintenance tasks more effectively and efficiently. The structure of the operator documents may differ from operator to operator, provided that the basic lines do not change. The documents prepared by the operators are listed in Table 3.

Table 3. Operator documents (Sirat ve Harun, 2006)

Document	Abbreviation
Technical policies and procedures manual	TPPM
Maintenance Organisation Exposition	MOE
Inspection manual	IM
Reliability program manual	RPM
Minimum equipment list	MEL
Task cards	TC

Operator documents created by airline companies are prepared in accordance with international standards, aviation authorities and aircraft manufacturers' documents. Businesses are subject to the inspections of the authorities while creating these documents and performing maintenance activities.

4. Methods

Despite the effective use of information technology systems such as cockpit systems, cabin systems, flight information and cargo systems in the aviation field and good results from these systems, these technologies cannot be used at the desired levels in aircraft maintenance activities. Today, maintenance activities in many organizations are still carried out on a single main computer and are carried out using systems developed in the 1970s (Sahay, 2012). These negativities observed in the field of care constitute the main agenda of the study. In this study, the current structure of aircraft maintenance documents was analyzed and evaluated through observations made in the maintenance fields, academic researches, and individual interviews and focus group interviews with maintenance technicians, technical instructors providing maintenance training and maintenance training students.

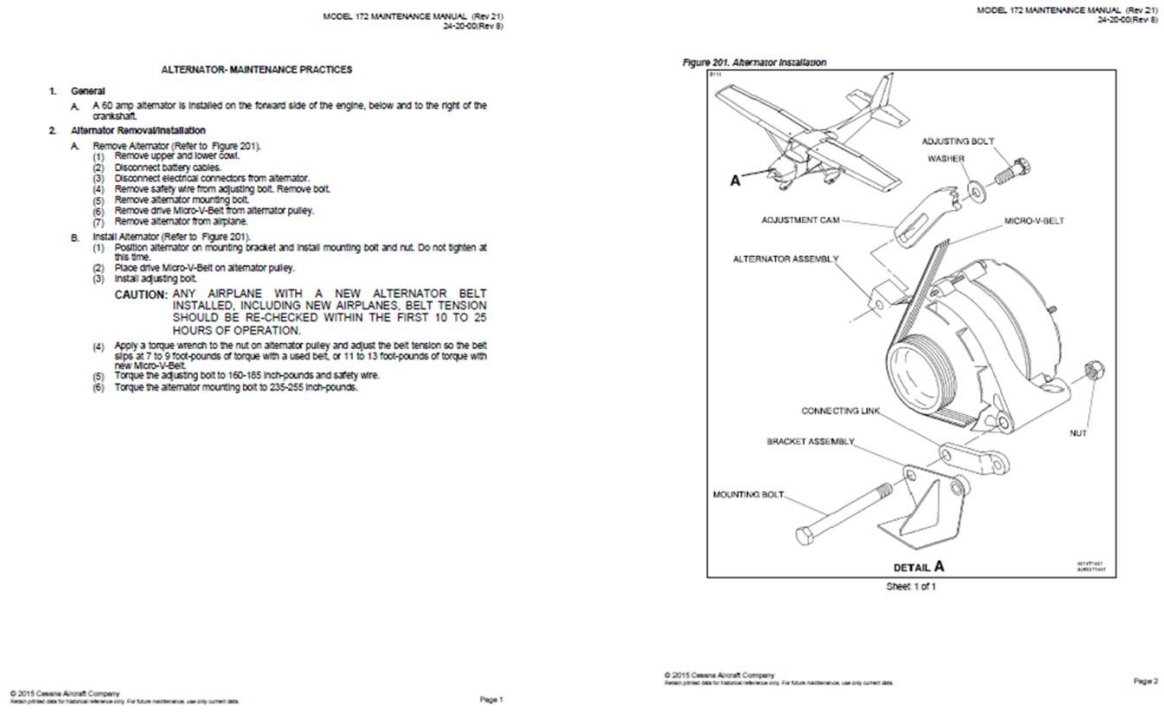
In this study, the current structure of maintenance documents has been tried to be analyzed in terms of aviation safety, human factors, compliance with maintenance operations and cost. As a result of the observations made in the maintenance areas and the preliminary interviews with the participants, among the aircraft maintenance document prepared for the Cessna 172 aircraft type, the "Alternator Replacement" maintenance task numbered 24-20-00 was deemed appropriate as the application subject of the study. After this maintenance task was examined in detail, interview forms were prepared for the evaluations to be made by the participants.

The analysis of the data obtained from a group of 74 participants consisting of maintenance technicians, technical instructors and students was tried to be analyzed using qualitative research methods. The data obtained as a result of the individual interviews and focus group

discussions were evaluated using the content analyzis method and codes and themes were created according to the participants' responses.

The biggest limitation encountered during the research process was the information and data sharing policies of the care organizations. Another limitation encountered was the deficiencies in the existing legal regulations. There are a number of obstacles in the legislation for the direct use of the studies in the field in working environments. With the increase in the studies on aircraft maintenance activities in the future, it is thought that the application areas will be more usable, and this study will contribute to both the field literature and the safer and more efficient implementation of maintenance practices.

In the first part of the application, after the participants were informed about the purpose and method of the research, the forms prepared for the relevant maintenance task and the maintenance task document (Figure 2) were distributed. Participants were asked to evaluate this maintenance task in terms of aviation safety, human factors, suitability for maintenance operations and cost.



MODEL 172 MAINTENANCE MANUAL (Rev 21)
24-20-00/Rev 8)

ALTERNATOR- MAINTENANCE PRACTICES

1. General
   A. A 60 amp alternator is installed on the forward side of the engine, below and to the right of the crankshaft.
2. Alternator Removal/Installation
   A. Remove Alternator (Refer to Figure 201).
      (1) Remove upper and lower cowl.
      (2) Disconnect battery cables.
      (3) Disconnect electrical connectors from alternator.
      (4) Remove safety wire from adjusting bolt. Remove bolt.
      (5) Remove alternator mounting bolt.
      (6) Remove drive Micro-V-Belt from alternator pulley.
      (7) Remove alternator from airplane.
   B. Install Alternator (Refer to Figure 201).
      (1) Position alternator on mounting bracket and install mounting bolt and nut. Do not tighten at this time.
      (2) Place drive Micro-V-Belt on alternator pulley.
      (3) Install adjusting bolt.
      CAUTION: ANY AIRPLANE WITH A NEW ALTERNATOR BELT INSTALLED, INCLUDING NEW AIRPLANES, BELT TENSION SHOULD BE RE-CHECKED WITHIN THE FIRST 10 TO 25 HOURS OF OPERATION.
      (4) Apply a torque wrench to the nut on alternator pulley and adjust the belt tension so the belt slips at 7 to 9 foot-pounds of torque with a used belt, or 11 to 13 foot-pounds of torque with new Micro-V-Belt.
      (5) Torque the adjusting bolt to 160-185 inch-pounds and safety wire.
      (6) Torque the alternator mounting bolt to 235-255 inch-pounds.

© 2015 Cessna Aircraft Company
Page 1

MODEL 172 MAINTENANCE MANUAL (Rev 21)
24-20-00/Rev 8)

Figure 201. Alternator Installation

Sheet 1 of 1

© 2015 Cessna Aircraft Company
Page 2

Figure 2. AMM Pages (Cessna 172)

At this stage, participants were asked to first examine the document and evaluate aviation safety, compliance with maintenance operations, human factors and cost.

5. Data Analysis

The data obtained as a result of the application were evaluated by content analysis and descriptive analysis methods. In the research, after analyzing the forms filled out by the participants, it was tried to be evaluated with the help of the coding technique. The results obtained as a result of the evaluations made were evaluated according to the responses of the participants. This technique was deemed more appropriate because the participants used more than one code or theme in their evaluations.

In the first section where the participants evaluated the documents in terms of safety, the code selected was "safety", while the codes created according to the participant evaluations

were "positive" and "negative". Due to the high rates of responses given by the participants with a negative code in this section, the code defined with its negative name is divided into the themes of "FOD (Foreign Object Damage) Risk", "Lack of Information", "Possible Errors and Personal Protection" and "Attention and Perception". Participants made a total of 82 different views in the first part, and therefore it was deemed appropriate to use more than one code and theme. The evaluation results for the first part are given in Table 4.

Table 4. Evaluation of maintenance documents in terms of 'Safety'

Evaluation of maintenance documents in terms of 'Safety'		**Answers**
Negative (%80,49)	FOD Risk	3
	Lack of Information	11
	Possible Errors and Personal Protection	38
	Attention and Perception	14
Positive (%19,51)		16

As a result of the evaluation, existing maintenance documents were evaluated negatively at the rate of %80.49 in terms of safety, while %19.51 were evaluated as positive. While %57.58 of the participants who evaluated the documents negatively evaluated that the lack of information about possible errors and personal protectors created a negative situation in terms of safety, they found that the documents could cause attention and perception errors at a rate of %21.21, that they contained information deficiencies at a rate of %16.67 and that the FOD risk was %4.54 evaluated that it can create. It was evaluated that using the documents as computer printouts creates difficulties in transportation and use for the technicians working under difficult working conditions in maintenance areas, and it was answered that this situation may create FOD risk on the ground or on the aircraft.

In the study of the National Aviation and Space Administration (NASA) examining aircraft accidents, it was emphasized that documentation problems play an important role directly or indirectly in the causes of the accident (Hobbs, 2008). In another study, it was stated that the maintenance tasks performed without depending on the documents constitute %64 of the total maintenance errors. (Zafiharimalala, 2014). Considering the aforementioned data and statistics together, it becomes evident that the current structure of maintenance documents has negative effects on safety and the need for improvements in this regard.

In the second part, participants were asked to evaluate maintenance documents in terms of compliance with maintenance operations. The selected codes were "positive" and "negative", while the themes selected for negative code were "not portable", "not usable" and "not portable and usable". Evaluation results are given in Table 5.

Table 5. Evaluation of maintenance documents in terms of 'Compliance with Maintenance Operations'

Evaluation of maintenance documents in terms of 'Compliance with Maintenance Operations'		**Answers**
Negative (%76,71)	Not portable	7
	Not suitable	29
	Neither portable nor usable	20
Positive (%23,29)		17

In this section, 73 different opinions were received from the participants. Maintenance documents were evaluated negatively at the rate of %76.71 regarding compliance with maintenance operations, while %23.29 were evaluated positively. In the themes selected under the negative code, %51.78 of the documents are not usable, %12.5 are not portable, and %35.72 are not portable and usable. In this section, it has been concluded that the content information of the documents is as important as the physical structure. While performing the maintenance tasks of the documents, it was evaluated that the technician could cause problems for both transportation and use during the mission, especially when working in hard to reach areas or in adverse weather conditions.

In the third part, the participants were asked to evaluate the maintenance documents in terms of airline costs. The codes selected in this section were "positive" and "negative". Evaluation results are given in Table 6.

Table 6. Evaluation of maintenance documents in terms of 'Airline Costs'

Evaluation of maintenance documents in terms of 'Airline Costs'	**Answers**
Positive (%4,41)	3
Negative (%95,59)	65

68 different opinions were received from the participants in this section. While %95.59 of the documents were evaluated as negative in terms of cost, %4.41 were evaluated as positive (Figure 8). Participants expressed the opinion that the use of the documents in the format of hardcopy brings a high amount of consumable costs. The Civil Aviation Authority (CAA) has revealed in its research that a maintenance technician devotes %25 of the total time to the review and use of maintenance documents while performing maintenance tasks (CAA, 2002). In the research conducted by Boeing, it has been suggested that with the transition to interactive methods in the creation and use of documents, an average of 4000 pages of paper per day can be saved in a maintenance organization (Douglas & Miller, 2014). When these data are evaluated, it is thought that by using interactive methods in the creation and use of maintenance documents, it is thought that both maintenance times will decrease and organizations will make significant contributions in terms of cost.

In the fourth part, the participants were asked to evaluate the documents in terms of human performance. While the codes selected in this section are "positive" and "negative", the themes selected under the code of negative are "Attention and Perception", "Situational Awareness", "Time Pressure" and "Workload". Evaluation results are given in Table 7.

Table 7. Evaluation of maintenance documents in terms of 'Human Factors'

Evaluation of maintenance documents in terms of 'Human Factors'		**Answers**
Negative (%80,67)	Attention and Perception	63
	Situational Awareness	11
	Time Pressure	5
	Workload	17
Positive (%19,33)		23

In this section, 119 different opinions were received from the participants. While the documents were evaluated negatively at a rate of %80.67 in terms of human performance, it was evaluated as positive at a rate of %19.33. When the themes selected under the code negative were examined, the documents were evaluated as %65.62 negative about attention and perception, %17.71 negative about workload, %11.46 negative about situational awareness and %5.21 negative about time pressure.

Pourcho suggested that the current structure of maintenance documents may negatively affect the performance of maintenance technicians and that the documents to be created can positively affect the technician perception of the documents to be developed and used, and a safer and more efficient working environment can be created (Pourcho, 2008).

6. Results

In this study, maintenance documents have been evaluated in terms of aviation safety, compliance with maintenance operations, cost and human factors. In the study, among qualitative research methods, individual interviews and focus group interviews methods were used. A study was conducted with a group of 74 people, consisting of aircraft maintenance technicians, technical trainers and maintenance training students, and the participants' opinions on the existing maintenance documents were received. As can be understood from the statistics given in the study, aircraft maintenance activities are very important in order to maintain aviation safety. In cases where maintenance activities cannot be carried out properly, maintenance errors may occur, incidents such as accidents and crimes may occur, and organizations may face serious cost problems. Although the impact of maintenance activities on aviation operations is known, the insufficiency of the technology used in maintenance areas and the current structure of maintenance documents can sometimes cause negative consequences, considering the difficult working conditions.

In this study, in which the current structure of aircraft maintenance documents was tried to be analyzed, the documents were evaluated in terms of aviation safety, human factors, compliance with maintenance operations and cost issues. Observations in care areas and academic studies on the subject were supported by individual interviews and focus group discussions with industry stakeholders. In line with the opinions of the participants, the documents were rated %80.49 negative and %19.51 positive in terms of safety. In the evaluations made under the code negative, the documents were %57.58 negative about possible errors and personal protectors, %21.21 negative about attention and perception, %16.67 negative about lack of information and %4.54 negative about FOD risk. It was evaluated. In the second part, the documents were asked to evaluate their suitability for maintenance operations. The documents were evaluated negatively at a rate of %76.71 and positive at a rate of %23.29 in terms of compliance with maintenance operations. In the evaluations made under the code negative, %51.78 are not usable, %12.5 are not portable and %35.72 are not portable and usable. In the third part of the study, the documents were asked to be evaluated in terms of airline costs. Documents were rated as negative at a rate of %95.59 and positive at a rate of %4.41 regarding cost. In the fourth part of the study, the documents were asked to be evaluated in terms of human performance. The documents were rated %80.67 negative and %19.33 positive in terms of human performance. In the evaluations made under the code negative, %65.6 were evaluated as negative about attention and perception, %17.71 negative about workload, and %5.2 as negative about time pressure.

According to the evaluations of the participants, aircraft maintenance documents were highly negatively rated in terms of aviation safety, human performance, compliance with maintenance operations and cost. The result is that there may be a risky situation in terms of safety, such as the lack of sufficient information about personal protective equipment and possible errors in

the mentioned maintenance document, the lack of explanation in written and visual expressions at the desired level, and deficiencies in technical information regarding maintenance tasks. The fact that maintenance documents are sometimes difficult to transport and use for technicians working in adverse weather conditions or in difficult to reach or dark areas creates negativities in terms of compliance with maintenance operations. The structure of the documents in the format of computer printouts in both usage and registration processes creates a significant cost to organizations. Thousands of pages of paper can be consumed in a day. The technician, who uses the current state of the documents, allocates a significant part of the maintenance tasks to the documentation works in the mentioned processes and thus a serious workload is created. This can also create time pressure for technicians.

Gordon Dupont, who has conducted studies on errors caused by human factors in the field of maintenance, advocates that the maintenance technician can make mistakes in subjects such as lack of communication, lack of knowledge, distraction, fatigue due to workload, complacency and lack of awareness in the "Dirty Dozen" classification (FAA, 2004). As explained in the study, the technician who accesses the maintenance documents in interactive environments, will be more likely to avoid errors arising from the mentioned titles.

Aircraft manufacturers, especially Boeing and Airbus, which have a say in the aviation field at an international level, have also revealed the problems observed in the aircraft maintenance sector and showed the necessity of using the maintenance documents with interactive methods ((Chaparro & Groff, 2002), (Douglas & Miller, 2014), (Pourcho, 2008), (Wade, 2011)). This situation is one of the important bases that the developments that can be observed in maintenance activities in the future will be in this direction.

The existing structure of maintenance documents should be prepared and used in interactive environments, benefiting from today's technologies, in order to minimize the mentioned negativities and thus create a safer and more effective maintenance area. In this way, the workload and time pressure of maintenance technicians will be reduced, maintenance times will be shortened, maintenance errors will be reduced, communication problems will be minimized. The use and transportation problems of documents will be eliminated and more ergonomically favorable working conditions will be created for maintenance technicians. A safer working area will be created by performing the maintenance tasks step by step and monitoring the maintenance activities instantly. For organizations, the amount of consumable materials used will decrease, and maintenance errors, accidents and crimes will decrease, so significant benefits will be achieved in terms of costs. In this way, an important service will be provided in the formation of a safer and more efficient airway transportation system.

Acknowledgments

We would like to express our thanks to Eskisehir Technical University and Faculty of Aeronautics and Astronautics' administration, employees and students who assisted to carry out our study.

References

- Aubin, B.R. (2004). Aircraft Maintenance-The Art and Science of Keeping Aircraft Safe. Washington: SAE International.
- Bao, M. and Ding, S. (2013). Individual-Related factors and management-related factors in aviation maintenance. Procedia Engineering, 80 (2014), 293-302.
- Civil Aviation Authority (CAA). (2002). CAP718 Human factors in aircraft maintenance and inspection. UK Civil Aviation Authority.
- Chaparro, A. and Groff, L. S. (2002). Human factors survey of aviation maintenance technical manuals. 16. Human Factors in Aviation Maintenance Symposium.

- Douglas, R. and Miller, P.S. (2014) New maintenance applications for iPad, Boeing Aero., 54, 13-18.
- Federal Aviation Administration (FAA). (2004). Final Report: A comparison of three evaluative techniques for validating maintenance documentation. U.S. Department of Transportation Federal Aviation Administration.
- Garris, J.T. (2003) Aircraft Maintenance. M. Davies (Ed.), The Standart Handbook for Aeronautical and Astronautical Engineers (pp. 18.1-18.82)., New York, A.B.D: McGraw Hill.
- Hessburg, J. (2001). J. Hessburg (Ed.), Maintenance Fundamentals," Air Carrier MRO Handbook (pp. 245-270). New York: McGraw-Hill Companies.
- Hobbs, A. (2008). An overview of human factors in aviation maintenance. Canberra City: Australian Transport Safety Bureau.
- Kinnison, H.A. (2007). Aviation maintenance management, A.B.D: McGraw-Hill Companies.
- Knotts, R.M.H. (1999). Civil aircraft maintenance and support fault diagnosis from a business perspective. Journal of Quality in Maintenance Engineering, 5, 335 – 348.
- Paluszek, G. (2014). Planning efficient airplane maintenance facilities. Boeing Aero., 54, 19-24.
- Pourcho, J.B. (2008). Augmented Reality Application Utility for Aviation Maintenance Work Instruction, Unpublished master's thesis. South Carolina: Purdue University.
- Sahay, A. (2012). Leveraging information technology for optimal aircraft maintenance, repair and overhaul (MRO), U.S.A.:Woodhead Publishing Limited.
- Sivil Havacılık Genel Müdürlüğü (SHGM). (2003). Sürekli Uçuşa Elverişlilik ve Bakım Sorumluluğu Yönetmeliği (SHY-M). Sivil Havacılık Genel Müdürlüğü, Ankara.
- Sivil Havacılık Genel Müdürlüğü (SHGM). (2014). Sürekli Uçuşa Elverişlilik ve Bakım Sorumluluğu Talimatı (SHT-M). Sivil Havacılık Genel Müdürlüğü, Ankara
- Shanmugam, A. and Paul Robert, T. (2015). Raking of aircraft maintenance organization based on human factor performance. Computers & Industrial Engineering, 88, 410-416.
- Toufexis, D. (2012). Aircraft Maintenance and Development of a Performance-based Creep Life Estimation for Aero Engine, Unpublished master's thesis, Bedfordshire: Cranfield University.
- Tretten, P. ve Normark, C.J. (2014). Human factors issues in aircraft maintenance activities: A holistic approach. Human Factors and Ergonomics Society Annual Meeting Portugal: Lisbon.
- Yu, J. Ve Gulliver, S. (2011). Improving aircraft maintenance, repair, and overhaul: A novel text mining approach. International Conference on Intelligent Computing and Intelligent Systems. Guangzhou, China.
- Yüksel, S. (2008). Türkiye'deki Havaaracı Bakım Faaliyetlerinde Dış Kaynak Kullanımının Araştırılması ve Değerlendirilmesi. Unpublished master's thesis. Eskişehir: Anadolu University.
- Van den Bergh J, De Bruecker P, Beliën J, Peeters J. (2013). Aircraft maintenance operations: state of the art. HUB Research Paper.
- Wade, E.G. (2011). Exploring the Effect of Human Factors Regulations on Aviation Maintenance Organizations, Unpublished doctoral dissertation, Arizona: Northcentral University.
- Zafiharimalala, H., Robin, D. and Tricot, A. (2014). Why aircraft maintenance technicians sometimes do not use their maintenance documents: towards a new qualitative perspective. The International Journal of Aviation Psychology, 24, 190–209.
- http://www.skybrary.aero/index.php/Service_Bulletin (Date of Access: 15.10.2020).