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DIGITIZATION OF AIRCRAFT MAINTENANCE PROCEDURES

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Abstract

This paper presents the results of research on the possibilities of implementing digitized procedures in the environment of heavy aircraft maintenance and deals with the design and implementation of digitized procedures in the hangar. The object of the paper is the maintenance procedures in section 10/20 of the BMD department in the company ATB s.r.o. which performs maintenance on the cabin and fuselage parts of the aircraft. In the paper we analyze current maintenance procedures in the designated department and examines the effects of digitized procedures on increasing work efficiency. It proposes the method and individual phases of the implementation of digitized procedures. In the first phase, a solution is implemented to replace the paper form of maintenance documentation, used by mechanics during maintenance, with their digitized form. The other two phases are described theoretically. The thesis identifies obstacles associated with the implementation of the proposed procedures and offers possible solutions.

Keywords

Maintenance, Paperless, Digitalization, Introduction

1. INTRODUCTION

In recent years more Airlines and MRO companies are looking for options to digitalize processes and reduce the need for paper usage in their operations. With evolving technologies and software solutions, it is becoming more available for them to make decisions and move toward paperless operations. In an aircraft maintenance environment trading paper for digital format doesn´t have an impact only on cost reduction and environment but can also enhance effectiveness and safety. [1].

Swiss International Air Lines recently invested in digital solutions to get rid of paper for their operations. Currently Swiss is one of a few airlines doing all CAMO and line maintenance work paperless. Engineers use tablets to work with maintenance documentation. They manage to save about 1.5 million sheets of paper a year with new digitalized solutions, saving time by eliminating time consuming process of transferring paper into IT and reduce the risk of mistakes during the transfer.[2]

In 2017, IATA published guidance material for the implementation of paperless aircraft operations in Technical operations. For paperless maintenance operations, they identified two production control key result areas: workflow optimization and time visibility. To accomplish these, the following measures are considered necessary:

1. Improved task card completion rates

2. Optimal utilization of manpower

3. Improved quality through data-driven process improvement.

In many plans, undue delays in productivity are a direct result of paper-based systems whereby records can be misplaced or destroyed. Some of the biggest productivity bottlenecks involve duplicate data whereby having more than one system in place can create unnecessary data storage that adds to the time and cost required to support business operations. [3]

Recently released software, by company Swiss AviationSoftware Ltd., AMOSmobile/EXEC, is an extension of current AMOS MRO software, designed for mobile devices.

AMOSmobile/EXEC offers a full-scope functional platform for line and base mechanics. It is designed with the goal to enable the paperless execution of all line & base maintenance activities and eliminate tons of paper created in the process of documenting all maintenance steps. [4]

Figure 1 - Amos mobile functions (https://www.swiss-as.com/amos-mro/amosmobile)

In our study, we participate in aircraft maintenance procedures in an MRO company based in Slovakia. As AMOS is the software used to manage maintenance operations in this company, the mobile extension provides an oprotunity to implement this system and move toward paperless operations in the hangar.

2. METHODOLOGY

In our research, we focused on collecting data through observation of maintenance procedures. We achieved this by participating in aircraft maintenance at MRO company based in Slovakia. Aircraft maintenance is a complicated process, its completion is divided into many stages and performed among multiple departments within the company.

2.1. Research environment

We conduct our research in a base maintenance department, which is responsible for conducting base maintenance operations on the aircraft. We focused on researching the procedures of 10/20 cabin/fuselage section mainly for these reasons:

1. It is the largest section of aircraft base maintenance.

2. It is the department with the most mechanics in one shift.

3. It contains a large variety of tasks, as well as structural inspections

4. Heavy workload and usage of maintenance documentation

Research is conducted during C check on A/C type Embraer 190(E190). It is a twin engine single-aisle passenger aircraft. As previously stated, we were focused on fuselage/cabin maintenance operations. On E190 it encompasses the cockpit, cabin externally/internally, front and aft cargo compartments.

2.2. Methods and focus

While participating in aircraft base maintenance procedures we focused on observation of maintenance procedures in cabin/fuselage section with the following analysis from the point of view of suitability for digitalization. In this paper, we cover two categories of maintenance procedures: Removal and Inspections/findings. During the period of month of research, we observed and documented current maintenance procedures. In the second part we conducted data collection and the following analysis. As a collection sample, we worked with 2 mechanics in the period of 10 working shifts. Here we collected data on the usage of maintenance documentation, printed maintenance documentation, usage of aircraft maintenance software on station computers, number of moves that are needed to be done during the shift and time spent on these events. In the last part we implement digitalized procedures, by replacing printed forms of documentation with a mobile device(iPad) and analyze their impact on aircraft maintenance in our examined environment.

3. RESULTS

In this part, we present and evaluate the results of our research. Our goal was to find a heavy maintenance environment and determine appropriate ways to digitize current procedures. As well as the course of our research, we divide its results into three main parts:

- Observation of maintenance procedures and their analysis
- Collection of data on the use of paper in heavy maintenance
- Proposal and implementation of digitized procedures

3.1. Observation of maintenance procedures and their analysis

This part of the research aimed to identify the procedures for individual parts of the maintenance performance, the documentation used in the execution of the work and to evaluate the possibilities of digitization of the current procedures and the impact on the efficiency of the work performance.

3.1.1. Removal

Removing panels and components from an aircraft is one of the first processes performed on an aircraft after it is accepted for maintenance. Their removal may be necessary for several reasons:

- The component has reached the limit of its service life and must be replaced or overhauled.
- A component or part is damaged and needs to be repaired/replaced
- A panel or part covers an area that needs to be inspected and needs to be temporarily dismantled

As one of the first steps, we found out what type of documentation is used in this process and in what form the mechanics have access to it. The first basic documentation that the mechanic uses is the Workorder, hereinafter referred to as WO. Original WO which is subsequently used as a legal document with a signature and is stored and can only be printed once. The mechanic therefore receives a printed copy marked as "working copy", which he subsequently throws away after the work is done. This document represents a work order, where the mechanic receives information about what performance of work is required of him. It is therefore a document that the mechanic has with him while working on the aircraft. The unique WO number is important information, the mechanic uses it to identify and match the dismantled part to the given WO through TRT and for the subsequent operations performed in the AMOS system, which represent recording the time for the performance of the given work, ordering the material and subsequently adding data to the WO before printing its final version.

Another type of documentation used by the mechanic is AMM, AIPC, Panel List. The AMM is a basic document that the mechanic must have with him during his work. This document contains a detailed procedure/instructions for performing the assigned work, according to which the mechanic proceeds. In the current processes, as well as the WO, it is necessary to obtain a paper version of the AMM. This results in the need to move from the plane to the station, search for the manual and then print it. After the work is completed, the manual is thrown away. It is not possible to store it for further use, the reason is to ensure the use of the current version, as the manuals are often revised and supplemented.

In this process, we identify several advantages for implementing digitized procedures in the form of a mobile device that would allow the mechanic to view maintenance documentation and access MRO software. The main benefit would be continuous access to the current version of the maintenance documentation, which can reduce the risk of errors when using their outdated version and reduce the number of movements performed during the performance of work. The benefit is also easier identification of individual components, which is important during subsequent inspections and reassembly and prevents delays in the event of problems with incorrect labeling of individual parts. We see the greatest contribution to the simplification of current procedures in the new addition to the AMOS system. With the possibility of implementing the latest version of the AMOSmobile system, which enables the electronic signing of documents, it would be possible to eliminate the printing of the paper form of the WO from the current procedures. [4]

Immediate access not only to the current maintenance documentation but also to the MRO software means simplifying the work for the mechanic and increasing the efficiency of the performed tasks. It allows the mechanic to perform all work directly at the aircraft without having to move to the station and then back to the aircraft. Another advantage is the possibility of ordering material directly from the plane. This reduces the risk of forgetting to order the necessary part, between the time the mechanic discovers the missing/damaged part and the time he gets to the software at the station and orders the goods. This is a key step in preventing a missing part when you go to reassemble components on the aircraft and find that the part is not ready. In some cases, the part is not even available in the company's stock, and it is necessary to wait a long time for its delivery, which can lead to an unwanted extension of the maintenance performance. Another advantage that we identify when ordering goods is the possibility to track the status of the delivery of the goods without having to go to the computer. Thus, the mechanic does not have to leave the plane several times or interrupt the performance of work to find out the availability of the necessary part or consumables that he needs to perform the work. He can monitor in real-time when the part he needs to perform the work was released from the warehouse and time the most suitable moment for its collection to affect the performance of his work as little as possible.

3.1.2. Inspection/findings

Inspections and records of findings are carried out after disassembly or are carried out simultaneously with the disassembly process, which takes place on another part of the aircraft. This process takes place as well as directly on the aircraft in the case of components that have not been dismantled or parts that are part of the supporting structure of the aircraft, as well as outside it in designated places during individual sessions. This is mainly in the case of dismantling components from the aircraft (e.g., PSU, overhead bin, panels).

The type of documentation used for component inspections is CMM. The mechanic uses the paper form of this maintenance documentation for the exact identification of specific components and their subsequent registration together with the damage found.

It is during off-aircraft inspections when it is necessary to carry out inspections on a large number of components such as "overhead bins", that we have identified the possibility of increasing efficiency with the help of digitized processes. This was mainly due to the need to record a high number of damages on a large number of components. Each damage must be assigned to a component and identified by P/N and/or panel number. Subsequently, this information must be transferred to the AMOS system when opening a finding WO. Currently, this data is written by the mechanic on paper, this can lead to errors when writing data and subsequent transfer to the AMOS system in the case of large quantities of components. Also, this process is lengthy and there is duplication of systems. When using the mobile version of AMOS mobile, the mechanic would be able to record this data in the system directly during inspections. [4] This would ensure a reduction in the risk of errors and incorrectly entered data when transferring data from paper form to digital, and at the same time reduce the workload required to perform the given work.

When analyzing the current and proposed digitized procedures, we identified one of the factors that causes a problem in the direct entry of data into the AMOSmobile system, in the case of components consisting of different types of materials. The reason for this is the need to divide the damaged components into groups, according to the method of repair, and then assign them to the appropriate department to repair. Damage to metal parts is sent for repair to the SM department and damage to composite materials to the WSD department. For this reason, it is necessary to perform inspections of individual components first, followed by division into groups according to the type of damage. Only after such a division of components is appropriately marked and assigned for repair to a specific department is it possible to open a discovery WO. In it, groups of components are subsequently entered according to damage, which allows them to be more easily divided into the relevant departments and ensures more efficient execution of the repair itself.

A possible solution for eliminating the intermediate step in the form of paper primary records is the creation of a template, in a program located in a mobile device, for performed inspections of a large number of components. the mechanic would record the damages found during the inspection and then they would be automatically assigned to groups according to the type of damage. This would allow the mechanic to simply copy the sorted lists into the AMOS software and open a new find WO. In this case, we consider the simplest solution to be the creation of a template in the Excel program, for the most frequently repeated inspections in which many components are checked. As a result, templates can be adapted and damage can be distributed to the materials that the component contains. [5] Excel offers options for easy data entry, sorting, and filtering. This will allow the mechanic to simply copy the individual panel names and part numbers from the maintenance documentation into a pre-prepared template and then transfer the sorted lists to the AMOSmobile system. The benefit is the streamlining of the work performed, the unification of all operations into one device, and the elimination of the need to transfer data from paper to digital form.

3.1.3. Data collection

The second part of the research is dedicated to the collection and analysis of data on the use of paper documentation in heavy maintenance processes. In this part, we focused on collecting information from two mechanics, during a time interval of ten days, with whom we cooperated during our work. The basic data, which we set for our research as supporting and at the same time according to IATA recommendations, are given as key indicators. [3] The basic elements that we monitored related to one work shift:

- Number of used maintenance documentation (and the necessity of printing)
- Number of movements from the plane to the station
- Number of uses of the AMOS system on a desktop computer
- The time that is spent during this activity
- The time required to move between the plane and the station

The goal is to present the possibilities of increasing the efficiency of work performance through the proposed digitized procedures. The examined indicators represent areas whose efficiency can be achieved by implementing mobile devices in maintenance procedures, equipped with the possibility of displaying maintenance documentation and enabling access to the AMOS system.

Table 1 - Measurments mechanic 1(Author)

Hodnoty za 10 dni					
Mechanik 1	Dokumentácia	AMOS	Čas(min.)	Počet pohybov	Čas(min.)
Spolu	40	55	375	61	153
Priemer	4	5,5	37,5	6,1	15,3

Table 2 - Measurments mechanic 2(Autor)

Hodnoty za 10 dni					
Mechanik 2	Dokumentácia	AMOS	Čas(min.)	Počet pohybov	Čas(min.)
Spolu	27	46	370	51	122
Priemer	2.7	4.6	37	5.1	12.2

In the collected data, we can observe the results of the mechanics individually, but also compare the investigated results of the observed factors with each other. An interesting phenomenon occurring in both mechanics is the ratio between the amount of maintenance used in documentation and using the AMOS system. It is clear from the collected data that the number of movements made to use the system is higher than to procure maintenance documentation. From these data, we can conclude that the implementation of the AMOS system. represents one of the basic benefits of increasing efficiency. For both mechanics, the average number of movements per shift is 5 to 6 movements per day. It is necessary to note that this data is variable during each shift and depends on several factors, which we describe later. We have divided the investigation of time into two categories. Measuring the time spent while performing movement and the time spent during activity for working with the system or searching and printing documentation.

An important point is also the evaluation of the factors that influence the collected data and the subsequently presented results. We, therefore, focused on the identification of these factors and their possible influence on the results presented by us.

The performance of heavy maintenance is a complex process, consisting of several individual actions, which take place depending on the difficulty of the given maintenance during several work shifts. Since this process is divided into several jobs, the workload on individual departments and sections of these departments is not evenly distributed over individual work shifts but has a rising and falling character. Our data collection took place during the initial phase of maintenance performance, so it does not include work shifts during which the workload is reduced or during phases in which maintenance documentation and MRO software are not used with increased frequency.

For future research, we consider it necessary to carry out more extensive measurements using the test version of AMOSmobile. This will make it possible to obtain more accurate data on the efficiency of the performance of individual works.

3.1.4. <u>Proposal and implementation of digitized procedures</u>

In the third part of our research, we focused on the design of digitized procedures for section 10/20 performing heavy maintenance, then implementing the procedures into the maintenance process, observing their effects on the performance of maintenance, and then analyzing their usability.

Before the actual implementation of the maintenance process, we prepared the software and hardware. It is the initial step leading to the implementation of procedures in practice. At the same time, it provides an opportunity to examine the compatibility of the used platform with the environment and systems at ATB.

Hardware: In our experiment, we use a tablet from Apple with the production designation iPad Air. [6] We consider this device suitable as a display unit for maintenance documentation intended for mechanics. It has a simple user interface that allows easy use during work, a sufficient size display with a diagonal of 27.69 cm, and a battery life of 10 hours, which allows it to be used during the entire work shift, without the need to charge it. This is necessary to enable the smooth performance of work without interruption. The tablet has a camera and the option of being equipped with a SIM card, which enables data connection even outside the range of the Wi-Fi signal. It is a key element for the use of the equipment during the performance of track maintenance or tests of the aircraft outside the hangar before the end of maintenance and handover to the customer. The tablet has the option of unlocking using fingerprint, which is important for ensuring user integrity and can serve as a form of electronic signature if necessary. [6]

To protect the tablet from damage, we used protective glass panzer glass, which provides protection against breakage, and scratches, and at the same time leaves the tactile properties of the display. [7] We also use the Spigen tough armor protective case, which is designed to protect against drops and damage, and raised edges to protect the camera and camera. It also has the option of placing a tablet, which allows the mechanic to work with the device more easily. However, for future use, we recommend securing the package with the option of attaching it to the arm or thigh using a belt. The reason is that it is easier to work with the device in an environment such as the upper part of an aircraft fuselage. It will enable the mechanic to perform his work more safely and protect the device from the risk of falling to the ground, which could result in injury to personnel and the destruction of the tablet.

The preparation of the software represented the security of the Embraer Tech pubs application. This app allows customers to access, view and download maintenance documentation on iPads and go paperless anywhere. It has the important function of creating folders and quick access to favorite and frequently used items. [8] The tablet is also equipped with Outlook, Excel, MS Teams applications.

While testing the mobile device in a heavy maintenance environment, we focused on examining several factors. The initial goal was to test the equipment and evaluate the positive and negative effects on the maintenance process and the usability of the equipment during the daily shift.

Among the basic benefits that we noted during the survey was the complete elimination of the need to secure paper forms of maintenance documentation and the elimination of the need to perform movements due to its procurement. During the processes of disassembly, as well as assembly of parts and components, imaging on a mobile device allowed us to view the necessary technical documentation, without the need to interrupt the performance of work.

When working in confined spaces such as aircraft cargo holds, mobile devices are a very useful tool. It replaces the number of papers necessary for the performance of work, which interferes with work. Visibility on the display is also an advantage even under dark lighting conditions.

3.1.5. <u>Disadvantages:</u>

The necessity of increased caution while working with the device. Even though the device is equipped with protective elements, increased attention during work is required to avoid its damage. The work is often carried out in the cramped spaces of the cargo area of the aircraft, where the display can easily be damaged.

During the research, we noticed relatively limited usability in the current phase of implementation. Even though the equipment helps to increase efficiency and reduce the workload of mechanics, in the current phase of implementation its usability is significantly limited, and we identified a relatively low utilization during the shift. The main reason is the restriction on displaying technical documentation, and not allowing access to the AMOSmobile system. The limited usability is also confirmed by the measurements obtained in our data collection, which point to a higher number of necessary movements and more time spent precisely when using the AMOS system. Also based on the mechanics' feedback, we believe that the introduction of this system into the maintenance process will bring a significant increase in work efficiency in some processes.

Even though, based on the review of the first phase of the implementation of the mobile device in practice, in which its usability is limited exclusively to the display of maintenance documentation, we see it as a fundamental step for the further development of digitized procedures in the company. And that is enabling the second phase of the AMOSmobile system implementation system, and the third phase enabling the electronic signing of documentation.

However, it also serves as an initial investment and the creation of a basic platform for other add-on systems such as UAV inspections. A collaboration between Mainblades and KLM Engineering & Manufacturing is working together to develop these solutions. The Netherlands Aviation Authority has approved companies to carry out paint damage inspections at airports in outdoor areas. Their application for conducting flights and inspections as well as damage categorization works on the iOS operating system. [9]

3.1.6. <u>Disadvantages:</u>

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4. CONCLUSION

In this paper, we describe the initial digitization of procedures in the hangar, when performing heavy maintenance. With developing technologies, new possibilities for increasing the efficiency of work and also safety. Using solutions from the field of information technology arise, and therefore we consider research in this area to be crucial. The digitized procedures and implementation of mobile devices proposed by us can serve as a basis for further research and the introduction of new technologies. Currently, the possibilities of carrying out inspections using UAVs are being investigated. This technology enables automatic inspections and recording of paint damage. The UAV performs high-resolution imaging, and the software then evaluates signs of damage such as missing labels. The mechanic then has the opportunity to track the found damages on his tablet and examine them in detail. This makes it possible to reduce the time required to perform these tasks up to three times. [10] We also consider it necessary to explore the possibilities of building digitized procedures, using virtual and augmented reality. [11]

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