Creation of a joint group and a decision support system to improve the after-sales support of civil aircraft

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Abstract. This work focuses on the problems of the existing approach to servicing Russian civil aircraft. The work aims to create a joint group for the analysis and processing of after-sales support flows, working together through the decision support system. The main difference from the current approach is the continuous joint work of all participants of the after-sales support, as well as the automated processing of the information received at all stages of the life cycles of aircraft. The work with a decision support system is presented as a work of joint group and operators through a decision support system. The presented methods and algorithms are the basis for increasing the competitiveness of Russian civil aircraft on the world market.

1. Introduction

Today, automation is introduced into aircraft manufacturing [1] and aircraft maintenance, repair, and overhaul (MRO) [2]. After-sales support processes are automated and analyzed by both aircraft manufacturers [3] and operators [4].

The development and implementation of a decision support system (DSS) are one of the ways to intellectualize after-sales services for aircraft. But effective use of DSS also requires a joint group that will analyze incoming data to create expert decisions as well as changes to documentation. The use of Continuous Acquisition and Life-cycle Support (CALS) technologies is being considered for after-sales support of aircraft. This topic has been studied by scientists such as Klochkov [5]. However, the approach to after-sales service is different from the use of Integrated Logistics Support instead of DSS. Which is primarily Supply Chain Management. The main purpose is to control the supply of components precisely on time, rather than to continuously conduct a comprehensive reliability analysis.

Scientists such as Gyazova and Gorelov have considered the Aircraft life management system and the economics of its implementation [6], but the article does not consider the system’s operating variant as an issue-response as well as the joint creation of decisions.

The selection of the DSS will allow to implementation of intelligent information processing and intelligent search. The use of such systems allows the creation of an interactive environment for after-sales support participants. The DSS allows answering unstructured questions [7], which is particularly important for the after-sales support of aircraft since this process is complex [8] and therefore the operator may not be able to structure the requests.
The preservation of information through the DSS allows for a more in-depth analysis of the service, which is particularly important since the maintenance process is key to the reliability of aircraft operations [9].

The work aims to improve methods and approaches of after-sales support of civil aircraft in Russia in two related ways. The joint group performs constant analysis and creates solutions that improve the quality of the aircraft and its operation. The DSS automates tasks and provides ready-made data to experts to speed up the creation of decisions.

2. Methodology

DSS is a system consisting of software, joint group, and system operators.

Consider the joint group of specialists (figure 1). A virtual structure for the analysis of after-sales support is being formed between all the organizations involved in after-sales support of aircraft (design-bureau, manufacturers, aircraft operators, and MRO operators). Each organization provides one or more specialists to work with such specialists from other organizations. This specialist is not necessarily an expert, his main duty is to be a link between experts of the enterprise, where he works with experts of other enterprises through interaction with such specialists. In this way, it is possible to analyze the information received by the different participants of after-sales support simultaneously and to take a common decision through interaction via a virtual structure.

![Figure 1. Joint group of after-sales support of aircraft.](image)

The successful operation of the proposed DSS requires the use of generalized models of after-sales support participants, as well as the creation of data, flows between participants. The proposed models and flows have been created previously [10]. The generalized model is a model of participants of after-sales support-design bureau, manufacturer, aircraft operators, and MRO operators. The knowledge base is also necessary for the effective operation of DSS.

Consider the formation of a knowledge base (KB) based on a database (DB) [11] (figure 2). The aircraft DB is loaded with the information generated during the operation of the aircraft. The flight service, the maintenance, and engineering (M&E), the flight data control, as well as the services responsible for MRO, upload into the DB the results of the analysis of flight data, MRO reports, reports of aircraft operations, as well as comments from all services. The information should come in a standard form, the form of which is jointly chosen by the participants of after-sales support. Two key
fields are intended to be used. The first is the flight number to which flight data reports are attached, as well as pilot reports (PIREPS) and maintenance reports (MAREPS) as defects. In turn, comments and spare parts removals are attached to the unique defect number. Through the specialists of the joint group, the experts of the participants of the after-sales support receive the necessary information and carry out a joint analysis of it. If there is a need for direct interaction between experts, the interaction between experts and documentation is possible without the involvement of a joint group specialist.

By analyzing the incoming information, the experts form ready expert analysis and decisions, which are then used to automate the solution of new problems arising during the operation of aircraft. The documentation is also modified if necessary. The analysis of the changes is done by all participants, so that by the time of implementation, aircraft operators, and MRO operators will be prepared to implement the changes. The processed experience of the aircraft operation type is formed in the form of question-and-answer forms, based on which the semantic search of the DSS is then carried out. All information is uploaded into the KB and used in the DSS.

![Figure 2. Building a knowledge base.](image)

### 3. Results

Consider the algorithm of the interaction of after-sales support participants with DSS.

Regardless of the type of work carried out (operational, transit, or scheduled maintenance), a formal report consisting of the PIREPS, MAREPS, flight data analysis results, and aircraft health monitoring (AHM) reports. The report is loaded to DSS. All components are automatically checked for off-limits. The limits are set as follows.

- Hard time flight hours, flight cycles (FH/FC). The number of hours or cycles for the component specified by the manufacturer, after which the component must be replaced.
- Soft time FH/FC number of hours and or cycles for the component based on an analysis of aircraft type operation. It is formed by a joint analysis by experts of the reliability of all participants of after-sales support.
- Defects of components or systems from minimum equipment list (MEL). If flight service, M&E, or MRO operator reports have keywords that contain a defect in the MEL list, the corresponding restrictions and MRO tasks are automatically generated.
- Limitations created by experts during the analysis of the aircraft type operation. By analyzing the incoming information, experts can introduce limitations and requirements other than those
specified in the documentation to anticipate and reduce the likelihood of more complex defects that may lead to aircraft on ground (AOG) situations. The expert may specify the time or region of application of restrictions and requirements, as defects may depend on seasonal and geographical factors.

Data from the standard report are automatically checked for output outside the specified limits (figure 3). If the defect is not critical, the flight service and M&E shall be provided with a list of restrictions on the following flights until the defect has been terminated. If the defect is critical, move to the next step of the algorithm.

- If there is more than one solution to the problem, the efficiency of the methods for the world fleet aircraft type.
- The most efficient method for this component is shown based on the experience of the aircraft operator.

Furthermore, the MRO operator or the aircraft operator performs the necessary work if the defect is fixed, then the report is loaded in the DSS. If the defect is not terminated, the information is transmitted to the aircraft operator as well as to the joint group for further. Based on the expert decision received, new MRO cards are formed.

Cleaned data and DSS reports are transferred to the joint group (figure 5). By cleaning the data, experts can significantly reduce the time needed to create a solution. Because data analysts are known to spend up to 80% of their time cleaning [12]. If the defect is critical, the analysis shall be prioritized before all non-critical defects. The specialists of the distributed structure and the experts involved carry out the analysis of the influence on the exploitation and create the expert decision. If the defect is not critical, it shall be analyzed in order of priority.

![DSS algorithm. Works after landing.](image-url)
Consider the operating principle of the DSS analysis (figure 6). Based on the information received, DSS provides the following analyses.

- **Frequency Analysis.** The defect rate of the entire aircraft type fleet is checked.
- **Performance analysis.** Fleet performance is automatically checked against parameters set by experts.
- **Analysis of the effectiveness of expert decisions.** Changes in the number of defects after the introduction of expert decisions are checked.

Based on this analysis, the following proposals are made.

- **Proposals for amendments on restrictions.** If the defect is not critical, but according to statistics it leads to other defects and consequently causes AOG it is proposed to convert it to critical category.
- **Efficiency analysis.** Fleet performance is automatically checked against parameters set by experts.
- **Analysis of the effectiveness of expert decisions.** Changes in the number of defects after the introduction of expert decisions are checked.
These offers as well as the cleaned data are delivered to joint group and experts for further analysis.

Figure 6. DSS algorithm. DSS work.

4. Summary
The represented system from the software and distributed group will automate the MRO tasks as well as improve the quality of data analysis of the aircraft operation. Simultaneous analysis of defects and queries will allow approaching the tasks from different sides. The system will allow, on the one hand, to automate the MRO tasks, on the other hand, to supply the joint group and experts with ready-made data for analysis, which will make it possible to minimize the time for processing raw data arising during the operation of aircraft.

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