Automated Management System of Technological and Production Processes of the Civil Aviation Air Enterprise Known as 'The Custom Module "The Operator"'

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Abstract

The article is devoted to the capabilities description of the custom module called "The Operator". The custom module "The Operator" is an automated control system for the technological and production processes of the civil aviation enterprise. The functional capabilities and features of the information system software components for collecting, processing and information reliability control of aircraft technical and resource state were scrutinized. A number of economic effects achieved through the "The Operator" deployment at the airline were noted as well. In addition, the information system features are considered in terms of operational and technical documentation management, evaluating the authenticity of aircraft components and applying control algorithms to the information completeness and reliability. In conclusion, it is believed to be advisable to use "The Operator" as a tool for a labor productivity increase at the airline supporting the technical operation of an aircraft.

Keywords: automated system, aeronautical engineering, information system, common information space, operational documentation.

Introduction

In 2001, the information and analytical system for monitoring the aircraft airworthiness was devised and commissioned at the Federal State Unitary Enterprise State Research Institute of Civil Aviation. The system operator is the Federal State Unitary Enterprise State Research Institute of Civil Aviation. The system development is based on the common information space principles in civil aviation and the aviation industry. It embraces all entities for the aircraft maintenance and its airworthiness control, i.e. developers, manufacturers, aviation enterprises operating aviation equipment or operators, aircraft maintenance organizations and repair, national aviation administration, as well as other entities involved in aircraft technical operation support processes (Ruzina et al., 2007).

When creating information and analytical system for monitoring the aircraft airworthiness the developers were guided by the conditions, which ensure the system functioning in accordance with the above principles (Glukhov et al., 2017):

- the system must adapt to the specific conditions of the each aircraft life cycle stage, while simultaneously having the ability to centrally maintain operational documentation at the industry level;

- the system should maintain the possibility to develop continuously by involving subject specialists participate in its modernization (i.e., each subject should be able to upgrade the system software components while being controlled.

The information purpose and analytical system for monitoring the aircraft airworthiness is to provide information on aircraft technical operation and monitoring its airworthiness.

Based on system subjects' functional tasks, there have been elaborated user modules with local databases.

Historically, the first and basic part of the information and analytical system for monitoring the aircraft airworthiness is the custom module named "The Operator", which is an automated control system of technological and production processes of aviation engineering service at the airline and aircraft maintenance organizations and repair.

The Custom Module Named "The Operator" as a Single Information Space Element of Information and Analytical System for Monitoring the Aircraft Airworthiness

"The Operator" designing was based on covering the maximum possible number of automated functions for recording and monitoring the operational parameters of aircraft and their components, as well as continuous monitoring of the aircraft technical state at the airline based on production information.

The implementation of these principles determined the "The operator" custom module's software part architecture as the set of software complexes interacting at the data level that implement the tasks of individual airline divisions (Fig. 1).

The automatization of typical production procedures at the airline in the custom module "The Operator", which are connected with the aircraft maintenance, allowed achieving the following economic effects:

- enhanced forecasting for failures and aircraft components malfunctions helped minimize the costs and aircraft component parts rental;

- rapid identification of non-authentic aircraft components and cost reduction connected with the urgent removal of non-authentic products from operation. It should be noted that in case of non-authentic aircraft products detection on the aircraft being in operation, the airline could lose up to millions of rubles per day. Therefore, there is the need to terminate flights and wait for the component to be replaced, however, if such components are identified during the planned aircraft maintenance and repair work, the costs are minimalized or do not arise at all while the service can be continued;

- increasing the speed of aircraft maintenance and repair due to the use of modern software tools that provide automatic informational interaction of operational, technical, regulatory and reference documentation;

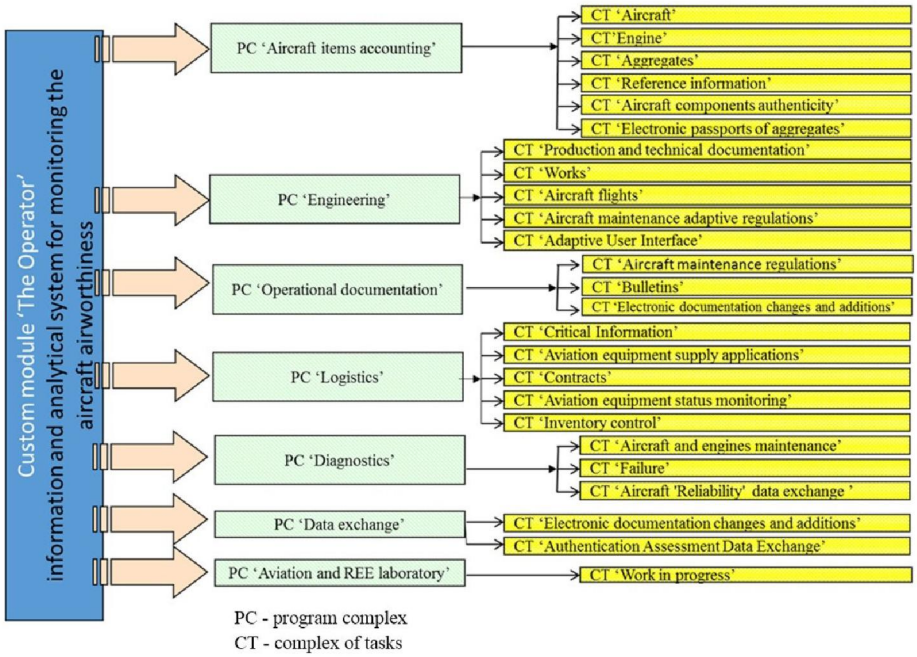

Fig. 1: "The Operator" custom module structure in information and analytical system for monitoring the aircraft airworthiness

– reducing the human factor influence when making decisions regarding the list and sequence of procedures performed on the aircraft during the scheduled maintenance. The custom module "The Operator" software tools provide the operational lists for aircraft maintenance in the correct (rational) technological sequence, which ensures minimizing the working time costs.

The custom module "The Operator" has automatized a number of functions:

– accounting for the resource and technical condition, and components of aircraft;

– planning the enterprise production processes and planning the aircraft use;

– automatized aircraft maintenance and repair operational documentation;

– electronic documentation;

– technological support for aircraft maintenance and repair, including updating electronic operational documentation of an aircraft;

– automated production and technical documentation generation (production tasks, selective operational statements and other documents);

– accounting for aircraft component malfunctions causes and methods of their elimination. Data analysis;

– information support for the aircraft technical operation;

- production preparation;
- logistics;
- full range automated generation of reporting documents to ensure their own activities and for submission;
- interaction with the central database of information and analytical system for monitoring the aircraft airworthiness;
- in order to obtain up-to-date information on the state of aircraft and operational documentation;
- automatic exchange files generation for the authenticity assessment and monitoring the airworthiness of aircraft.

"The Operator" usage by airlines within a single information space gives each of them a number of advantages:

- ensuring compliance with certification requirements;
- operational documentation;
- and reducing operating costs for maintaining documentation in working condition;
- increasing confidence and completeness of aircraft maintenance and repair and other work;
- more quality taken decisions in professional activity;
- reducing the aircraft operating costs by preventing irrational losses of material and other resources.

"The Operator" software provides the airline units task automation. This is all because of the data automatic interaction from the on-line documentation of aircraft components, operational and technical documentation and regulatory and reference documentation, labor costs associated with monitoring the technical condition an aircraft are reduced (Klimenko et al., 1999) (Fig. 2).

The custom module "The Operator" is quite flexible and is open to be modernized anytime so that it could quickly reflect changes in international or national air law and the changing needs of each airline.

At the same time, there is a possibility of "The Operator"s' improvements and modernization by the enterprise based on its own production tasks. Changes made are analyzed by the information and analytical system for monitoring the aircraft airworthiness and they can be extended to the entire system to be accessible to other entities (Brusnikin, Glukhov and Garanin, 2017).

The custom module's advantages are as follows:

- centralized electronic operational documentation;
- authenticity assessment materials preparation. Aircraft components assessment is based on constantly updated production information on the actual technical condition of aircraft components;
- continuous monitoring of information completeness and reliability. The information is introduced into the module database based on data processing algorithms and their assessment of compliance with established requirements.

PC	Tasks to be Solved
Aircraft items accounting	aircraft operating time
	maintaining aircraft logbooks, engines and components
	control over the resources use and the individual service frequency
	aircraft items resources extension
	dispatch department reporting
Engineering	operational statement generation
	aircraft components list maintaining, which is discarded during aircraft maintenance and repair
	dispatch schedule keeping
	introducing into the database completed production performed
	maintaining control copies of aircraft maintenance and repair regulations
	maintaining adaptive regulations for aircraft maintenance and repair, taking into account bulletins, directives, changes to regulations, etc.
	access to control and logbook information for reporting on aircraft maintenance and repair
	operational documentation generation based on adaptive regulations
	Generating EASA Form One, FAA Form 8130, etc., with the e-filling out possibility
Reliability	entering information on the causes and methods of troubleshooting in the electronic passports of aircraft components and troubleshooting charts
	generating and entering into the database non-destructive control chart of aircraft components
	diagnostics results input, non-destructive control chart implementation, ground control and diagnostic systems verification
	automatized report generation based on the information introduced into the database
Operational documentation	aircraft maintenance and repair regulations
	bulletins
	changes and additions to operational documentation
Data exchange	data exchange with central database and information and analytical system for monitoring the aircraft airworthiness
	data exchange generation for transmission to a central database
	exchange files data automated import from a central database
Laboratory A and RED	maintenance and troubleshooting
	aviation equipment maintenance results input and checks on the data composition system
	reporting on aircraft maintenance and repair completed work as well as aviation and electronic equipment
Logistics	aircraft components location registration
	aircraft components movement control
	aircraft components movement report throughout its life cycle

Fig. 2: Tasks distribution solved by a custom module "The Operator"

The Advantages of the Custom Module "the Operator" in Automating the Production Processes of Civil Aviation Enterprises

Centralized management of aircraft documentation in "The Operator"

Operators and aircraft maintenance and repair organizations are required to have and maintain operational documentation, production and technical documentation and other working documentation by operating regulatory documents.

However, the evidence that the operators exercise the established requirements, involves submitting the documentation during the certification period or during the inspection issuing or renewing a certificate.

Since the certificate is issued for a certain period, it is therefore sufficient for operators to present documentation to inspectors by the required date. At the same time, the documentation is not monitored during the cross-inspection period. Seeing this, the airline operational documentation during this period, as well as, its correct application in aircraft maintenance and repair cannot be controlled. The peculiarity of the operational documentation in "The Operator" control system is due to the significantly expanded amount of information exchanged between information and analytical system for monitoring the aircraft airworthiness compared to the data set regulated by foreign specifications and standards (Brusnikin, 2018). Federal standard R 54080-2010 defines the minimum requirements that determine the information systems composition of the information space participants in the information and analytical system for monitoring the aircraft airworthiness. These data cover the following arrays of airline production information:

– aircraft current state;

- engines current state;
- aircraft components state, i.e. aggregates and components;
- the use of aircraft;
- history of engines motion;
- work done on aircraft;
- flight hours;
- engine operating time;
- electronic operational documentation (regulations or maintenance work program).

Based on these data, the so-called adaptive maintenance schedule for each aircraft, the information appears in the system, is automatically generated in the "The Operator" database.

The adaptive regulation of an aircraft maintenance work is an electronic operational documentation adapted to the particular operator conditions and to the operator's aircraft individual characteristics.

The adaptive aircraft maintenance work regulation includes operational documentation for a specific operator in a formalized form.

The purpose of the adaptive aircraft maintenance work regulation is to create a load of work to be done on an aircraft. Moreover, creating a set of requirements for performing this work with the fullest possible consideration of the actual aircraft operating conditions, time characteristics and individual aircraft characteristics.

To achieve this goal, the operational documentation provided by the aircraft developer is used, as well as the production and technical documentation of the aircraft maintenance work done by the explant to maintain the airworthiness of the aircraft operated. These documents must be recorded in the database of the user module installed by the operator. This is the input to the adaptive regulation management process.

The result of managing the adaptive regulations of the aircraft maintenance work is a production task for the aircraft maintenance work, in the form of a selective operational list. The adaptive regulation of aircraft maintenance work in coordination with the aircraft use plan ensures the selective production program development for the operator (Alekeanyan, 2011).

A selective statement and a selective operation program are types of production and technical documentation generated as a result of electronic documentation automatic interaction, adaptive regulations and reference information of a specific aircraft.

While the user module is operating, the information and analytical system for monitoring the aircraft airworthiness are constantly adjusted to the input data. For this reason, the principle of feedback is used.

The feedback principle provides the following sequence of procedures:

- non-stop monitoring of aircraft status information;
- received information processing in accordance with established algorithms;
- control impact elaboration.

For example, the control action in case of changes in the operating conditions and / or the actual resource state of the aircraft can be a change in the set of work during the next aircraft maintenance work or their technological sequence.

When the next task for aircraft maintenance work is produced, the results of the adaptive regulation of aircraft maintenance work, including all changes are made. Thus, the stability of aircraft compliance with the airworthiness standards is ensured.

The custom module "The Operator" material preparation for the aircraft authenticity assessment

The requirement to ensure the authenticity of aircraft components is due to the reliability requirements established by the design documentation of the aircraft developer, as well as the requirements for maintaining the airworthiness of an aircraft during its life cycle, established by the regulatory documents of aircraft registration states.

The procedure's normative and methodological basis for assessing aircraft components authenticity is established by Federal standard R 55256-2012.

The aircraft components authenticity is determined by the authenticity assessment results carried out by the information and analytical system for monitoring the aircraft airworthiness operator. The purpose of aircraft components authenticity establishment is to confirm the reliability of information on the life cycle of these components and their documentation (Shapkin et al., 2018). Accordingly, unauthentic or unapproved ones should include aircraft components with dubious data or documentation, as well as aircraft components, which revealed inaccurate information or traces of intentional changes in information about the stages of their life cycle.

The custom module "The Operator" allows to automatize the data preparation process for aircraft components authenticity assessment. The material preparation process is carried out in a fully automatic mode due to production information, which is constantly introduced into the custom module database by the aircraft operator. The accumulated data can be automatically transferred to the information and analytical system for monitoring the aircraft airworthiness operator, according to a pre-agreed schedule for data exchange.

The frequency of assessing the aircraft components authenticity is determined by the need to confirm the technical condition of the particular aircraft, when the documents and materials received at the process output are used by interested organizations as part of evidence and other necessary documentation (Sharypov et al., 2018).

Features of data control algorithms introduced by users of custom module "The Operator" into the database

In order to exclude incorrect information being introduced into the database and the correct operation of the "The Operator" custom module, its software automatically monitors information using the built-in input control system. The database contains information that passed control (Sudov et al., 2006). The previously introduced and stored information in the database is automatically checked by the logical control system, which compares the data in the database with the established requirements and criteria.

The information, which passed control, is available in unified formats at any operator's workstation connected to the database.

If information inconsistency is detected, the input control system or the logical control system gives an error message, which the user must correct in the established way to continue working.

Information interaction with related systems is carried out by sending electronic information in exchange files via available communication channels having acceptable bandwidth.

Between the operator and the information and analytical system for monitoring the aircraft airworthiness operator, the operating procedure should be agreed, including the synchronization method, information content, formats, frequency and data transmission channels which help exchange information.

The information received is analyzed and verified by the information and analytical system for monitoring the aircraft airworthiness operator. Information that has been verified, as well as updated information, is placed by the operator information and analytical system for monitoring the aircraft airworthiness in a central database.

Examples of functional diagrams of data processing algorithms in the custom module "The Operator" are given below (Fig. 3).

A fragment of the operator's production and technical documentation management scheme for organizing and performing aircraft maintenance and repair is shown in Fig. 4.

The types of operator's operational documentation are as follows:

- aircraft planning documentation, i.e. airworthiness directives, service bulletins, various regulations (aircraft downtime for maintenance, component consumption, materials, spare parts, etc.), aircraft flight schedule, maintenance regulations, technical and resource status data aircraft, information on the availability and condition of components, materials, spare parts in warehouses and other storage places, data on the availability and qualifications of engineering personnel;

- aircraft maintenance and repair documentation, i.e. information about the air fleet, dispatch schedule, reports on aircraft maintenance and repair (including a schedule for maintenance);

- aircraft work documentation, i.e. production tasks for maintenance and other works, other production and technical documentation, regulatory requirements for the organization and implementation of aircraft maintenance and repair.

The result of aircraft maintenance and repair is production-related information:

- dispatch schedule;

- documents on aircraft fleet condition.

- The (Control, C) process elements are as follows:

- model regulations (programs) of aircraft maintenance, airworthiness directives of aircraft, standards, specifications, etc.

- regulatory requirements for the organization and implementation of aircraft maintenance and repair (federal aviation regulations, manuals, instructions, etc.).

Resource support for the (Mechanisms, M) process includes:

- resource information and analytical system for monitoring the aircraft airworthiness;

- operator personnel (i.e. aircraft maintenance and repair organizations);

- other types of resources needed for production.

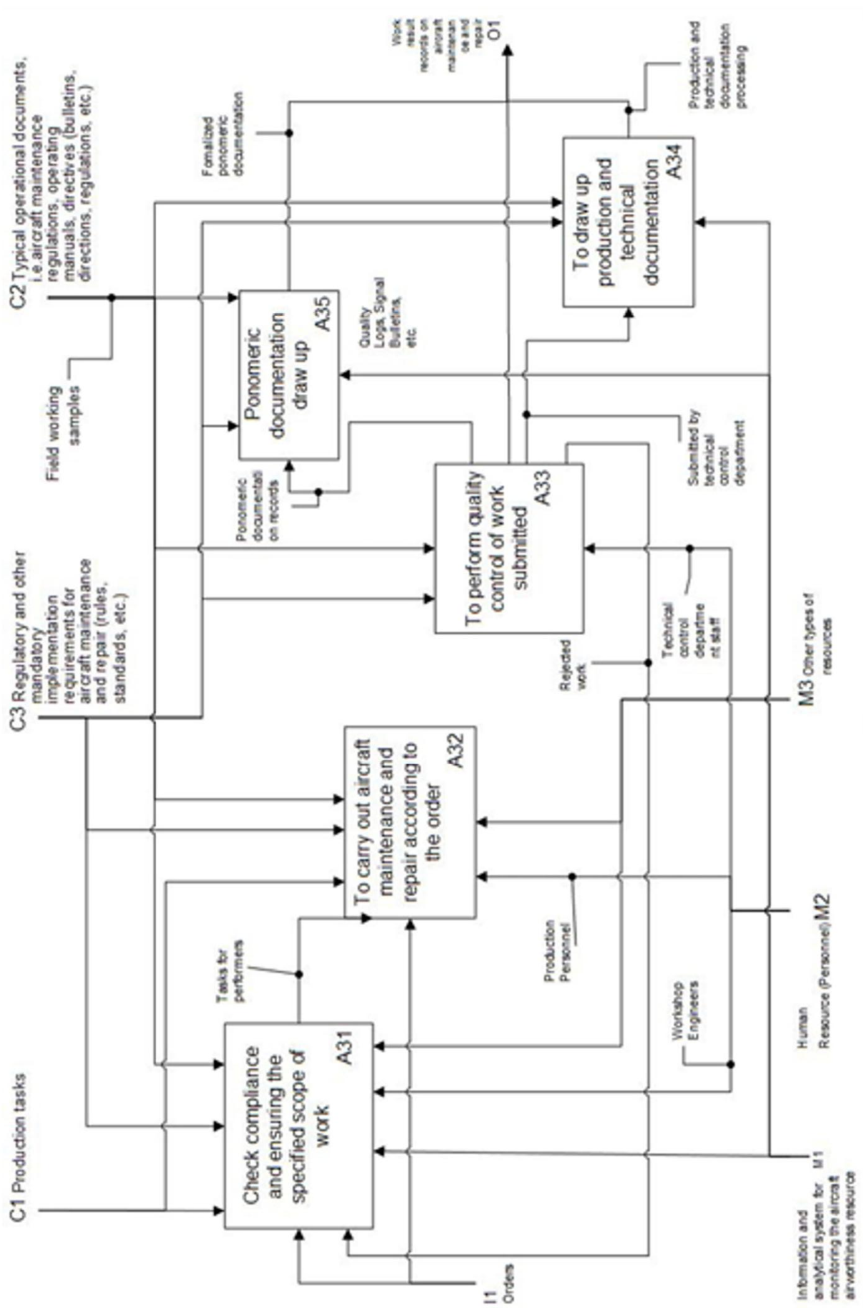

Fig. 3. Algorithm for managing production and technical documentation of the operator.

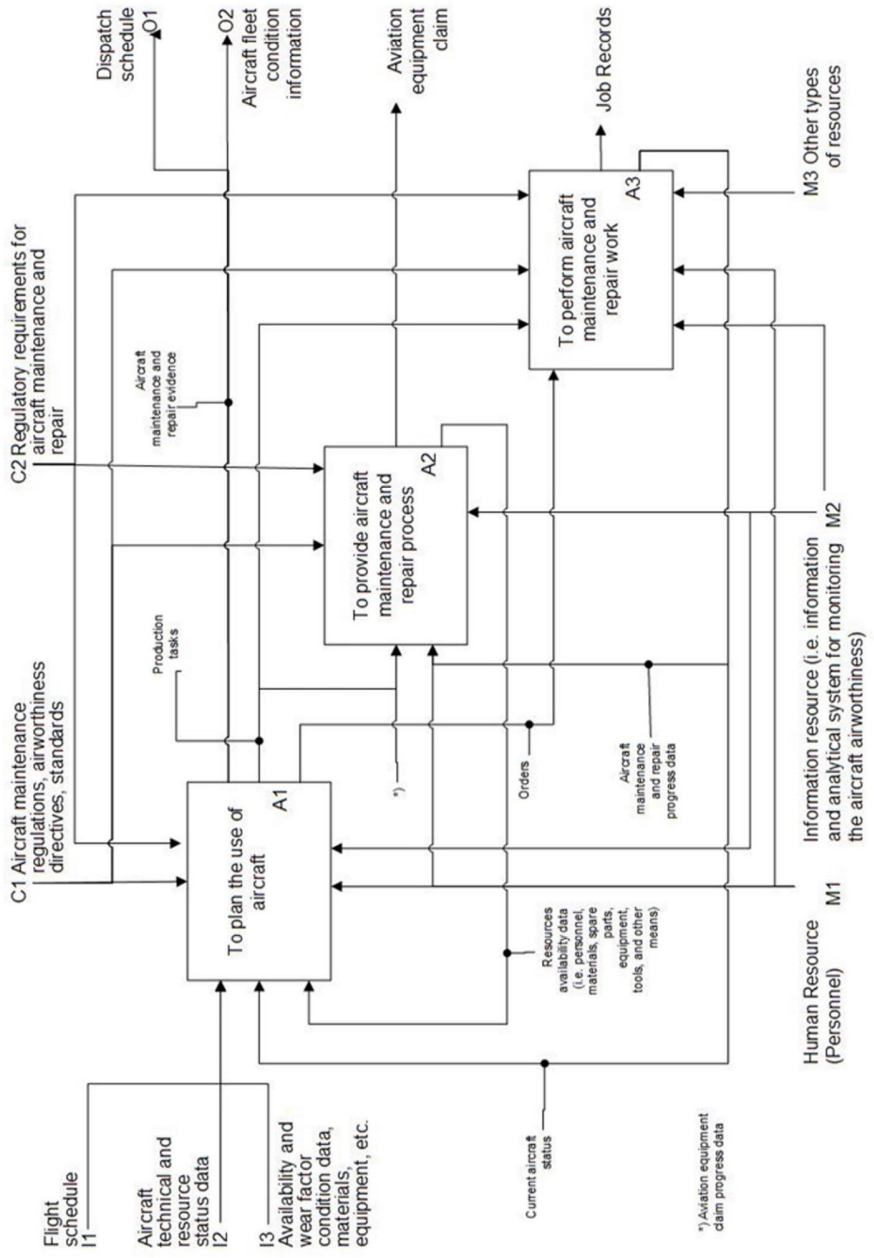

Fig. 4. Aircraft maintenance and repair documentation algorithm

The process functioning.

Data introduced into the database of the custom module is processed according to a special algorithm with consideration for the changing input data.

The results of sub-process A2 are as follows.

The A1 sub-process results in production task generation, which then goes to the A2 sub-process and later it appears to be the control action for the A3 sub-process.

- resources availability data, a declared components receipt including materials, spare parts, equipment, tools, etc. These data as a negative feedback have a corrective effect on the sub-process A1, and as a result, the input process A3 receives selective operational statements, including only resources provided works;

- purchase requests for components, materials, spare parts, equipment, tools, etc.

The result of sub-process A3 is as follows:

- progress records and implementation results of a given amount of work on the aircraft for the production task;

- the aircraft state data being serviced in a specific unit of time, progress data and results of aircraft maintenance and repair. This information, arriving at the inputs of sub-processes A1 and A2, respectively, as negative feedback, leads to their adjustments, which improves the output.

The general process functions similarly, in cases of changes or additions to regulatory documents, when processing a newly received order for additional air transportation, etc.

The output documents analysis (i.e. dispatch schedule, documents on aircraft serviceability), helps make decisions about the aircraft use as a part of the flight schedule, the additional air transportation organization (i.e. charter flights), the aircraft maintenance and repair improvement, etc.

In addition, an individual process could be divided into stages or sub-processes. Such a division is possible even up to individual technological operations, if it is advisable.

Input data, results, tools and mechanisms are similar to those shown in Fig. 4.Therefore any additional explanations are not required.

Conclusion

Despite numerous attempts to create and implement systems of after-sales support for the aircraft maintenance from the aviation industry, at the moment, civil aviation aircraft operators remain the main source of information about the real technical aircraft condition. At the same time, the competitive environment calls upon the operating aviation companies to progress constantly in accelerating production processes related to the tasks of aircraft technical support in order to minimize aircraft downtime and increase flight operation time during which the company makes a profit. In this regard, the development, implementation and modernization of automated control systems for the production and technological processes of civil aviation enterprises is the most promising area of work to reduce time and production costs when performing aircraft maintenance work.

The time and labor costs of an aircraft operating enterprise within the framework of strict state requirements for ensuring airworthiness can be minimized by automating the information interaction of services and units of the enterprise that provide technical support for the aircraft maintenance. Automatization of these processes allows to increase labor productivity when performing aircraft maintenance and repair and, as a result, to minimize aircraft downtime.

The custom module "The Operator" is a fully-functional automated control system of technological and production processes of civil aviation enterprises and allows you to automate the production processes of the civil aviation aircraft operator associated with the aircraft maintenance.

The functioning of the custom module in a single info space provides the possibility of centralized electronic operational documentation maintenance, thereby increasing the efficiency of maintenance and repair work of operating equipment.

In addition, the module's functionality includes procedures for preparing and sending to the operator the necessary and sufficient information to perform work on assessing the authenticity of aircraft components.

These procedures can be performed automatically without additional burden on users of the custom module based on production data arising in the airline during the aircraft maintenance.

The information completeness and correctness control entered by users is ensured by means of appropriate algorithms for monitoring user actions, which in turn ensures the accuracy of the entered information about the real technical and resource state of the aircraft used. It also reduces labor costs for further information processing.

Now, the custom module "The Operator" is implemented and used in 35 civil aviation enterprises of the Russian Federation and other countries (e.g. Kazakhstan, Cuba).

In addition, the custom module "The Operator" invariance as well as the information and analytical system for monitoring the aircraft airworthiness for the aircraft types and its operational strategies should be noted. The system easily adapts to aircraft maintenance and service support programs for running domestic and foreign aircraft.

The development and modernization of the custom module "The Operator" and other similar information systems is caused by the constantly growing requirements of the aviation administrations, i.e. ICAO (International Civil Aviation Organization) for organizations operating aviation equipment in terms of data collection for the flight safety level (International Civil Aviation Organization, 2018). This assessment requires the constant data availability on the operating aircraft state.

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