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TECHNOLOGICAL PROCESSES AND QUALITY CONTROL IN AIRCRAFT ENGINE MAINTENANCE

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Abstract. The paper analyzes some issues which refer to the quality assessment of operations performed by aviation specialists when maintaining aircraft. Technological processes and quality control in aircraft engine maintenance are considered.

Keywords: flight safety, human factor, aircraft maintenance.

1. Introduction

It is necessary to use a system approach to flight safety in order to reduce the influence of the human factor when performing aircraft maintenance operations and inspections (ICAO Circular… 1995).

In the field of aircraft maintenance, problems of systematic risk mitigation have been paid less attention than flight procedure issues. However, flight accidents and incidents are more often caused by human factors than by failures of mechanical and electronic equipment.

2. Formalized model of aircraft maintenance

Airworthiness engineering support is a set of organizational, technical and technological operations which are carried out by aviation specialists when maintaining aircraft. Aircraft maintenance procedures are described by the following sequence of components (Gubinsky 1993):

$$\Phi = \varphi\left[\Gamma_o(X), \Gamma_f(X), F_f(X)\right], \quad (1)$$

where Φ(X) is the performance of a specified function under X conditions;
$\Gamma_o(X)$ is the status of the maintenance system at the moment an application is received;
$\Gamma_f(X)$ is an attribute of the ergatic system stability;
$F_f(X)$ is the quality of the performance of a specified function under X conditions.

The initial status of the ergatic system $\Gamma_o(X)$ determines the possibility to commence maintenance operations. With this in mind, it would be appropriate to take into consideration the availability of aviation specialists and facilities required for maintenance operations; the efficiency and self-discipline of aircraft maintenance personnel, technological procedures that support the operability of equipment, information technology for optimal aircraft maintenance (Sahay 2012), and the necessary resources that help to perform the function described, as follows:

$$\Gamma_o(X) = \varphi_\Gamma\left[P(X), S(X)\right], \quad (2)$$

where *P(X)* is the capability of the ergatic system to perform maintenance operations under X conditions;
S(X) is the level of the ergatic system stability, which is sufficient to perform maintenance operations.

During aircraft maintenance operations, the ergatic system should support operational capability (R_f), effective self-discipline (E_f), technology (T_f) and goal determination (Q_f) for the whole time during which the specified function is being performed (Gubinsky 1993):

$$\Gamma_f(X) = \varphi_\Gamma\left[R_f, E_f, T_f, Q_f\right]. \quad (3)$$

The quality of aircraft maintenance operations performed by aviation specialists depends on the components that are included in the following equation:

$$F_f(X) = \varphi_F\left[U, Y, Q\right], \quad (4)$$

where *U* is the timeliness of the commencement of maintenance operations;
Y is the success rate of maintenance operations performed under X conditions (preparedness for operations, compliance with technologies, accuracy, and precision);
Q is a characteristic of operation quality control.

3. Analysis of factors influencing the efficiency of maintenance service

The effectiveness of the ergatic system (E_c) is provided owing to the operational quality of the function F_c, productivity, reliability depending on the possible external influence of the system level Z_c, and operating factors X_c:

$$E_c = f\left[F_c, X_c, Z_c\right]. \quad (5)$$

The operational quality of the function F_c depends on the quality of specified operations F_3 and the logical and temporal structure of operations $L_{3\text{-o}}$:

$$F_c = \varphi\left[F_{3i}, X_{3i}, Z_{3i}, L_{c-3}, U_{c-3}, y_{c-3}\right], \quad (6)$$

where X_3 indicates the factors being operated;
Z_{3i} – the actions affecting the operation quality;
U_3 – the restrictions affecting the structure;
$У_3$ – the factors being operated within the structure.

The quality of specified operations F_3 depends on the quality of each single operation F_o and the logical and temporal structure of the operations $L_{3\text{-o}}$ (Gubinsky 1993):

$$F_3 = \gamma\left[F_{oi}, X_{oi}, Z_{oi}, L_{3-o}, U_o, Y_o\right], \quad (7)$$

where X_{oi} and Z_{oi} are the factors being operated and the actions affecting the operation quality;
U_o and Y_o are the factors being operated and the restrictions affecting the structure.

The diagram illustrated by Figure 1 is based on the following specifics:

- comparative calculation of F_i values, which allows turning complex processes into simple ones;
- accounting of the parameters and the system structure, which may lead to both structural and parametrical optimization;
- comparative accounting of affecting and operating factors, which allows researchers to estimate both of these factors, in particular, their possible level of influence.

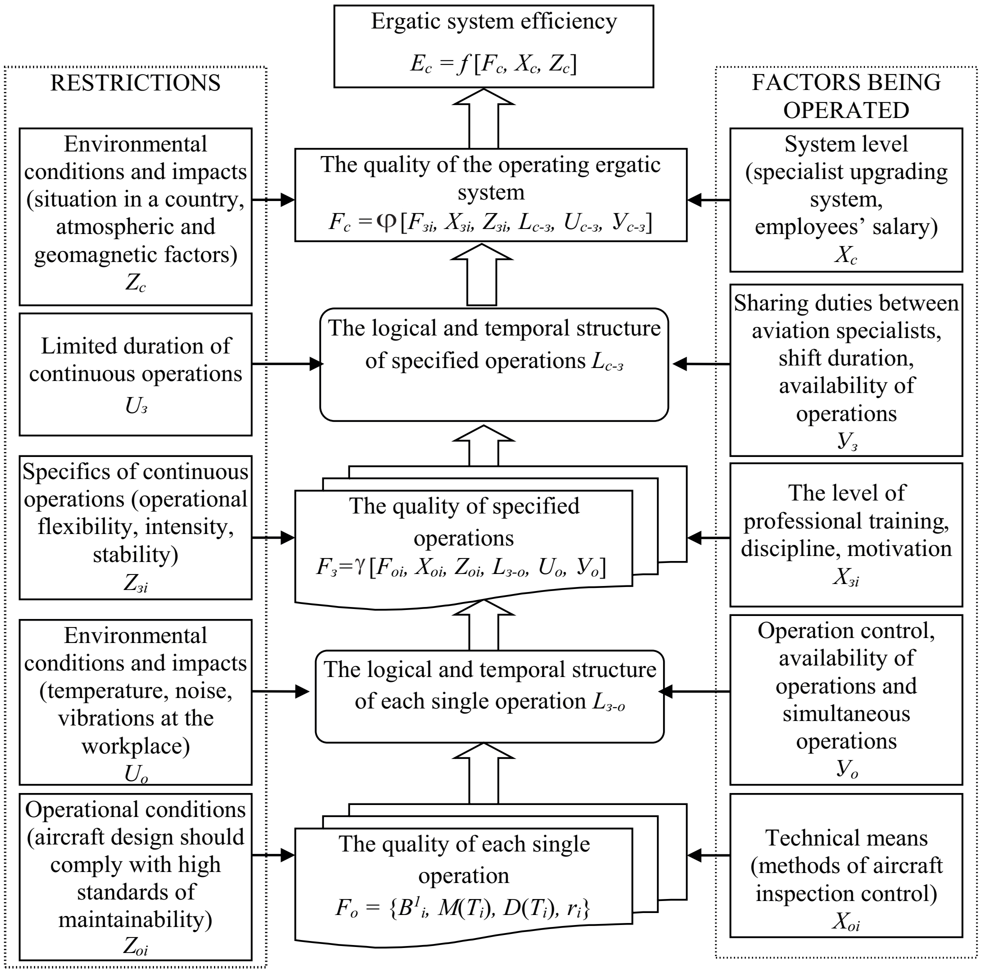

Fig. 1. The diagram of efficiency development of maintenance processes, factors being operated and the restrictions of aircraft maintenance

4. The quality assessment of aircraft maintenance

The quality assessment of aircraft maintenance at an operational level can be illustrated as follows:

$$F_o = \left\{B_i^1, M\left(T_i\right), Д\left(T_i\right), r_i\right\}, \qquad (8)$$

where B_i^1 is the probability of an effective *i*-operation; $M(T_i)$, $Д(T_i)$ are the mathematical expectation and dispersion of the *i*-operation runtime; r_i is costs.

The quality assessment of aircraft maintenance at the task level can be illustrated as follows:

$$F_з = \left\{П_з^1, M\left(T_з\right), Д\left(T_з\right)\right\}, \qquad (9)$$

where $П_з^1$ is the probability of an effective task performance; $M(T_з)$, $Д(T_з)$ are the mathematical expectation and dispersion of the task performance runtime.

The quality assessment of aircraft maintenance at the system level can be illustrated as follows:

$$F_c = \left\{П_c^1, Q_c^1(t), U(r)\right\}, \qquad (10)$$

where $П_c^1$ is the probability of an effective solution of all tasks set to a maintenance organization;
$Q_c^1(t)$ is the probability of a timely solution of all tasks;
$U(r)$ is the probability of available resources sufficient for task solutions.

According to (Dmitriyev *et al.* 2011), there are some operating factors that help to solve a certain number of tasks. These factors are the following:

– variations in the number of aviation experts and options of their interaction;
– distribution of functions for aviation experts;
– determination of the quantity of jobs and crews;
– changes in work and rest schedules (number of shifts, period of operation, etc.);
– implementation of professional selection;
– application of preventive measures against negative environmental impacts.

The operating factors that help to solve a single task are:

– change in the structure and technique of task solution;
– function allocation between human and equipment;
– validation of workplaces;
– higher requirements to the experts' qualification, professional selection and informational support intended to achieve an effective task solution.

Operating factors that help to perform particular operations are:

– operational control and its distribution according to occupational requirements;

– enhancement of the skill level of operational performance.

Quantitative values of original characteristics of effective operations and quantitative values of operational time are estimated on the basis of the results of aircraft maintenance operations and quality control records. If experimental data have not been obtained, it is necessary to apply the method of expert evaluation. This method allows one to assess the operational effectiveness of aircraft maintenance personnel, such as aircraft mechanics and service technicians (Farr, Shatkin 2009).

The following equation contains the indicators showing that a task may be fulfilled in time during the period calculated as *t* £ $t_д$:

$$Q(\tau) = P(\tau \le t_\partial) = \int_0^{t_\partial} f(\tau)\,d\tau, \tag{11}$$

f(*t*) is the function of time distribution for the experts involved in the task solution.

The probability of an effective maintenance operation can be described as follows:

$$\phi(\beta,\tau) = \pi(\beta)Q(\tau).$$

If there is a lack of time needed for the performance of maintenance operations, it is necessary to consider the operational intensity of aviation experts.

Taking into account the operational intensity of aviation experts and the conditions of their activity, the quantitative values of the indicators showing the effectiveness of maintenance operations and the operational time can be calculated in accordance with the following equations:

$$\beta_{iн} = \beta_i - \frac{(1-\beta_i)(H-1)}{P-1},\quad M_н(T) = \frac{M(T)}{H},\quad D_н(T) = \frac{D(T)}{H}, \tag{12}$$

where *P* is an intensity indicator, selected depending on the personal qualities of each aviation expert, between 1,9 ¸ 2,4;

H is an operational intensity indicator.

The operational intensity indicator is calculated as follows:

$$H = \frac{MT'}{\tau_f}, \tag{13}$$

where MT› is the time required for maintenance operations;

τ_f is the time given for maintenance operations.

To calculate the value of the operational quality of an aviation expert during the process of aircraft maintenance, the following algorithm has been developed (Fig. 2).

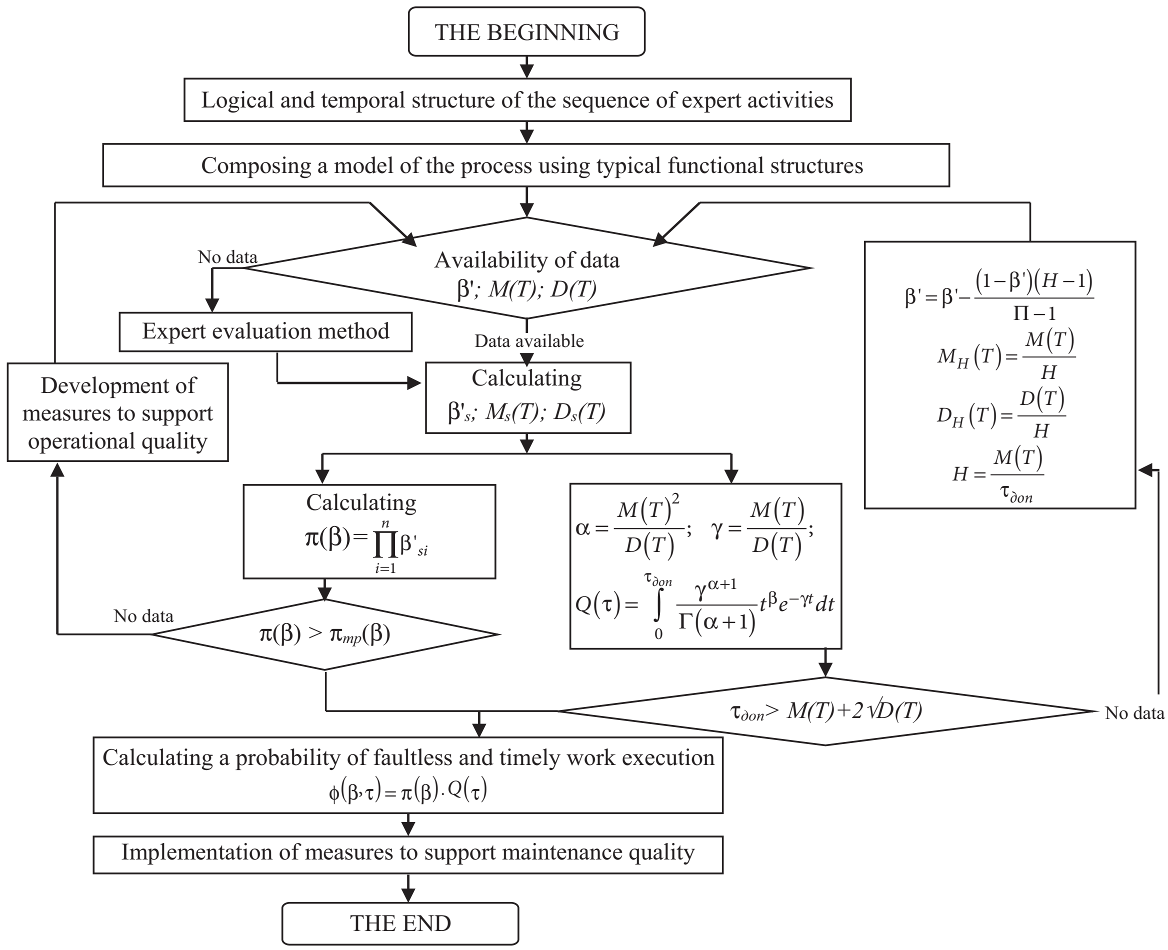

Fig. 2. The algorithm of the aviation expert operational quality

According to Dmitriyev *et al.* (2011), the methods, measures, and actions described above allow an operator to provide the following:

– optimum monitoring and control of the quality of operations performed by aviation experts;
– monitoring of the functional conditions of ergatic elements and maintaining of a necessary level of operational capability;
– personal work safety;
– achievement of effective operational activity of aviation experts by means of the establishment of a system of moral and financial benefits;
– formulation of requirements for the professional qualification of aviation specialists so that they could perform each job related to aircraft maintenance effectively;
– training, certification and upgrading of aviation experts, etc.

During the process of aircraft maintenance, the assessment of the operational quality of aviation experts is based mostly on the monitoring and quality control of their activity to support their moral state sufficient to perform maintenance operations, and to create conditions for continuous improvement of operational quality, including automated systems of operational control. To attain this goal, great attention ought to be paid to the process of continuing airworthiness support, in particular to the process of improving the continued airworthiness of civil aircraft (National Research... 1998).

5. Conclusions

The authors have analyzed some issues that pertain to the quality assessment of operations performed by aviation specialists when maintaining aircraft. It has been proven that technological processes and quality control of aircraft engine maintenance are the key factors for advancing the process of continuing airworthiness support.

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