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MANAGEMENT OF AIRCRAFT CONTINUING AIRWORTHINESS PROCESSES ON THE BASIS OF INCOMPLETE INFORMATION

The article discusses the issues of aircraft continuing airworthiness based on an analysis of the reliability of aircraft components. New approaches are proposed to ensure their reliability using models of complex systems. [dx.doi.org/10.29010/88.6]

Keywords: *airworthiness; aircraft; complex system; aircraft maintenance; reliability.*

1. Introduction

One of the main features in real operation is the presence of incomplete information, that is, decision-making at all levels of management occurs under conditions of varying degrees of uncertainty, which significantly affects the quality of decisions.

It should also be noted that monitoring and diagnosing aircraft components allow implementation in operations practice more efficient maintenance processes based on modern information technologies [1-6].

2. Approach Development

Management of the processes of aircraft continuing airworthiness means the procedures of improvement functioning of aviation systems as more as possible. This is the process of goal achievement by choosing rational paths (optimal solutions) on the basis of available information [7-10].

The development of complex systems models with restoration necessitates need an intermediate stage of formalization, considering processes from general, formal-theoretical positions and fixing in a sign form all the basic properties and relationships in complex systems.

The process of functioning of a complex system can be represented through the evolution of its condition in time:

$$H = (S, P, W, V), \tag{1}$$

where S is the vector of the structural design of the system, P is the vector of system elements conditions, W is the environment vector, V is the control vector.

For a discrete description of the process of system condition changing $H(n)$ it is necessary to determine the sequence of changes in these parameters at each $n + 1$ process step. The process $H(n) \to H(n + 1)$ state and c ontrol changes $V(n) \to V(n + 1)$ systems on $n + 1$ a step is represented by a series of consecutive mappings:

$$\overline{P}:\{P(n),\ S(n),\ W(n),\ V(n),\ \Delta t(n)\} \to P(n+1), \tag{2}$$

$$\overline{W}:\{W(n),\ P(n+1),\ \Delta t(n)\} \to W(n+1), \tag{3}$$

$$\overline{S}:\{P(n+1), S(n), W(n+1), V(n), \Delta t(n)\} \to S(n+1), \tag{4}$$

$$\overline{V}:\{P(n+1),\ S(n+1),\ W(n+1),\ V(n),\ \Delta t(n)\} \to \\ \to V(n+1), \tag{5}$$

$$\Delta\overline{t}:\{P(n+1), S(n+1), W(n+1), V(n+1), \Delta t(n)\} \to \\ \to \Delta t(n+1), \tag{6}$$

where $\overline{P}$, $\overline{S}$, $\overline{W}$, $\overline{V}$, $\overline{\Delta t}$ – operators that implement the change of the corresponding vectors.

This mathematical scheme gives the structural and functional trends of development in a complex system and can serve as the basis for its formal-theoretical description, the subject of analysis and the basis for the implementation of the mathematical model [11].

In order for the general formal approach given above to become a research tool, it is necessary to synthesize in it the mechanism of purposeful work of system elements. When choosing control actions, it is necessary to reflect as much as possible all the properties of a real control system that can be formalized. This is the functional structure of the subsystems, the relationship of the elements and their objective characteristics, as well as the principles and conditions that must be taken into account when making decisions in a real system.

Moreover, the presence of uncertainty is defined as a mapping $\overline{R}$ real condition of $\overline{H}$ in the information image of the system H^R:

$$\overline{R}:\{H\}\rightarrow H^R, \qquad (7)$$

where $H^R:\left\{S^R,\ W^R,\ P^R\right\}$.

Display operator $\overline{E}$, implements analysis and synthesis of available information and determines the hypothesis about the state of the system:

$$\overline{E}:\left\{H^R, J\right\}\rightarrow H^J, \qquad (8)$$

where $J = \{J_i(r_i)\}$ – awareness of the elements of the system and their relationship – r_i.

So the sequence of mappings $\overline{R}$ (7) and $\overline{E}$ (8) determine on the basis of the available information about the estimated state of the system, on the basis of which the control solution is chosen:

$$\overline{C}:\left\{H^J,\ V_0\right\}\rightarrow V_i, \qquad (9)$$

where V_0 – a coordinating, directive control effect (for example, certification basis requirements, airworthiness directives, etc.).

The choice could be made according to various decomposition options and the optimal option is selected from all alternatives.

The fundamental dependence of control actions on the reliability of hypotheses reflects the most important property of a control system – adaptation, as a means of resolving uncertainty. This property of control systems makes them a flexible and sensitive tool for managing any complex system.

Also artificial intelligence for the maintenance repair and overhaul procedures will be required [12]. This problem could be solved on the basis of the entropy approach realized in the view [12, (9)] or [14, (35)].

The sense of the solution is to find some optimal measure for the coefficient of a proportional governor augmentation in the aircraft navigation and motion linear model inertness-less object control system as continuous alternatives individual preferences densities distributions (using subjective entropy maximum principle) in case of one [12, (9)]:

$$H_\pi = -\int_0^{1000} \pi_t(k_\delta)\ln\pi_t(k_\delta)\,dk_\delta - \ln\Delta k_\delta, \qquad (10)$$

and two-dimensions [14, (35)]:

$$H_h = \int_{t_0}^{t_1}\left(\int_{k_{\delta_0}}^{k_{\delta_1}}\left\{-h(t,k_\delta)\ln h(t,k_\delta)\right\}dk_\delta\right)dt - \ln(\Delta t\Delta k_\delta). \qquad (11)$$

where H_π is the subjective entropy of individual preferences $p_t(k_p)$, k_δ is coefficient of the governor augmentation; H_h is the entropy of the hybrid optional function distribution density $h(t, k_\delta)$; t is time.

Simulation of any real process is represented as a set of a limited set of typical functional structures for which mathematical dependencies are developed for the estimation of their quantitative characteristics.

Generally speaking, entropy paradigm is a promising approach to evaluate the uncertainty of different kinds. For example [13] – entropy methods of traditional subjective analysis were applied to solve a problem of aircraft operation depending upon the uncertainty of maintenance alternatives.

There, in article [13], the optimal distribution process of airlines' aircraft fleets for the available aircraft maintenance organizations has been modelled with respect to the optimal values of the process participants. Each time the uncertainty of the optional multi-alternativeness was evaluated, the corresponding preferences entropy has been used. The entropy was similar to mathematical expressions (1), (2).

The newly formulated doctrine [14] of the hybrid optional functions uncertainty conditional optimization is also applicable to objectively existing diversity of processes. For instance, it was used in optimal maintenance periodicity obtained on the multi-optional basis.

Similar problems of entropy conditional optimization were considered in [15]. Theoretical core of the study is a synthesis of a hybrid approach on the basis of an optional uncertainty pattern. Mentioned in the introductory section of this paper problems of diagnostics and recognition models has a variety in use. It was an evolution element of the subjective analysis theory into the multi-optional doctrine.

It touches in actual fact the widest application of that kind of modelling, optimization, control, and all types of: artificial intelligence involvements, starting with that for aircraft engines and their maintenance and diagnosing respectively, as well as robust design works likewise up to other aviation problems such as aviation noise and radio equipment qualities and finally ending with the social and economical ones.

3. Conclusions

The proposed approach gives the general idea of constructing a formal theory of control synthesis and allows you to build practical methods of mathematical modelling of complex systems. The choice of criteria and limitations corresponds to the choice of factors and the nature of the actions by which the achievement of tasks is achieved.

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ПРОБЛЕМЫ УПРАВЛЕНИЯ ПРОЦЕССАМИ ПОДДЕРЖАНИЯ ЛЕТНОЙ ГОДНОСТИ ВОЗДУШНЫХ СУДОВ НА ОСНОВЕ НЕПОЛНОЙ ИНФОРМАЦИИ

В статье рассматриваются вопросы поддержания летной годности воздушных судов на основе анализа надежности компонентов воздушных судов. Рассматриваются новые подходы для обеспечения их надежности используя модели сложных систем. Предлагаемый подход дает общую идею

построения формальной теории синтеза управлений и позволяет строить практические методы математического моделирования сложных систем. Выбор критериев и ограничений соответствует выбору факторов и характера действий, с помощью которых достигается выполнение задач. Принципиальная зависимость управляющих воздействий от достоверности гипотез отражает важнейшее свойство системы управления - адаптацию, как средство разрешения неопределенности. Это свойство систем управления делает их гибким и чувствительным инструментом управления любой сложной системой. [dx.doi.org/10.29010/88.6]

Ключевые слова: *летная годность; воздушное судно; сложная система; техническое обслуживание.*

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