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Multi-optional doctrine with the uncertainty degree evaluation for the aircraft airworthiness support technologies

The fourth part of the generalization for the degrading state maximal probability determination in the framework of the hybrid-optional functions entropy conditional optimality doctrine initiated in the preceding reports was presented in the given report. The issue will be continued with a following sequence of reports.

Introduction. Continuing the previous research dedicated to optimal periodicity of aeronautical engineering units' maintenance, it is an important issue to generate some original theoretical and practically applicable approaches to the scientific research elements [1-35].

State of the problem. Aircraft reliability is the basis of its airworthiness and flight safety. As per reference [1] several mathematical, simulating, and econometric models have been created. As a result of modeling the effective integrated safety management and quality system can be successfully implemented into the airline flight operations.

Purpose of the paper. It is to prolong the proposed approach (doctrine) likewise in [8-16] based upon the Jaynes' principle [17, 18], developed to [19], and subjective entropy maximum principle [7, 20-23]. It, in actual fact, follows [8-16]. A generalization has to be done with the use of the mathematics in order to opportunely reconsider the problems of [1-35] in the framework of the discussed concept.

Problem setting. The optimal values of the aeronautical engineering maintenance periodicities can be obtained not only in the entire probabilistic way, but also in a hybrid: partially probabilistic and partially optional way [8-16].

The essence of the doctrine (method, idea, approach, concept) is to consider the process developing in the system from the position of some hybrid optional functions distribution optimality.

Consider the options essential to a simplified system having the following three possible discrete states: "0" – the up state of the system; "1" – damage; "2" – failure; randomly changed in time t – deemed to be a continuum [24], at the initial conditions of the states' probabilities: $P_0\big|_{t=t_0}=1$, $P_1\big|_{t=t_0}=P_2\big|_{t=t_0}=0$, $t_0=0$.

Objective functional, like proposed in references [8-16], is as follows [8-10, p. 35, (55)], [11, p. 90, (11)]:

$$\Phi_h=-\sum_{i=1}^{3}\left[xF_1^{(i)}\right]\ln\left[xF_1^{(i)}\right]-\frac{t_p^*}{\lambda_{01}}\sum_{i=1}^{3}\left[xF_1^{(i)}\right]\left(M_{12}^{(i)}\right)+\gamma\left[\sum_{i=1}^{3}\left[xF_1^{(i)}\right]-1\right], \quad (1)$$

where x is an unknown parameter; $h_i=xF_1^{(i)}$ is the multi-optional hybrid functions depending upon the options effectiveness functions of $F_1^{(i)}$; t_p^*/λ_{01} is the intrinsic parameter of the system and the process, which is the ratio of the optimal (delivering the sought maximal value to the probability) time t_p^* of the maintenance periodicity, it is unknown yet for such problem formulation and the time of t_p^* is going to be determined as a solution, i.e. it is not the equation obtained on the basis of the absolutely probabilistic methods so far, however it will be, that is why the indication is the same, to the flow intensity λ_{01}; $M_{12}^{(i)}$, is the algebraic addition of the initial elementary intensities matrix $\mathbf{M}$, formed in the style likewise from the Erlang's system [24], element of m_{12}; γ is the parameter, coefficient, function (uncertain Lagrange multiplier, weight coefficient) for the normalizing condition; [8-10, p. 35, (55)], [11, pp. 90, 91, (12), (13)]:

$$F_1^{(i)} = \frac{M_{12}^{(i)}}{\Delta(\mathbf{M})} = \frac{k_i\lambda_{01} + c_1}{p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right)}, \tag{2}$$

$$M_{12}^{(i)} = k_i\lambda_{01} + c_1, \qquad \Delta(\mathbf{M}) = p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right), \tag{3}$$

where

$$k_3 = 0, \quad k_{1,2} = \frac{-e_1 \pm \sqrt{e_1^2 - 4f_1g_1}}{2f_1}, \quad e_1 = \mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10} + \lambda_{01} + \lambda_{02}, \tag{4}$$

$$f_1 = 1, \quad g_1 = b_1 + c_1 + d_1, \quad b_1 = \lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}, \tag{5}$$

$$c_1 = \lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}, \quad d_1 = \lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10}, \tag{6}$$

and the corresponding values of the failure intensities λ_{ij} and restoration intensities μ_{ji} for the three states system transitions, and p is the complex parameter (variable) of the Laplace transformation; one need to go on to obtain the maximum of the non-failure state probabilities.

Consider the extremum existence necessary conditions for the objective functional of (1), [8-10, p. 35, (56), (57)], [11, p. 91, (14), (15)]:

$$\frac{\partial\Phi_h}{\partial h_i} = \frac{\partial\Phi_h}{\partial\left[xF_1^{(i)}\right]} = 0, \qquad \forall i \in \overline{1,3}. \tag{7}$$

After that, we have got the *law of subjective conservatism* [34] on one hand and on the other hand the similar to the entirely probabilistic approach expression [8-10, p. 36, (59), (60)]:

$$\ln\left[xF_1^{(1)}\right] - \ln\left[xF_1^{(2)}\right] = \frac{t_p^*}{\lambda_{01}}\left[\left(\lambda_{01}k_2 + c_1\right) - \left(\lambda_{01}k_1 + c_1\right)\right]. \tag{8}$$

After that likewise in case of the completely probabilistic approach, [8-10, p. 36, (61)]:

$$t_p^* = \frac{\ln\left[F_1^{(1)}(\cdot)\right] - \ln\left[F_1^{(2)}(\cdot)\right]}{k_2(\cdot) - k_1(\cdot)} \quad . \qquad (9)$$

And finally, equivalent with the absolutely probabilistic equation with taking into account Eq. (2)-(7) for the roots, [8-10, p. 36, (62)]:

$$t_p^* = \frac{\ln \dfrac{k_1\lambda_{01} + c_1}{p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right)} - \ln \dfrac{k_2\lambda_{01} + c_1}{p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right)}}{k_2(\cdot) - k_1(\cdot)} \, . \qquad (10)$$

As a result, [8-10, p. 36, (63)], [11, p. 91, (16)]:

$$t_p^* = \frac{\ln\left(k_1\lambda_{01} + c_1\right) - \ln\left(k_2\lambda_{01} + c_1\right)}{k_2(\cdot) - k_1(\cdot)} \, . \qquad (11)$$

Thus, the result of the entirely probabilistic approach is obtained in absolutely not probabilistic rather in the **MULTI-OPTIONAL HYBRID-EFFECTIVENESS FUNCTIONS UNCERTAINTY MEASURE CONDITIONAL OPTIMIZATION DOCTRINE** way through (1)-(11), [8-16].

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