UDC 629.735.083(076.5)

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Considerations for the aeronautical engineering degrading state probability determination

The second 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 report was presented in the given report. The issue will be continued with a following sequence of reports.

Introduction.

Continuing the previous research dedicated to initial considerations aimed at optimal periodicity of aeronautical engineering units' maintenance, it is an important issue to find the parameter for the optimal periodicity determination [1-6].

State of the problem.

The optimal periodicity is considered with taking into account the dynamical characteristics of the maximum probability of a non-failure state which sometimes is a proper criterion for the optimal periodicity of the aeronautical engineering units' maintenance [1, Chapter 15, pp. 170-172, especially Sub-Chapter 15.4, p. 172, Fig. 15.2]. Technically, such due maintenance is an indispensable component for continuing aircraft airworthiness [4].

All in all, it could be stated that the aircraft given functional system maintenance improvement [1, 4-6], developed at someone's choice, is a matter of the one's individually subjective preferences introduced and discussed in reference [7] on subjective analysis; and, on the other hand, such improvement inevitably influences the corresponding values of the worsening rates λ_{ij} and restoration rates μ_{ji} determining the process going on in the system [8-16].

Thus, there is a necessity to consider the objectively existing characteristics of the system functioning, which are the probabilities of the system's state that relate with the parameters of λ_{ij} and μ_{ji}.

Purpose of the paper.

It is to prolong the proposed approach (doctrine) likewise in [8-16] based upon the Jaynes' principle [17-19] and subjective entropy maximum principle [7, 20-23]. It resembles [24], however in actual fact follows [8-16]. A generalization has to be done with the use of the mathematical apparatus [25] in order to opportunely reconsider the problems of [26-34] in the framework of the discussed concept.

Problem setting.

Having determined, in a simplified system of the 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], for example, in case of Laplace transformations [25] at the initial conditions of the states' probabilities: $P_0\big|_{t=t_0} = 1$, $P_1\big|_{t=t_0} = P_2\big|_{t=t_0} = 0$, $t_0 = 0$, the Laplace transformants (images) F_i of the corresponding initial functions, or originals, of the probabilities of P_i ; one need to go on to obtain the wanted probabilities.

Traditional concept.

The ratios for the transformants F_i ; of the expressions of [8-10, pp. 28, 29, (34)-(38)]:

$$F_0 = \frac{p^2 + pa_1 + b_1}{p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right)}, \qquad (1)$$

where p is the complex parameter (variable) of the Laplace transformation [25];

$$a_1 = \mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10}, \quad b_1 = \lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}, \qquad (2)$$

$$e_1 = \mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10} + \lambda_{01} + \lambda_{02}, \quad c_1 = \lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}, \qquad (3)$$

$$d_1 = \lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10}, \qquad (4)$$

where the corresponding values of the deterioration rates λ_{ij} and restoration rates μ_{ji} will determine the process going on in the system [24];

$$F_1 = \frac{p\lambda_{01} + c_1}{p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right)}, \quad F_2 = \frac{p\lambda_{02} + d_1}{p\left(p^2 + pe_1 + b_1 + c_1 + d_1\right)}; \qquad (5)$$

represented in the view of the simplest fractions (elementary ratios); will be found with respect to the roots k_1 , k_2 , and k_3 of the equations of (1) and (5) with taking into account (2)-(4) [8-10, p. 29, (39), (40)]:

$$k_3 = 0, \qquad k_{1,2} = \frac{-e_1 \pm \sqrt{e_1^2 - 4 f_1 g_1}}{2 f_1}, \qquad (6)$$

where $f_1 = 1$ and $g_1 = b_1 + c_1 + d_1$ correspondingly with the denominators of Eq. (1) and (5), i.e. of the determinant corresponding roots, here; and with corresponding coefficients of the decomposition.

At last for the image (transformant) (1) [8-10, p. 29, (41)]:

$$F_0 = \frac{\frac{b_1}{k_1 k_2}}{p} + \frac{1 - \frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1} - \frac{b_1}{k_1 k_2}}{(p - k_1)} + \frac{\frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1}}{(p - k_2)}. \qquad (7)$$

And for the probability (original), for (7), [8-10, p. 30, (42)]:

$$P_0(t) = \frac{b_1}{k_1 k_2} + \left(1 - \frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1} - \frac{b_1}{k_1 k_2}\right) e^{k_1 t} + \left(\frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1}\right) e^{k_2 t}. \qquad (8)$$

Or on the other hand, equivalent to (8) [8-10, p. 30, (43)]:

$$P_0(t) = \frac{k_1 e^{k_1 t} - k_2 e^{k_2 t}}{k_1 - k_2} + a_1 \frac{e^{k_1 t} - e^{k_2 t}}{k_1 - k_2} +$$

$$+ \frac{b_1}{k_1 k_2} + \left(-\frac{b_1}{k_2(k_2 - k_1)} - \frac{b_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{b_1}{k_2(k_2 - k_1)} \right) e^{k_2 t} . \quad (9)$$

For the other two probabilities in the style of (1)-(9) [8-10, p. 30, (44), (45)]:

$$P_1(t) = \lambda_{01} \frac{e^{k_1 t} - e^{k_2 t}}{k_1 - k_2} +$$

$$+ \frac{c_1}{k_1 k_2} + \left(-\frac{c_1}{k_2(k_2 - k_1)} - \frac{c_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{c_1}{k_2(k_2 - k_1)} \right) e^{k_2 t} \quad (10)$$

and

$$P_2(t) = \lambda_{02} \frac{e^{k_1 t} - e^{k_2 t}}{k_1 - k_2} +$$

$$+ \frac{d_1}{k_1 k_2} + \left(-\frac{d_1}{k_2(k_2 - k_1)} - \frac{d_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{d_1}{k_2(k_2 - k_1)} \right) e^{k_2 t} . \quad (11)$$

For this stage of the presented research it is remarkable that it deals with the objectively existing characteristics of the process. Therefore, it is no use to apply the subjective analysis so far.

The consideration for the probabilities extremums and further generalization steps in the following (1)-(11) ideas [8-10, pp. 28-30, (29)-(45)] will appear in the next report.

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