UDC 629.735.083(076.5)

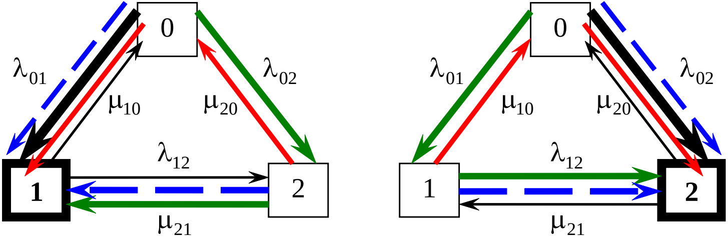
A.V. Goncharenko, Dr
(National Aviation University, Ukraine)

Symmetrical solution for a reliability problem within the multi-optional uncertainty degree evaluation doctrine

The fifth 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 formulate the own concept (idea, problem, hypotheses), some original theoretical and practically applicable approaches [1-34].

State of the problem. In accordance with the graphs illustrated in Figure 1 [10, p. 37, Figure 3], one may state that the aircraft given functional system maintenance improvement, developed in someone's work [1-6], influences the corresponding values of the failure rates λ_{ij} and restoration rates μ_{ji} determining the process going on in the system.



a) *b)*

Fig. 1. Diagrammatic graphs of the three states of an aircraft functional system illustrating the prevailing flows with the maximum of the probability at the state of: *a)* – "1"; *b)* – "2"; [10, p. 37, Figure 3]

Here, in Figure 1 *a)*, "0" designates the up state of the system; "1" – damage; "2" – failure. For the substantiated reasons, for the state of "2" to be a state without an "exit", it has to be satisfied the conditions of $\mu_{20} = \mu_{21} = 0$. Then, it, the state of "2", will be a real failure. In Figure 1 *b)*, in an analogous manner "1" – failure; "2" – damage. And, it has to be $\mu_{10} = \lambda_{12} = 0$ in order the state of "1" should be a real failure.

Purpose of the paper. It is to prolong the proposed approach (doctrine) likewise in [8-16] considering the possibility of the situation depicted in Figure 1 *b)*.

Problem setting. The problem might be, for instance, to choose an optimal maintenance periodicity for the improved aircraft given functional system. In its turn, it might be done likewise in example described in the previous reports as well as in references [8-16]. The same approach as to the damage options effectiveness functions of $F_1^{(i)}$ is applicable for $F_2^{(i)}$ in the case when "1" – failure; "2" – damage (see Fig. 1 *b)*) with yielding the parallel to the Eq. (1), [8-10, p. 36, (63)], [11, p. 91, (16)]:

$$t_p^* = \frac{\ln(k_1\lambda_{01}+c_1)-\ln(k_2\lambda_{01}+c_1)}{k_2(\cdot)-k_1(\cdot)} \qquad (1)$$

results, where t_p^* – optimal (delivering the sought maximal value to the probability) time of the maintenance periodicity;

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

$$f_1 = 1, \quad g_1 = b_1 + c_1 + d_1, \quad b_1 = \lambda_{12}\mu_{20}+\mu_{10}\mu_{20}+\mu_{10}\mu_{21}, \qquad (3)$$

$$c_1 = \lambda_{01}\mu_{20}+\lambda_{01}\mu_{21}+\lambda_{02}\mu_{21}, \quad d_1 = \lambda_{01}\lambda_{12}+\lambda_{02}\lambda_{12}+\lambda_{02}\mu_{10}. \qquad (4)$$

Now we ought to say that for the situation when the probability of state "2" $P_2(t)$ undergoes the extremum instead of the probability of state "1" $P_1(t)$ (see Fig. 1 *b)* and compare with Fig. 1 *a)*), the problem, **due to the symmetry**, has a symmetrical solution [8-10, p. 36, (64)], [11, p. 91, (17)]:

$$t_p^* = \frac{\ln(\lambda_{02}k_1+d_1)-\ln(\lambda_{02}k_2+d_1)}{k_2-k_1}. \qquad (5)$$

That is the system according to the developing stationary Poison flow process has the possible states optimal options related with either the system of parameters $\{k_i, \lambda_{02}, d_1\}$ or $\{k_i, \lambda_{01}, c_1\}$ values for the initial moment probability of the state "0" being equaled to "1".

These theoretical speculations and hypotheses can be represented with the diagrammatic graphs illustrating the flows shown in Figure 1.

In Figure 1 *a)*, for instance, for the system of parameters of $\{k_i, \lambda_{01}, c_1\}$, as well as for the equation of M_{12}, which leads to 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}, values; it is shown the prevailing flows that dominate the developing process [10, p. 37, (65)]:

$$M_{12} = p\lambda_{01}+c_1, \qquad c_1 = \lambda_{01}\mu_{20}+\lambda_{01}\mu_{21}+\lambda_{02}\mu_{21}, \qquad (6)$$

where p is the complex parameter (variable) of the Laplace transformation.

It is visible that intensities of λ_{12} and μ_{10} do not calibrate the optimal options' dispositions. In that particular case, none of the flows from the state "1" is taken into account. The solutions in the view of either equation (1) or its symmetrical reflection solution as equation (5) are the general ones. That is, the partial cases are obtained from them.

Objective functional for procedures (1)-(6), like proposed in references [8-16], is as follows [8-10, p. 35, (55)], [11, p. 90, (11)] and expressed with formula (7):

$$\Phi_h = -\sum_{i=1}^{3}\left[xF_1^{(i)}\right]\ln\left[xF_1^{(i)}\right] - \frac{t_p^*}{\lambda_{01}}\sum_{i=1}^{3}\left[xF_1^{(i)}\right]\left(M_{12}^{(i)}\right) + \gamma\left[\sum_{i=1}^{3}\left[xF_1^{(i)}\right] - 1\right], \quad (7)$$

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.

References

1. Максимов В. А. Совершенствование методов технической эксплуатации тормозных колес / В. А. Максимов, Ю. С. Ермилов // Совершенствование методов технической эксплуатации авиационной техники: сб. научн. тр. – Москва: ГосНИИГА, ДСП, 18.04.85, №320-85 ДСП.

2. Богданович А. И. Кинетические и энергетико-активационные характеристики износостойкости и совместимости материалов трибосопряжений [Текст] : автореф. дис… к-та техн. наук : 05.02.04 / КИИГА. – К., 1987. – 20 с.

3. Kończak J. Impact of the decision on transport systems' reliability in emergency situations / J. Kończak, M. Mieteń, K. Szafran // Journal of Science of the Military Academy of Land Forces. – 2017. – vol. 49, no. 4(186). – pp. 216-230.

4. Goncharenko A. V. One theoretical aspect of entropy paradigm application to the problems of tribology / A. V. Goncharenko // Problems of friction and wear. – 2017. – № 1(74). – pp. 78-83. (ISSN 0370-2197 print)

5. Technological processes and quality control in aircraft engine maintenance / S. Dmitriev, V. Burlakov, O. Popov, D. Popov // Aviation. – 2015. – vol. 19, iss. 3. – pp. 133-137.

6. Дмитрієв С. О. Модель технологічного процесу технічного обслуговування авіаційної техніки. / С. О. Дмитрієв, В. І. Бурлаков, О. І. Юрченко // Вісник НАУ. – 2005. – № 3(25). – С. 64-68.

7. Kasianov V. Subjective entropy of preferences. Subjective analysis: monograph / V. Kasianov. – Warsaw: Institute of Aviation Scientific Publications, 2013. – 644 p.

8. Continuing Aircraft Airworthiness (ICAO Doc 9760) : Self-Study Method Guide . Part II . Application of the Multi-Optional Functions Entropy Doctrine to

Assess the Aircraft Maintenance Process Improvements / compiler: A. V. Goncharenko. – K. : NAU, 2018. – 48 p.

9. Continuing Aircraft Airworthiness (ICAO Doc 9760) : Self-Study Method Guide . Part I . Reliability Measures to Assess the Aircraft Maintenance Process Improvements / compiler: A. V. Goncharenko. – K. : NAU, 2018. – 48 p.

10. Continuing Aircraft Airworthiness (ICAO Doc 9760) : Term Paper Method Guide / compiler: A. V. Goncharenko. – K. : NAU, 2018. – 48 p.

11. Goncharenko A. V. Generalization for the degrading state maximal probability in the framework of the hybrid-optional entropy conditional optimality doctrine / A. V. Goncharenko // Problems of friction and wear. – 2018. – № 1(78). – pp. 89-92. (ISSN 0370-2197)

12. Goncharenko A. V. Aeronautical and aerospace materials and structures damages to failures: theoretical concepts / A. V. Goncharenko // International Journal of Aerospace Engineering. – Volume 2018 (2018), Article ID 4126085, 7 pages https://doi.org/10.1155/2018/4126085; 2018. – pp. 1-7.

13. Goncharenko A. V. Multi-optional hybrid effectiveness functions optimality doctrine for maintenance purposes / A. V. Goncharenko // 14th IEEE International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET-2018). – February, 20-24, 2018, Lviv-Slavske, Ukraine. – 2018. – pp. 771-775.

14. Goncharenko A. V. Optimal UAV maintenance periodicity obtained on the multi-optional basis / A. V. Goncharenko // 2017 IEEE 4th International Conference “Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)” Proceedings. – October, 17-19, 2017, Kyiv, Ukraine. – 2017. – pp. 65-68.

15. Goncharenko A. V. A hybrid approach to the optimal aeronautical engineering maintenance periodicity determination / A. V. Goncharenko // Proceedings of the NAU. – 2017. – № 3(72). – pp. 42-47.

16. Goncharenko A. V. Aeronautical engineering maintenance periodicity optimization with the help of subjective preferences distributions / A. V. Goncharenko // Proceedings of the NAU. – 2017. – № 2(71). – pp. 51-56.

17. Goncharenko A. V. Measures for estimating transport vessels operators’ subjective preferences uncertainty / A. V. Goncharenko // Науковий вісник Херсонської державної морської академії. – 2012. – № 1(6). – pp. 59-69.

18. Goncharenko A. V. A particular case of a variational problem of control in an active aviation system / A. V. Goncharenko // Transactions of the institute of aviation. – 2013. – № 228, pp. 3-12.

19. Goncharenko A. V. A diagnostics problem of a-posterior probability determination via Bayes’ formula obtained in the multi-optional hybrid functions entropy conditional optimization way / A. V. Goncharenko // Problems of friction and wear. – 2017. – № 4(77). – pp. 95-99.

20. Goncharenko A. V. Several models of artificial intelligence elements for aircraft control / A. V. Goncharenko // 2016 IEEE 4th International Conference “Methods and Systems of Navigation and Motion Control (MSNMC)” Proceedings. October, 18-20, 2016, Kyiv, Ukraine. – 2016. – pp. 224-227.

21. Goncharenko A. V. Navigational alternatives, their control and subjective entropy of individual preferences / A. V. Goncharenko // 2014 IEEE 3rd

International Conference “Methods and Systems of Navigation and Motion Control” Proceedings. October, 14-17, 2014, Kyiv, Ukraine. – 2014. – pp. 99-103.

22. Goncharenko A. V. Expediency of unmanned air vehicles application in the framework of subjective analysis / A. V. Goncharenko // 2013 IEEE 2nd International Conference “Actual Problems of Unmanned Air Vehicles Developments” Proceedings. October, 15-17, 2013, Kyiv, Ukraine. – 2013. – pp. 129-133.

23. Goncharenko A. V. Several models of physical exercise subjective preferences / A. V. Goncharenko // Clin. and Exp. Psychol. – 2016. – 2: 121. – pp. 1-6. doi:10.4172/2471-2701.1000121. (ISSN: 2471-2701 CEP)

24. Овчаров Л. А. Прикладные задачи теории массового обслуживания / Л. А. Овчаров. – М.: Машиностроение, 1969. – 324 с.

25. Goncharenko A. V. Subjective entropy maximum principle for preferences functions of alternatives given in the view of logical conditions / A. V. Goncharenko // Штучний інтелект. – 2013. – № 4(62). – 1 G. pp. 4-9.

26. Goncharenko A. V. Applicable aspects of alternative UAV operation / A. V. Goncharenko // 2015 IEEE 3rd International Conference “Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)” Proceedings. October, 13-15, 2015, Kyiv, Ukraine. – 2015. – pp. 316-319.

27. Goncharenko A. V. An alternative method of the main psychophysics law derivation / A. V. Goncharenko // Clin. and Exp. Psychol. – 2017. – 3: 155. – pp. 1-5. doi: 10.4172/2471-2701.1000155. (ISSN: 2471-2701)

28. Goncharenko A. V. Artificial versus natural intellect in control of optimality / A. V. Goncharenko // Інтелектуальні системи прийняття рішень та проблеми обчислювального інтелекту: міжнародна наукова конференція, Євпаторія, 20-24 травня 2013 р.: матеріали конф. – Херсон: ХНТУ, 2013. – pp. 20-22.

29. Goncharenko A. V. Alternativeness of control and power equipment repair versus purchasing according to the preferences of the options / A. V. Goncharenko // Electronics and control systems. – 2016. – № 4(50). – pp. 98-101.

30. Goncharenko A. V. A concept of multi-optional optimality at modeling ideal gas isothermal processes / A. V. Goncharenko // Electronics and control systems. – 2017. – № 2(52). – pp. 94-97.

31. Goncharenko A. Aircraft operation depending upon the uncertainty of maintenance alternatives / A. Goncharenko // Aviation. – 2017. Vol. 21(4). – pp. 126-131.

32. Goncharenko A. V. Aircraft maximal distance horizontal flights in the conceptual framework of subjective analysis / A. V. Goncharenko // Proceedings of the NAU. – 2013. – № 4(57). – pp. 56-62.

33. Goncharenko A. V. Control of flight safety with the use of preferences functions / A. V. Goncharenko // Electronics and control systems. – 2013. – № 3(37). – pp. 113-119. (ISSN: 1990-5548)

34. Goncharenko A. V. Horizontal flight for maximal distance at presence of conflict behavior (control) of the aircraft control system active element / A. V. Goncharenko // Матеріали XI міжнародної науково-технічної конференції “АВІА-2013”. (21-23 травня 2013 р., Київ). – Т. 4. – К.: НАУ, 2013. – pp. 22.30-22.33.