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Dynamic model of estimation of fail-safe feature boothing ergatic interface

Boothing integrated interface of the system is a «crew–aircraft–environment is a key complex in the tasks of realization of strength security of flights of air ships. Amount of the aviation incidents accomplished through fault of «human factor», achieves 80 % from an incurrence. ICAO offered to the entire countries to create the control system by safety of flight on new principles of organization and quality.

Introduction. Modern to aircraft with the functional computer-controlled systems, crew with all system of preparation to activity, influences of environment and system of their warning require the estimations of quality and depth of joint co-operation in questions perfection of the system of the crews, system of priorities and values of providing of safety of flights training, to development on principle new side equipment.

Such approach is grounded by the analysis of aviation incidents (AI): on the stake of *human factor* is from 65 to 85 % all AI, from which to 80 % behave to erroneous actions of crews in difficult situations Cost of error of crew constantly grows from permanent growth of primary cost of modern airplane increase of capacity of passenger salons and growth of cost of the crews training. Catastrophe of aircraft with the large number of passengers is perceived as state and national calamity. Exactly a high accident rate at passenger transportations disturbs ICAO, offering to the entire countries to create the control system by safety of flight on new principles of organization and quality.

We will consider the possible ways of realization of decline of influencing of «human factor», including in the advanced airlines Boeing and Airbus (in transcription) of conception «electronic pilot».

There are the following contradictions in development of the functional systems of aircraft:

1. The fault tolerance of FS rises from one side, the resource of engines is multiplied, sides and ground methods and backer-ups strength security of flights are perfected, and with other - in sky above Europe, Japan, America becomes «all closer». Air space is intensively loaded besides by small aviation.

2. Conception of crew will be realized on the economic considering in composition two persons. The «truncated» crew has the limited possibilities and less chances to go out well from an extreme situation.

3. Introduction of the computer-controlled systems of warning about the collision with the obstacles promoted strength security of flights substantially, however computer-integrated these systems not are in a single informatively-managing complex. The systems not are reliable, subject to electromagnetic

influences. The single multifunction complex of computer-integrated information is needed for *the increase of reliability of activity of crew on wing*.

Analysis of dynamic processes of influencing of interactive emergencies factors on safety of flights it is expedient to carry out with the use of probabilistic estimation of fail-safe feature. The chart of cooperation of the system is fixed in basis of model «crew–aircraft–environment», having the mutual correlation chart of influencing of elements of this system.

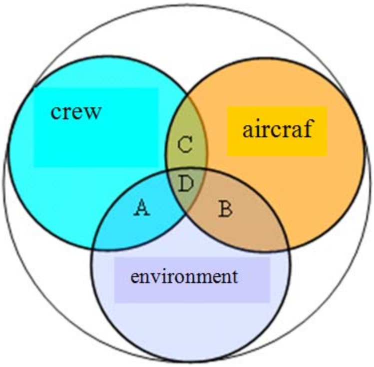

Figure. Cooperation of causal factors on wing

Problem statement. Region A (fig.) is examined as probabilistic space of influence of environment only on a pilot (limited flight visibility, inadequate commands of controller, unsatisfactory luminosity, runway other). These factors do not render influence on the capacity of the functional systems and glider [1].

Region B determines influences of environment only on an airship and indirectly on a crew (temperature, humidity, pressure of air, turbulence). Thus always there is probability of hit in a dangerous environment „displacement" wind, „dust" storm, strong icing meeting with birds and other

Region C corresponds to the cases, when the errors of crew, caused by different reasons, are laid on on structural and ergonometric imperfections of concrete type of aircraft.

Region of D is examined as the incorporated influences of refusals of the functional systems and glider, errors of crew and simultaneous influences of environment on a crew and aircraft. Points of D form space of the most difficult, but rare flights situations, when saltatory probability of aviation incident increases.

Important that here each the component of the aviation transporting system and environmentdoes not exceed possible limits and does not create the threat of safety of flights. Can account for combination of complicative factors by the display of system effect of synergetics character, resulting in the result of negative character – heavy aviation incident [2,3].

The probabilistic model of estimation of the fail-safe feature system is a «crew – aircraft – environment», taking into account laying out on the substages of descriptions of flight of aircraft, must be dynamic and universal. Basic assumptions: random events in the system «crew– aircraft – environment» independent and combinations of co-operation of the system take place „on to the chainlets": A (crew – environment), B (environment - aircraft), C (crew - aircraft) and D (crew – aircraft – environment), where A,B,C,D, are regions of cooperation of elements, and crew, aircraft, environment, are elements of triad accordingly crew, aircraft and environment [4].

Solution of problem. Dynamic model of estimation of the fail-safe feature system of «crew – aircraft –environment»

We will enter denotations:

Q_E is conditional probability of errors of crew, negative factors caused by an aggregate;

Q_C is conditional probability of negative influences of environment;

Q_{BC} is conditional probability of refusals of the functional systems and glider of aircraft on wing;

Q_D is conditional probability of joint influence of erroneous actions of crew, negative influence of environment and refusals FS and glider (systems «crew–aircraft–environment»).

Conditional probability of origin of event of erroneous actions of crew and negative influences of environment.

$$Q_{A(E+BC)} = Q_E Q_c - Q_E Q_C Q_{BC} = Q_E Q_C P_{BC} \quad (1)$$

Conditional probability of joint event of negative influence of environment and refusals of FS and glider.

$$Q_{B(C+BC)} = Q_c Q_{BC} P_E \quad (2)$$

Conditional probability of origin of joint event of erroneous actions of crew and refusal of FS and/or glider.

$$Q_{C(E+BC)} = Q_E Q_{BC} P_C \quad (3)$$

Difficult flight situation compound situation (CS) at joint influences in elements (C-F-E) and possibly heavy aviation incidents (emergencies, catastrophes). Conditional probability of origin of situations: CS, crash situation (CrS) or catastrofe situation (CatS) at combination of all refusals „small" (C-F-E)

$$Q_D = Q_E Q_{BC} Q_C .$$

Passing to probabilities of origin of events of A,B,C,Д, we use expression $Q_i = 1 - P_i$:

$$\begin{aligned}
&\text{A} \quad P_A = 1 - P_{BC} + P_E P_{BC} + P_C P_{BC} - P_E P_C P_{BC} . \\
&\text{B} \quad P_B = 1 - P_E + P_{OC} P_E + P_{BC} P_E - P_C P_{BC} P_E . \qquad (4)\\
&\text{C} \quad P_C = 1 - P_C + P_E P_C + P_{BC} P_C - P_E P_{BC} P_C \; 1 - P_{TS} = (1 - P_E)(1 - P_{BC}) \; P_C ; \\
&\text{D} \quad P_D = P_E + P_{BC} - P_{BC} P_E + P_C - P_E P_C - P_{BC} P_C + P_C P_{BC} P_E .
\end{aligned}$$

Conditional probability of total effect Q_A, Q_B, Q_C, Q_D:

$$Q_{\sum} = Q_A + Q_B + Q_C + Q_D = 4 - P_A - P_B - P_C - P_D .$$

Probability of happy end of flight at the job processing:

$$P_{\text{hef}} = 1 - P_E - P_{BC} - P_C + P_A + P_B + P_{TS} + 3P_D , \quad (5)$$

where P_A is probability of that event And {erroneous actions of crew and negative influence of environment will not happen at the flight job processing}; P_B it is probability of that event In { joint event of negative influence of environment and refusals of FS and/or glider} at the flight job processing will not happen; P_C it is probability of that event with { joint event of errors of crew and refusals of FS and/or glider} at the flight job processing will not happen.

Passing in expression (5) to the probabilistic form of function of time for areas, it is possible to get analytical expression of probability of happy end of flight in the form of time of exploitation. It allows at the known statistical estimation of events A, B, C and to carry out D statistical design of complex index of fail-safe feature aircraft:

$$P_{\text{hef}}(\Delta t_{\text{f}}) = 1 - P_E(\Delta t_{\text{f}}) - P_{BC}(\Delta t_{\text{f}}) - P_C(\Delta t_{\text{f}}) + P_A(\Delta t_{\text{f}}) + P_B(\Delta t_{\text{f}}) + P_{TS}(\Delta t_{\text{f}}) + 3P_D(\Delta t_{\text{f}}), \quad (6)$$

where $t_{\text{f}} = \sum_{i=1}^{n} \Delta t_i$.

Conclusions.

1. The analysis of reasons of origin of aviation incident (AI) rotined that majority of AI is conditioned by combination of a few causal factors, where every factor was within the limits of border of the expected external environments, and together created an unfavorable total effect (region of D).

2. A probabilistic model (6) is universal for the estimation of fail-safe feature aircraft and can be resulted to the known form for the complex index of fail-safe feature (1) at the independent events of the system «crew is aircraft is environment», when regions A,B,C and D degenerates in the empty sets.3. The analysis of statistical information on the stages of flight (Δt_i) $t_{\text{f}} = \sum_{i=1}^{n} \Delta t_i$ allows to draw structural conclusion about the increase of the fail-safe feature system «crew is aircraft is environment» and to expose the tense dynamic areas of stages of flight of aircraft, the coefficient of risk of activity of crew can serve as the numeral index of these modes and capacity of aircraft.

4. Automation and cooperation of elements of the system is a «crew is airship is environment» of cab interface of aircraft are those key bases of increase of strength security of flights and efficiency of the air system, when the variety of processes can be conditioned by the examined probabilistic dynamic model of fail-safe feature and quantitative results of researches.

References

1. *Шишкин В. Г.* Безопасность полетов и бортовые информационные системы. Иваново: МИК,2005. – 240 с.
2. Руководство по предотвращению авиационных происшествий. М. : ИКАО, 1984. – 18 с.
3. *Воробьев В.М., Киселев А.Д., Захарченко В.А., Вашку О.Ж., Воробьев А.В.* Системная эффективность функционирования авионики/Кибернетика и вычеслительная техника. 2000. – Вып. 126, С. 48-76.
4. *Воробьев В. М., Киселев А.Д., Захарченко В. А., Семида В. С., Енчев С.В.* Современные проблемы и тенденции автоматизации и взаимодействия кабинного интерфейса комплекса «экипаж – воздушное судно – среда» / Кибернетика и вычислительная техника. – 2008. – 26 с.