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Improvement of Air Traffic Control Considering the Peculiarities of the Technical Condition of Aircraft

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Abstract:

A logical-probabilistic approach to supporting air traffic control decision-making in emergency situations is presented. The proposed system integrates expert assessment and analytical processing of flight data under uncertainty regarding damage consequences, improving decision validity. The approach combines fuzzy logic analysis with Markov modelling of aircraft operation processes. A forecasting methodology based on logical-statistical processing of databases describing the technical condition of aircraft airframe structural elements is developed. By comparing the condition of damaged structural components with historical database records, the system estimates the feasibility of further operation. The paper also proposes interpretation schemes for forecasting results and their application in decision-making under operational constraints and uncertainty.

Keywords:

air traffic, flight safety, special situation, decision making, technical condition

1 Introduction

The main component of the complex technical means of the air traffic services system is a network of computing centers, the mathematical and software equipment of which is aimed at performing calculations for the fulfillment of requirements for the management of the process of safe completion of flights of aircraft (AC). The results of the calculations are provided directly to the controllers who are in constant contact with the flight crews (FC) of the aircraft.

Controllers control the level of flight safety to avoid the occurrence of special flight situations, when the level of flight safety decreases due to the influence of adverse factors (AF) or their combination. Such factors are failures, malfunctions, combat damage to individual structural elements of the airframe and its systems, as

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well as the aircraft engine. In addition, it is necessary to take into account the possibility of special flight situations because of flight crew errors during the flight control of the aircraft and actions to eliminate failures and damage of aviation equipment.

Such circumstances necessitate the study of the AC-FC system from the point of view of observance of flight safety conditions and prevention of serious traffic incidents in difficult, extreme conditions, radically different from the conditions of regular normal flights, the safety of which is systematically ensured by the relevant service services.

Serious incidents are characterized by the following signs:

- aircraft goes beyond the expected operating conditions,
- the occurrence of significant harmful effects on the FC, for example, the destruction of the glass of the pressurized cabin because of contact with birds,
- a significant increase in the workload on the design of the airframe of the aircraft and its systems, engines and power lines during the performance of complex types of maneuvers,
- significant deterioration of technical characteristics and complications in the control of AC.

For many years, to assess the flight safety of the complex ergatic system AC-FC, mainly analytical methods have been used, which make it possible to determine the possible transitions of the AC-FC system to various random states. Such conditions may include failures of aviation equipment, errors of power lines, serious incidents, accidents or catastrophes.

The diversity of special situations arises from the effects of rapidly and slowly developing, identical and different, as well as dependent and independent AF acting on the AC-FC system, thereby influencing the outcome of the flight. Special situations differ in the number of random states and the interdependence between them.

Random changes in the states of the AC-FC system can be estimated at a certain level of reliability because of the mathematical apparatus of the theory of random processes. Uncertainty about the specifics of a particular special situation motivates the use of the mathematical apparatus of artificial intelligence, in particular decision-making methods based on the theory of fuzzy sets, which allow the formal use of the experience of air traffic control experts.

2 Problem Statement

2.1 Statement of the Task and its Relevance

Within the designated airspace, N aircraft are being monitored and controlled by air traffic control personnel. The computing center receives a variety of information on the types of the specified number of aircraft, the parameters of their movement, the technical condition of the airframe and its systems, and the aircraft engine. An array of information data consists of both data with numerical discrete values and continuous values. In addition, dispatchers receive information in the form of linguistic terms.

If special flight situations occur simultaneously on N_j aircraft $N_j \leq N$, $j = 1, \cdots, N$, the damage severity of each aircraft is assessed, and the aircraft are ranked accordingly ($Rang_1 > Rang_2 > \cdots > Rang_N$). The resulting priority list serves as the basis for issuing appropriate instructions to the flight crews (FC) to mitigate the consequences of the special situations.

2.2 Analysis of Previous Studies

The problematic issues of preventing the occurrence of special flight situations have been studied in many works. In particular, to support decision-making in conditions of high uncertainty and military operations, the fuzzy logic apparatus is actively involved, which allows formalizing subjective expert assessments of threats [1]. At the same time, the assessment of the dynamics of degradation of aircraft structural elements is effectively implemented based on Markov reliability models [2, 3]. The current trend in the development of flight safety systems is the introduction of elements of artificial intelligence and cluster analysis for processing large arrays of flight data [4, 5]. However, the issue of integrating fuzzy rules, Markov processes and expert-analytical analysis into a single modular air traffic control system in special periods remains not fully resolved, which determines the relevance of this study.

2.3 The Purpose of the Work

The purpose of the work involves the study of ways to build mathematical support of decision support systems based on the combined use of logical-probabilistic models and the results of the experience of expert assessments by dispatchers of ways to eliminate damages in the AC-FC system.

3 Research Methodology

The modular structure of the system of mathematical safety footprints of the dispatchers in times of special situations is shown in Fig. 1.

Fig. 1 shows the proposed modular structure of the system of mathematical safety footprinting of dispatchers in times of special situations.

Module 1 is designed to process the database of the operation process in relation to both a specific aircraft and the entire aircraft fleet to prepare information to ensure its further processing in other modules.

Based on the processing of data on the reliability of operation of aviation equipment, it was found that a significant number of damages and incidents fall on the airframe and its systems, as well as on the engines, which creates conditions for the occurrence of special situations in flight.

The results of statistical processing of the database make it possible to establish the values of the parameters of the laws of distribution functions and the probability density of failures of the airframe elements and its systems, aircraft engine and, accordingly, to perform calculations of the values of probabilities of changes in the state of the AC-FC system.

Methods of statistical processing of experimental data are given in many works, in particular [6].

Module 2 is designed to calculate the values of probabilities of changes in the state of the AC-FC system in relation to three types of failures: P_b is the probability of unexpected failures, P_f is the probability of failures due to physical deterioration, P_e is the probability of failures of natural aging.

Failures of aircraft structures and systems that were caused by their damage are differentiated by the consequence of further safe or dangerous kinetics. Linear or nonlinear phenomenological models of damage accumulation are used, as well as the results of experimental studies of degradation of the properties of materials, assemblies and elements of aviation equipment during operation.

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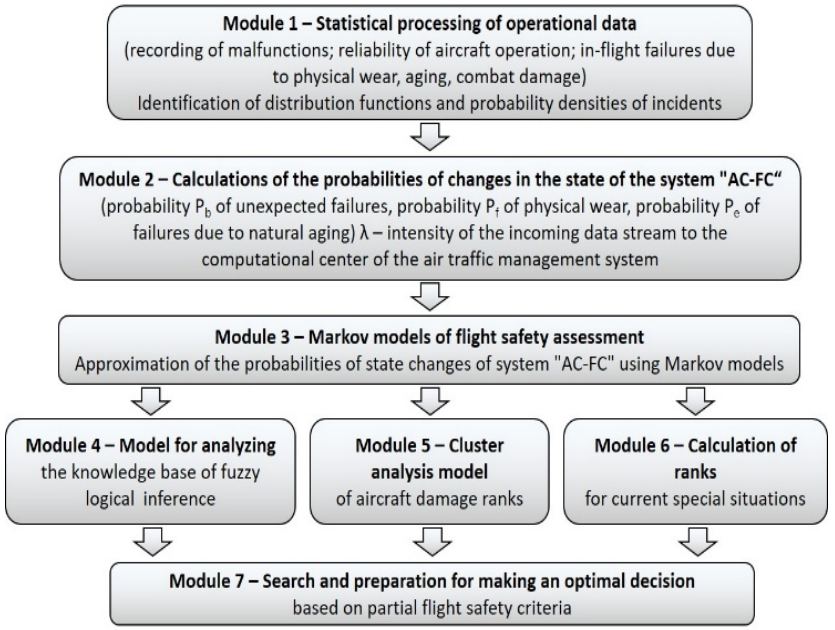


Fig. 1 Modular structure of the system mathematical support for dispatcher's decisions

If we assume that failures are distributed independently of each other, then the probability, for example, of failure-free operation of an aircraft engine P can be represented as

$$P = P_{\mathrm{b}} \times P_{\mathrm{f}} \times P_{\mathrm{e}} \tag{1}$$

where the calculation of probabilities is performed according to the laws: exponential for P_{b}, normal for P_{f} and P_{e}.

The values of the parameters of the laws are obtained as the results of calculations in module 1.

A general approach to the application of methods for preparing draft decisions based on the theory of random processes to assess flight safety is to study the structure of a branched graph of logical analysis of special situations, which is shown in Fig. 2.

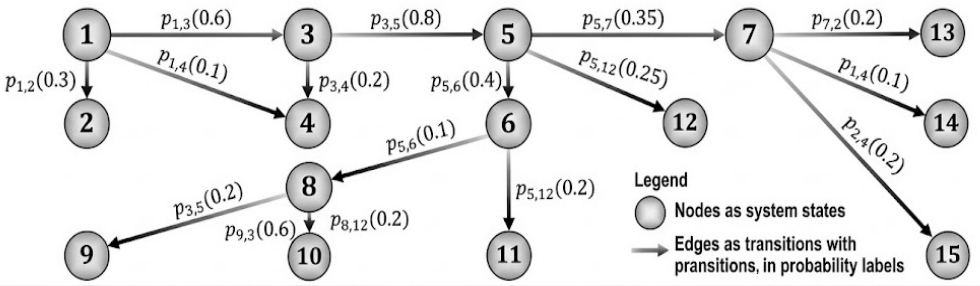


Fig. 2 General structure of the graph showing the logical scheme of possible states for the "AC-FC" system

The nodes of the graph correspond to the following states:

1) Initial state.
2) No occurrence of AF with probability P_f.
3) Impact of AF with probability $q_f = 1 - P_f$.
4) Restoration of aircraft serviceability after AF action with probability R_f.
5) Failure to eliminate the consequences of AF with probability $R_n = 1 - R_f$.
6) Ejection during transition to it with probability q_k.
7) Incident during landing with probability q_p.
8) No errors of FC during ejection with probability P_{lk}.
9) Accident due to successful ejection in case of failure-free operation of emergency rescue means with probability $P_{tk} = 1 - q_{tk}$.
10) Disaster during ejection due to failure of emergency rescue means with probability q_{tk}.
11) Disaster during ejection due to crew error with a probability of $q_{lk} = 1 - P_{lk}$.
12) Disaster due to lack of ejection and landing capability with a probability of $P_{кр}$.
13) Disaster during catastrophic landing with probability q_{pkf}.
14) Breakdown as a result of successful landing with probability q_{pc} (if after AF the landing is completed without damage to the aircraft and tramming of the FC, then such a state of the AC-FC system refers to the successful completion of the flight, since it is the result of eliminating the action of AF and restoring the operability of the aircraft).
15) Accident during emergency landing with probability q_{pab}.

Based on the analysis of the graph, we obtain the values of the probabilities, for example, of the successful completion of the flight:

$$P_{bp} = P_f + q_f \times R_f \tag{2}$$

in the event of an incident:

$$Q_i = 1 - P_{bp} \tag{3}$$

occurrence of an incident during landing:

$$Q_{ip} = Q_i \times q_p \tag{4}$$

destruction of one of the structural elements of the airframe and its systems, aircraft engine:

$$Q_p = Q_{ip} \times q_{pus} \tag{5}$$

accident during an emergency landing:

$$Q_{av} = Q_i \times q_{pav} \tag{6}$$

Module 3 describes mathematical methods [7] that allow determining the estimation the estimation of the probability of occurrence of special situations in the structure of AC-FC systems. For this purpose, mathematical methods of Markov processes are used, both with a continuous and with a discrete parameter (Markov chains) [8]. Fig. 3 shows, as an example, a graph of states of AC-FC systems based on a Markov process with a discrete parameter.

The use of the graph structure allows you to predict the probabilities of transition between the nodes of the graph:

- q_1 and q_2 are aircraft engine failures (AF_1) and FC errors (AF_2), which can mutually affect the occurrence of each other,
- R_1 and R_2 – elimination of the consequences of AF_1 and AF_2,

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- R_{24} and R_{34} – ignoring the consequences of AF_1 and AF_2,
- r_{23} and r_{32} are the probabilities of mutual influence of AF_1 and AF_2.

Module 4 is aimed at analyzing the knowledge base of fuzzy logical inference. The main stages of a fuzzy logical conclusion are the following actions:

- formation of a base of rules for products of fuzzy inference systems,
- fuzzification of input variables,
- aggregation of sub conditions in vague rules,
- activation or composition of conclusions in vague rules,
- accumulation of conclusions of unclear product rules.

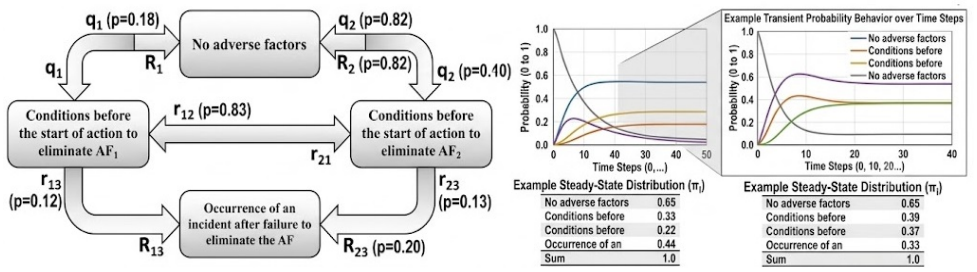


Fig. 3 Comprehensive Markov chain analysis: State transitions, transient probability behavior and steady-state distributions

The list of input linguistic variables can be increased according to the necessary information stored in the database and in the knowledge base, for example, the remaining fuel on board the aircraft, which determines the possible time τ_P of the accident elimination. It is also possible to take into account such linguistic variables as the level of personnel qualification, calendar service life, and the probability of the system state after the impact of AF [9].

Based on the information of the database, the set of solutions for classifying the technical condition of the structure $\Omega = (\omega_1, \omega_2, \omega_3, \omega_4, \omega_5)$ is considered as initial data:

ω_1 – minor damage,
ω_2 – weak damage,
ω_3 – medium damage,
ω_4 – severe damage,
ω_5 – destruction of aircraft.

The determination of the boundary boundaries between clusters of technical condition is carried out using one of the methods of pattern recognition theory when applying Markov chains for the glider [8].

Module 5 discusses cluster analysis of aircraft damage ranks. The list of input and output data allows us to propose the implementation of an expert and analytical approach to determining the ways to eliminate failures and combat damage according to algorithms that provide for the presence of the degree of damage. The boundaries of these intervals are justified by the classical psychophysical thresholds of Harrington's desirability scale, historically derived from the exponential distribution of human perception limits, and actively applied in modern aviation risk assessment models [10]. Fixed Harrington intervals are used as kernels or center points of trapezoidal/triangular

membership functions. At the boundaries of the intervals (e.g., 0.20, 0.36, 0.64, 0.80), the membership functions of neighboring clusters intersect. This models the smooth transition of the technical condition from one class to another and reflects the uncertainty of expert assessments. Using Harrington intervals as a basis for constructing membership functions allows the air traffic control system to operate with concepts such as: "the aircraft condition belongs to the class with probability 0.7, and to the class with probability 0.3", which provides the controller with a margin of time for making flexible decisions.

The Harrington scale is based on a double exponential transformation. The psychophysical desirability function has the form:

$$d = \exp\left[-\exp(-y)\right] \tag{7}$$

where y is the convolution of real physical parameters (in this case, glider defects and Markov chain probabilities), and d is the dimensionless desirability score (variable *Rang* from 0 to 1).

The threshold values are obtained mathematically through the ordinates of the characteristic points of this curve:

- outside the sensitivity zone (lower limit): $d = -\exp(1) = e^{-1} \approx 0.3679$ (rounded by the authors to 0.36),
- optimal balance point: $d = 1 - \exp(-1) \approx 0.6321$ (rounded to 0.64),
- critical state limit: $1 - 0.632 \approx 0.368$, and the extreme points of the extrema of the subjective perception of a human expert gave the limits 0.20 and 0.80.

The ranks of expert assessments are adjusted relative to the values of the probabilities of the states of Markov chains, which were previously calculated in Module 3. The integral rank has the form of the function:

$$Rang_{\text{final}} = f\left(Rang_{\text{expert}}, P_{\text{Markov}}\right) \tag{8}$$

The behavior of the model at "break points" (at the boundaries of intervals, for example, *Rang* = 0.36 and *Rang* = 0.64) is considered.

When input data vary, when the error of expert assessment or Markov chain calculation is ≤ 5 %, the result for Harrington's clear limits will be a change in the input parameter by 2 % in the area of the point 0.64. This will lead to a jump in the control decision: from "follow the controller's instructions" (ω_3) to "further flight is not advisable" (ω_5 or rigid ω_4). The system is hypersensitive (unstable) at the limits.

Result for fuzzy boundaries (from Module 5): Due to clustering and fuzzy inference, changing the parameter by ≤ 5 % near the point 0.64 will only change the degree of membership.

The sensitivity analysis of the mathematical model of Module 5 showed that the introduction of fuzzy logic inference and rank clustering eliminates the trigger effect of the hard limits of the Harrington scale. The model demonstrates resistance to noise in the input data (expert errors and instrumental errors of the airframe sensors) within ≤ 7 %. This prevents the issuance of false or panic recommendations to air traffic control system controllers during transit fluctuations in the technical condition of the aircraft.

The production rules of logical inference, which are included in the knowledge base, are as follows:

- if the *Rang* value is within the range [0.00, 0.20], then the technical condition is classified as ω_1 (Cluster 1), corresponding to a very high level of safety. At the

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same time, actions are performed to control the aircraft in accordance with the instructions for flight operation of the aircraft,

- if the *Rang* value is within [0.20–0.36], then the technical condition is classified as ω_2 (cluster 2), corresponding to a high safety. At the same time, actions are performed to control the aircraft in accordance with the instructions for flight operation of the aircraft,
- if the *Rang* value is within the range [0.36–0.64], then the technical condition is classified as ω_3 (cluster 3), corresponding to a medium safety level. At the same time, actions are performed to control the aircraft in accordance with the methodological recommendations provided by air traffic management system controllers,
- if the *Rang* value is within the range [0.64–0.80], then the technical condition is classified as ω_4 (cluster 4), corresponding to a low safety. At the same time, it is necessary to timely and accurately follow the methodological instructions of air traffic management system controllers,
- if the *Rang* value is within the range [0.80–1.00], then the technical condition is classified as ω_5 (cluster 5), corresponding to a very low safety. In this case, it is necessary to decide on the inexpediency of further flight.

The list of production rules for the logical conclusion of the initial variable Ω is determined based on the analysis of the list of decisions that, in the decision-making support system, are made by experts of the dispatch service, research institutions, aircraft repair enterprises based on the results of aircraft operation.

Module 6 provides calculations of the ranks of current special situations. In the model of rank calculations, a direct method of inference is used, which is implemented by transforming individual linguistic variables of the problem area into specific values of the functions of belonging to the conditions of fuzzy products [11].

After this transformation, according to one of the methods of fuzzy composition, the values of the membership functions corresponding to the right-hand parts are determined according to the respective rules. The process of forming a conclusion by direct method can be recursive (iterative).

Module 7 defines ordered sets of decision-making options to ensure flight safety. The set of alternative solutions $U = (u_1, \cdots, u_m)$ is formed based on the results of the fuzzy classification of current special situations (obtained in Module 6), as well as taking into account the current load of controllers – the number of aircraft N_{zad} that they simultaneously control from the total fleet N.

Each solution option $u \in U$ is evaluated according to two conflicting criteria:

- $f_1(u) = Rang \rightarrow \min$ – integral danger rank (minimization of risk for flight safety),
- $f_2(u) = \tau_P \rightarrow \min$ – time required to eliminate damage or localize failure of the alternating current – fuel pump (AC-FC) system.

Since minimizing the failure elimination time τ_P often requires actions that can temporarily increase the risk rank Rang (or vice versa), the problem of choosing a rational solution belongs to the class of multi-criteria (vector) optimization problems.

For the case of two criteria ($n = 2$), a mapping is given:

$$\varphi : U \rightarrow R^2 \tag{9}$$

which associates each solution $u \in U$ with a two-dimensional quality vector $f(u) = (Rang(u), \tau_P(u))$.

At the first stage of optimization, known ineffective options are cut off and a set of Pareto-optimal solutions $U_P \subset U$ is formed, for which it is impossible to improve any of the criteria without worsening the other.

In practice, to uniquely select a single optimal solution $u^* \in U_P$ in the contour of an automated air traffic control system, the lexicographic optimization method (ranking of criteria by priority) is used. Given the specifics of aviation safety, the criteria have a strict priority: $f_1(Rang) \succ f_2(\tau_P)$.

The algorithm for selecting the optimal solution u^* is implemented in the following steps:

- Step 1. The maximum permissible (critical) value of the hazard rank $Rang_{\max}$ is set according to flight safety standards. A subset is selected from the common solution space that satisfies the condition:

$$U_{acc} = \{u \in U_P \mid Rang(u) \le Rang_{\max}\} \tag{10}$$

- Step 2. If there are several options in the subset U_{acc}, the final choice of solution u^* is made, which minimizes the system recovery time τ_P:

$$u^* = \arg_{u \in U_P} \min \tau_P(u) \tag{11}$$

- Step 3. If no solution satisfies the $Rang_{\max}$ constraint (extreme situation), the system generates an alternative signal about the inexpediency of continuing the flight (as specified in the algorithms of Module 5) and issues a recommendation to the controller for an emergency landing.

The formed methodological apparatus of multi-criteria choice is directly integrated into the algorithmic support of the computerized decision support system (DSS) of the aviation controller. Due to the automation of the calculation of fuzzy safety ranks and the operational cutting off of Pareto-inefficient options, the DSS allows to significantly reduce the cognitive load on the human operator during peak loads of the N_{zad} aircraft fleet. This approach transforms the concept of the controller's interaction with the automated system: instead of independently analyzing arrays of raw data on airframe defects or failures of on-board equipment, the operator receives from the DSS a limited and clearly ordered set of rational control decisions U_{acc}, according to the priority of safety.

The mathematical basis for constructing such multi-criteria selection procedures and trade-off analysis under conflicting objective functions is substantiated in detail in fundamental works on decision theory, in particular in the study [12]. According to this theory, the lexicographic ordering of optimization criteria, where flight safety (*Rang*) has absolute priority over time costs (τ_P), is most justified for socio-technical systems of critical purpose.

The proposed method of using logical-probabilistic models and the algorithm for multi-criteria decision selection in the AC-FC system was successfully tested on aircraft operation databases in real conditions. For each aircraft, a forecast of changes in the technical condition was calculated individually, taking into account the operational damage received and performed maintenance work. The correctness of the forecast was checked in operation by monitoring the Rang value and controlling the specified level of flight safety according to algorithms that predict the degree of damage.

4 Results and Verification

Forecasting of changes in technical condition, using the proposed method, was performed by the authors in the system of maintenance of serviceability of state aviation aircraft. When the aircraft acquired signs of exceeding the expected operating conditions, the authors, by order of the operation management body, conducted appropriate studies. Cluster analysis to determine the ranks of damage was performed individually for each aircraft with the development of recommendations on the need to adjust the air traffic control system, or further use of this aircraft for its intended purpose.

Further, based on the recommendations provided, the aircraft was allowed for further operation for a certain period, with the execution of the relevant permits. The entire process of further operation was carried out under the scientific and methodological support of the authors, who periodically received data on the technical condition of the aircraft, its defects and malfunctions. The trend of changes in the technical condition was monitored, the values of the rank parameters *Rang* were checked and the level of flight safety was controlled. At the same time, it was clearly monitored that the value of *Rang* did not change during the controlled period of operation.

Since the service life extension was implemented in successive two-year stages, the changes in the Rang value and the verification of the predicted changes in the technical condition were evaluated for each of these periods. That is, for each aircraft, the changes in technical condition, the prediction of the technical condition for the subsequent period, and the verification of the prediction accuracy were performed iteratively for each successive two-year period. Over a fairly long period of such scientific support (about 20 years), prediction was carried out for over 40 aircraft of various types. The use of relatively small stages of extension and constant monitoring of changes in the technical condition ensured a forecasting error within < 5 %.

The summary performance metrics and the results of the long-term empirical validation are presented in Tab. 1.

The implementation of the developed methodology into the decision-making system made it possible to reduce the time for forming a decision and implementing measures to maintain operability, optimize resource allocation, and increase the limits of using aircraft resource indicators – the service life of experimental aircraft was extended more than twice – from 20 years, which was set by the developer, to 40, ⋯, 45 years, which gives a significant practical and economic effect.

Tab. 1 Summary of long-term validation results and performance metrics

Metric Parameter	Value / Operational Characteristic
Number of analyzed aircraft (*N*)	➢ 40 units (State Aviation fleet)
Total observation period	≈ 20 years
Incremental monitoring interval	2-year phases (step-by-step extension)
Achieved forecasting error	< 5 %
Observed range of danger rank (*Rang*)	0.20–0.64
Target safety clusters reached	Cluster 2 (“High safety”) & Cluster 3 (“Medium safety”)
Service life extension effect	From 20 years (developers limit) up to 40–45 years

The key aspects of verification are the compliance of the results with the specified reliability criteria. The results of the predictions were confirmed in real operating conditions – the Rang values are within [0.20 ÷ 0.64], i.e. the technical condition corresponds to the clusters high level of safety and medium level of safety.

According to the results of the prediction, the impact of AF or their combination was reduced by eliminating failures and malfunctions of individual structural elements of the airframe and its systems. This is objective evidence that the data obtained are not erroneous or distorted. The experience of accident-free operation of aircraft for which the prediction is made proves the absence of discrepancies between the predicted values AC and the actual ones.

5 Conclusions

For the first time, a novel methodology has been developed to support timely and well-founded operational management decisions for the operation of various types of aircraft under conditions of uncertainty.

The proposed methodological approach to building a mathematical model of data processing for special flight situations is advisable to use in decision-making support systems for air traffic controllers, which will allow a reasonable choice of a method for eliminating damage and ensuring flight safety.

The systematically considered methodology is an integral part of the formation of a new promising comprehensive approach to developing a decision-making support system for the operation of aircraft beyond the limits of resource indicators.

The direction of further research is the development of methods and algorithms of Pareto-optimal solutions for predicting the state of the AC-FC systems after the restoration of the technical condition of the airframe and its systems, as well as its engines.

List of Abbreviations

AC	aircraft	DSS	decision support system
AF	adverse factor	FC	flight crew
AC-FC	aircraft-crew ergatic system		

References

[1] ŻYLUK, A., K. KUŹMA, N. GRZESIK, M. ZIEJA and J. TOMASZEWSKA. Fuzzy Logic in Aircraft Onboard Systems Reliability Evaluation – A New Approach. *Sensors*, 2021, **21**(23), 7913. DOI 10.3390/s21237913.

[2] LI, Y., X. WANG and Z. LI. An Optimizing Maintenance Policy for Airborne Redundant Systems Operating with Faults by Using Markov Process and NSGA-II. *Reliability Engineering & System Safety*, 2023, **236**, 109257. DOI 10.1016/j.ress.2023.109257.

[3] MORATO, P.G., K.G. PAPAKONSTANTINOU, C.P. ANDRIOTIS, J.S. NIELSEN and P. RIGO. Optimal Inspection and Maintenance Planning for Deteriorating Structural Components Through Dynamic Bayesian Networks and Markov Decision Processes. *Structural Safety*, 2022, **94**, 102140. DOI 10.1016/j.strusafe.2021.102140.

[4] PFINGSTL, S., C. BRAUN, A. NASROLLAHI, F.-K. CHANG and M. ZIMMERMANN. Warped Gaussian Processes for Predicting the Degradation of Aerospace Structures. *Structural Health Monitoring*, 2023, **22**(4), pp. 2104–2126. DOI 10.1177/14759217221127252.

[5] KÜÇÜKER, F.U. and B. YET. Reliability Prediction for Aircraft Fleet Operators: A Bayesian Network Model That Combines Supplier Estimates, Maintenance Data and Expert Judgement. *Journal of the Operational Research Society*, 2023, **74**(10), pp. 2187–2198. DOI 10.1080/01605682.2022.2129486.

[6] OKORO, O.C. and S.A. DMYTRIIEV. A Model for Reliability Analysis of Aircraft Systems and Structures. In: *IEEE XIX Technical Scientific Conference on Aviation Dedicated to the Memory of N.E. Zhukovsky*. Moscow: IEEE, 2022, pp. 10–14. DOI 10.1109/TSCZh55469.2022.9802497.

[7] JIANG, D., T. CHEN, J. XIE, W. CUI and B. SONG. A Mechanical System Reliability Degradation Analysis and Remaining Life Estimation Method – With the Example of an Aircraft Hatch Lock Mechanism. *Reliability Engineering & System Safety*, 2023, **230**, 108922. DOI 10.1016/j.ress.2022.108922.

[8] CHENG, D., Z. LU, J. ZHOU and X. LIANG. An Optimizing Maintenance Policy for Airborne Redundant Systems Operating with Faults by Using Markov Process and NSGA-II. *Reliability Engineering & System Safety*, 2023, **236**, 109257. DOI 10.1016/j.ress.2023.109257.

[9] *EUROCONTROL Implementation Plan and Report 2024* [online]. 2024 [viewed 2026-01-09]. Available from: https://www.eurocontrol.int/sites/default/files/2024-10/eurocontrol-implementation-plan-report-2024.pdf

[10] BOLOHIN, A., Yu. BOLOHINA and Yu. TYMCHUK. Ranking of the Technical Condition of Aircraft According to the Diagnostic Data of the Glider Design. *System Research & Information Technologies*, 2025, **2**, pp. 98–106. DOI 10.20535/SRIT.2308-8893.2025.2.06.

[11] KYRYK, V.V. *Mathematical Apparatus of Artificial Intelligence in Electric Power Systems* (in Ukrainian). Kyiv: Polytechnic Publishing House, 2019. ISBN 966-622-969-2.

[12] VORONIN, A.M. and Y.K. ZIATDINOV. *Theory of Multi-Criteria Decision Making* (in Russian). Saarbrücken: LAMBERT Academic Publishing, 2018. ISBN 613-9-88890-5.