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PROCESSING OF FLIGHT INFORMATION OF OBJECTIVE CONTROL SYSTEMS UNDER THE CONSIDERATION OF FACTOR RESONANCE

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Abstract—*In the article, flights are considered as extremely complex multifactorial resonance processes. The issue is focused on the complexity of the application of the objective control systems data in airlines that use graphs (oscillograms) of flight transcripts. A new method of processing data on objective control systems is proposed – the transition from graphs of the objective control systems to flight management cards for determining the factor resonance phenomenon. Such cards are universal and can be applied on a single form as flight crews and airline managers. Entropy models are used that describe the interaction of a large number of factors. It leads to an increase the amplitude of the oscillatory process of the parameters of flight and called the phenomenon of factor resonance. The proposed processing of flight information of objective control systems allows consideration of factor resonance.*

Index Terms—Objective control systems; factor resonance phenomenon; multifactor resonance; entropy models; task of accounting a large number of factors; flight information processing; process analysis.

I. INTRODUCTION

Flights as extremely complex multifactor processes are such processes, in the structure of which there are not only regular components, such as flight stages (taking-off, cruise flight, landing approach, landing), as well as elements of the stages (turns, maneuvers, etc.), but also factor components, including zones of factor resonance, effects of factor overlaying, groups of interacting factors.

Analytics should contain not only regular analytics, but also the actual component. At the same time, in random processes are used non-stationary, non-ergative and non- differentiable processes.

Such an approach to flights is necessary primarily to address the issues of flight safety management and for the prevention of accidents and incidents.

II. FLIGHT PROCESS CONCEPT

Currently, ICAO assesses the multifactor character of flights of ADREP systems and creates multifactor structural models, such as the Reason model, as well as lists of active factors [1].

A classification of flights according to the general theory of processes is proposed, where flights are considered as extremely complex, multifactorial resonance processes (Fig. 1).

Such a structural scheme has the following advantages:

- classifies flights on flights «without comment» and other (from flights «with comments» to accident), while the first category is considered to be the main statistical base for managing aviation safety, in accordance with Annex 19 of the ICAO Aviation Safety Management Convention [2];
- it is multipurpose, because designed for airlines (flight control engineers, technical manager, flight personnel.

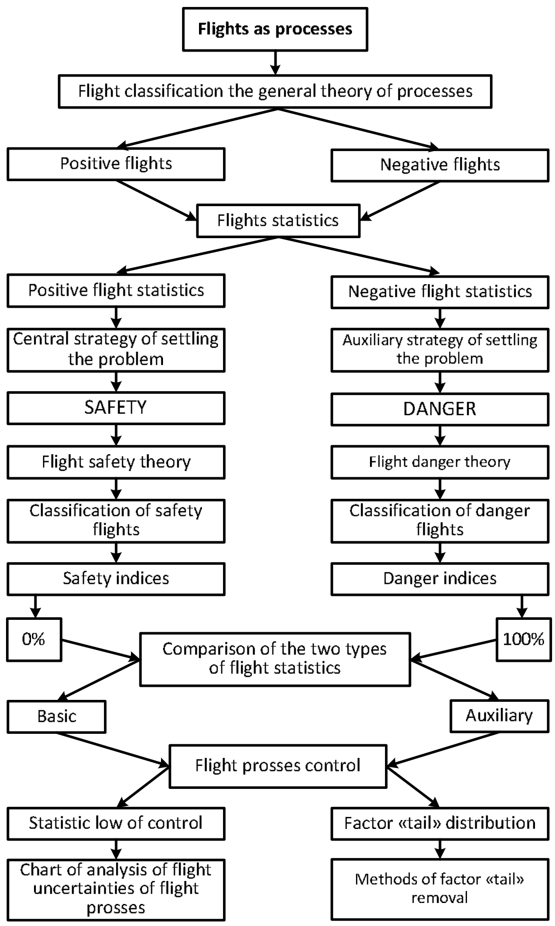

Fig. 1. The problem of aviation safety in terms of process analysis

Flight operations are managed through the functional diagram of the information management structure (Fig. 2).

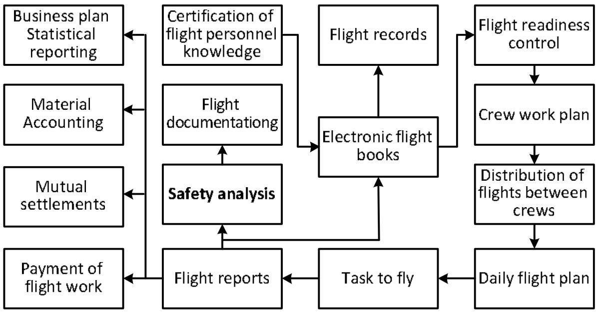

Fig. 2. Functional diagram of the information management structure (IMS)

When managing flight operations, the "Flight Safety Analysis" unit is essential for the evaluation of flight operations on the histogram of flights and the factor resonance phenomenon map.

Currently, the development of avionics systems often involves the calculation of reliability with the help of exponential failure model. A more correct calculations can be done using a non-differential failure model. It is also necessary to develop a general plan of activities in this direction.

III. MULTYFACTOR RESONANCE ANALYSIS

However, the analysis of flights as resonant processes under the action of factor disturbance and complexes of factors, i.e. the actual effect of multifactorial resonance has not been studied by ICAO. Therefore, the processes of aircraft crashes, as multifactor resonance processes, are not considered.

Multifactor resonance – is the phenomenon of maximum increase in the amplitudes of flight parameters (roll, pitch, angle of attack) when exposed to groups of hazard factors. It is observed in zones of multifactorial resonance, at the beginning of the development of an emergency [3], [4].

Also, for the analysis of the processes of accidents occurrence, as multifactorial processes, entropy models for interaction with a large number of factors (ILNF) are proposed. Entropy models of ILNF are additive, multiplicative, and combined models of interacting factors for studying the effects of multifactor disturbance, actions of factor overlays (Fig. 3). At the same time, there are observed the effects of information compression with an increase in the factors number, the effect of information "zeros", i.e. the disappearance of information. Hence there are reasons of suddenness when an emergency or situation occurs. Thus, there are zones of factor resonance in flights from the point of view of process analysis.

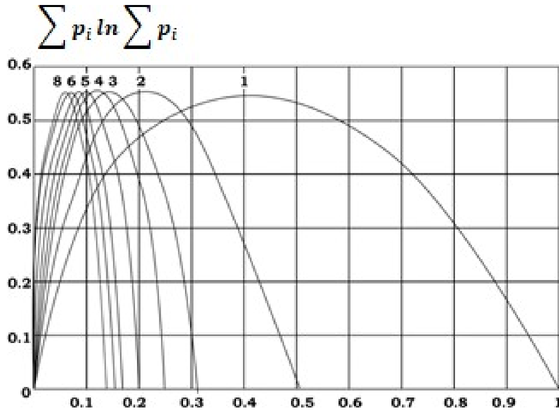

Fig. 3. Entropy models of ILNF (additive form)

This is proved by using the ILNF entropy models [3] – [5]. The dynamics of the acting factors is shown: with an increase in the factors number, the information zone decreases:

$$S = \sum p_i \ln \sum p_i ,$$

where, S is the entropy; p is a probability factor; i is the number of factors. Under the dynamics analyzing, the probability of factors are used in the full range from 0 to 1.

The zone of factor resonance is called the flight segment in which the oscillatory process of movement of the parameters amplitudes of the piloting technique is observed (for example, during reversals, after the 4th reversal, during an emergency or catastrophic situation).

IV. OPERATIONAL FLIGHT MANAGEMENT CARD

Currently, aviation safety is intensively addressed in flight safety. From the point of view of process analysis, flights are divided into positive and negative [6], [7]. The features of this flight analytics are such that the flight analysis is carried out without comments. Its distribution is shown in Fig. 4.

This classification divides positive flights into factor-safe, relatively factor-safe and extremely factor-indeterminate. (Fig. 5).

The proposed maps of factor resonance phenomena are intended to prevent aviation incidents, as well as to analyze factor overlays. With their help, we can remove a (false) negative safety assessment and control the flight safety. Thus, to solve such an important and urgent task, it is proposed to build a process concept of flight safety [7]–[9].

Oscillograms and objective control system (OCS) graphs are graphical and digital data of onboard parametric and voice recorders. Signal processing (flight information) is carried out by OCS specialists. The factor resonance phenomenon (FRP) map is an operational flight management card that minimizes risks to improve flight safety. It has a single form for flight crews, airlines, airline regions.

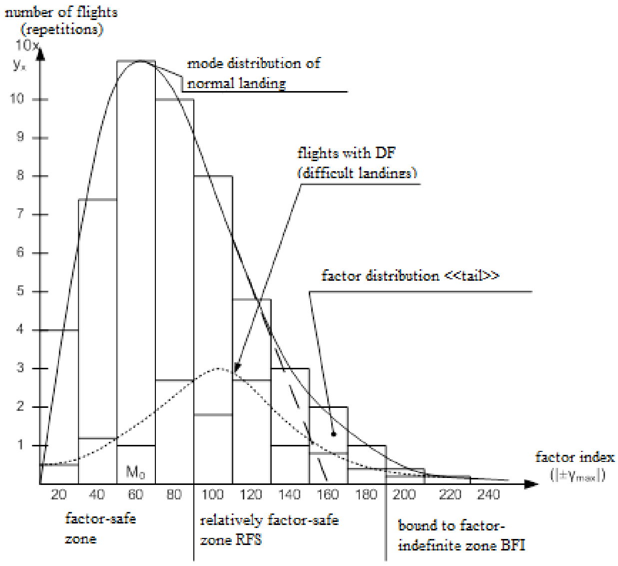

Fig. 4. Histogram of the distribution of flights

Factor resonance phenomenon maps are designed for operational flight control and minimizing risks to improve flight safety.

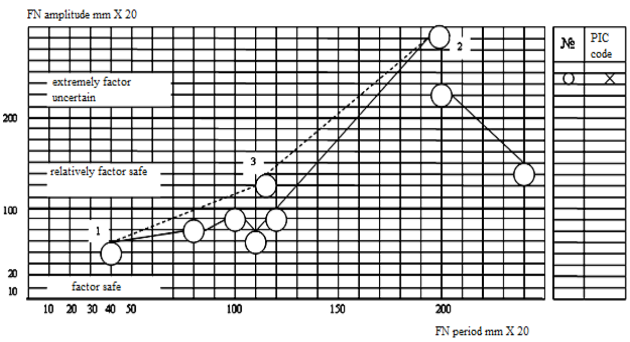

Fig. 5. Factor resonance phenomenon map

The mapping methodology includes the following features:

- determination of the data set on the flights “without comment” by the AFR specialists;
- investigation of factor resonance zones in the data array (for example, landing approach);
- factor indexation of the limiting parameters of the piloting technique and the construction of factor indices according to the maximum amplitudes and periods of the indices.
- determination of factor indices (points) on the FRP map. According to the results of determining the indices on the FRP map, it can be seen that the flight marked by point 2 is extremely factor-indeterminate, i.e. the flight was made with great difficulty, as confirmed by the pilot of this flight. The flight marked on the map, indicated by point 1, is factor-safe zone, made by the captain of the aircraft without difficulty, which shows a high level. Other flights (for example, point 3) are of medium difficulty – relatively factor-safe zone.

V. CONCLUSIONS

Entropy models are proposed for taking into account a large number of factors in which flights are considered as extremely complex multifactor processes.

A new method for processing flight information of aircraft flight recorders was proposed to minimize risks using flight distribution histograms and flight map of the factor resonance phenomenon.

The probabilistic and statistical laws of the distribution of the limiting parameters of the piloting technique, their distribution to the canonical and «tail» parts and the determination of safety risks have been constructed.

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Г.А. Положевець. Обробка польотної інформації з систем об'єктивного контролю з урахуванням факторного резонансу

Вперше польоти розглядаються як гранично складні поліфакторних резонансні процеси. Увага акцентується на складність застосування систем об'єктивного контролю в авіакомпаніях, що використовують графіки (осцилограми) систем об'єктивного контролю. Пропонується новий спосіб обробки даних за системами об'єктивного контролю – перехід від графіків систем об'єктивного контролю до карт льотних керівників для визначення перших ознак явища факторного резонансу. Такі карти носять універсальний характер і можуть за єдиними бланками застосовуватися на рівні як льотних екіпажів, так і льотних керівників авіаринку.

Ключові слова: система об'єктивного контролю; аналітика польотів; явище факторного резонансу; поліфакторних резонанс; ентропійних моделі ЗУБКФ; обробка польотної інформації; факторний індекс.

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Положевец А.А. Обработка полетной информации с систем объективного контроля с учетом факторного резонанса

Впервые полеты рассматриваются как предельно сложные полифакторные резонансные процессы. Внимание акцентируется на сложность применения систем объективного контроля в авиакомпаниях, использующих графики (осциллограммы) систем объективного контроля. Предлагается новый способ обработки данных по системам объективного контроля – переход от графиков систем объективного контроля к картам летных руководителей для определения первых признаков явления факторного резонанса. Такие карты носят универсальный характер и могут по единым бланкам применяться на уровне как летных экипажей, так и летных руководителей авиарынков.

Ключевые слова: система объективного контроля; аналитика полетов; явление факторного резонанса; полифакторный резонанс; энтропийные модели ЗУБКФ; обработка полетной информации; факторный индекс.

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