

Structural Components of the System of Managerial Procedures and Their Interconnections at Introduction and Implementation of Flight Safety in Large-Scale Aviation Systems

Ageeva Natalia, Minaev Eduard

Moscow Aviation Institute (MAI), Volokolamskoe highway, 4, 125080 Moscow, Russia

Abstract – Developing the instruments of managerial procedures on flight safety is based on the complex solution and opportunities to intensify social-economic effects of aircraft engineering. They are used to achieve more precise assessment of the uncertainty and other factors that influence the results of the safety of product designs and their operation.

Keywords – management, procedures, flight safety.

1. Introduction

Increasing the significance of the research on flight safety management in the world is connected with radical innovative transformations of aircraft engineering in conditions of severe competition and global markets [3, 8]. Adaptation to them in the sphere of management technologies is capable of providing positive development of the great majority of aviation systems in the world. The current interpretation of managerial procedures on flight safety management is excessively simplified, there is

essentially no clear understanding of characteristics of the processes. Existing researches on this subject are fragmented or generalizing. Individual local changes on flight safety are considered as reactions to events. The system of managerial procedures on promotion of flight safety has not been formed as an integral conception in terms of methodology yet [1].

The scientific novelty of the research is in forming an integral system of managerial procedures and assessments ingenious in matter, which are used at promotion of flight safety of aircraft engineering.

Elaborating a system of managerial procedures and their interconnection at introduction and implementation of flight safety is a complicated and multidisciplinary process. It is connected with the search of forms and procedures of management as well as with assessment of a large amount of different factors and scenarios of developing aircraft engineering products in the changing business environment. At the same time, it is necessary to consider a number of International Civil Aviation Organization (ICAO) initiatives on flight safety management for all the aviation industry participants and the countries members of ICAO [6, 10].

The purpose of the research is to widen the conception of elaborating the mechanism constituents on promotion of the flight safety, which must be aimed at increasing competitive advantages of the aircraft products by means of a complex of managerial procedures on perspective activity directions including information exchange of development and operation enterprises.

For a set and solution of this problem one needs appropriate tools that allow to consider quantitative interconnections in the impact of the progress of science and technology and macroeconomic regulators on the character of organizational and managerial processes at the enterprises dealing with development and operation of aircraft engineering as a whole.

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Corresponding author: Ageeva Natalia,
Moscow Aviation Institute (MAI), Moscow, Russia


Email: agueva@yandex.ru

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Structural constituents of managerial procedures are considered together with applied technologies and approaches to management of flight safety implementation as well as with development directions of the opportunities on enhancing the product efficiency.

In combination they balance all the sides of the organizational-productive and managerial system in the composition of elements. A complex system is formed in the structure of the bounds between the elements and the characteristics of the system aimed at maintenance of economical, informational, process, dimensional and other characteristics. That means that there is the opportunity to determine the set of structural components of the system of managerial procedures and their interconnections that entirely determine the object and subject of the assessment and characterize their functioning.

The set of these structural constituents that characterize the level of system functioning organization with regard to its structure, composition and characteristics form the vectors of the system structure, composition and characteristics respectively. There are reference vectors or vectors of target state corresponding to each of these vectors.

The whole accessible set of managerial procedures and their interconnection for assessment and selection of managerial procedures on introduction and implementation of flight safety is formed in the area of unbound subsets of stable and unstable regions. The modes of behavior in these regions are suggested to select according to:

1. Assessment and selection of strategic priorities in promotion of flight safety at the stages of design and operation.
2. Managing a set of advanced works on promotion of flight safety.
3. Preemptive risk management for flight safety.

The description of management system processes involves forming not only assessment models and management technologies on promotion of flight safety, but also the assessment of interconnections in the system on life cycle of creating and operating the aircraft production as a set of structure elements and interconnections between these elements [5].

Thus, the possible variants of interconnection of these suppositions provide a set of assessment methods, each of those has its own peculiarities and purpose. Therefore, application of this approach allows to get a significant range of assessment methods necessary for managerial procedures while forming and implementing flight safety at the enterprises of aviation complex. We will give characteristics to basic constituents of the managerial model of the process of ensuring the system flight safety.

2. Assessment and selection of strategic priorities in promotion of flight safety

At the setting stages of developing the programs of flight safety promotion, the managerial issues were connected generally with defining the priorities while distributing scientific and technical resources and with funding technological developments. However, while executing these programs there were difficulties, particularly due to the fragmentation of activity and dispersion of statistical resources, and also while getting strategic information about cooperation of industry organizations and the enterprises operating aircraft engineering which is necessary to make decisions [2].

Systematical approach to management of promotion of flight safety is expressed in functional interpretation of the system where the main attention is paid to the issues on how development of different system functions happens and how the bounds between them are provided and whether the interaction between them leads to generation of significant strategic priorities of development in the products. However, for implementation of this approach extremely high level of management for appropriate analysis and comprehension of key pinch points in sophisticated systems is needed.

That is why for efficient embodiment of the strategic approach to management of flight safety promotion it is suggested that «management of social-technological transit» instruments should be applied. Management of transit is a flexible policy, which is aimed at such long-term system changes as a basis for development of policy in short-term period and is implemented with constant assessment and adaptation of transition purposes and applied instruments. That allows to take into consideration interests, opinions, points of view of the enterprises of development and operation of equipment simultaneously at different levels and in different areas of knowledge [4].

In addition, while introducing the complex policy, great attention is paid to coordination issues on supporting the development and introduction of the concrete flight safety technologies for every product design that play a key role for solving the most important economic and social problems at forming strategic plans of development and application of these technologies.

That is, there is a suggested transit from the promotion of flight safety policy aimed at minimization of negative consequences at implementing to coordination-oriented policy, where the persons responsible for decision making exchange the information, knowledge with other concerned parties forming new interaction coalitions

where the informational “strategic intellect” will be collected.

Coordination-oriented policy is aimed at involving the widest range of concerned parties in joint science-technical and operational activity as well. It also supposes creating the new and broadening the existing nets of cooperation encouraging coordination of uniting efforts of different subjects – the state, science, producing and operational enterprises – in defining strategic priorities and development directions in elaborating strategic research programs and forming cooperative programs of scientific and technological development as well as defining the ways of implementation of these researches.

Structural components of the system of managerial procedures and their interconnection at promotion of flight safety based on coordination-oriented approach use primarily vertical coordination of multilevel aviation systems and horizontal coordination of structural units of developing flight safety directions.

Vertical coordination of multilevel aviation systems is connected with the management hierarchy between the microlevel (individual enterprises, big industrial estates), meso level (industry, region) and macrolevel (state). It is the complexity that distinguishes large-scale aviation systems from other fields of activity.

Horizontal coordination in interaction between the units of developing and operational enterprises is aimed at the search of opportunities of joint developing of managerial solutions that take into account the purposes of process development of introducing and implementing the directions on promotion of flight safety. This allows to form not only new organizational structures by the hierarchy levels coordinating these processes but also to show their tight interconnection.

Thus, despite extensive use of coordination mechanisms, their methodological base that allows to plan and operate managerial activity needs not only to adapt the directions of the research data in Russian practice but also to consider additional spheres of application of this approach. One should take into consideration that the choice of strategic priorities in promotion of flight safety involves a thoroughly organized multilateral solution aimed at increasing the development level.

3. Managing a set of advanced works on promotion of flight safety

The basic components of organizational management processes of advanced works on promotion of flight safety starting from early stages of designing on developing enterprises are aimed at constant improving the whole system of flight safety

promotion at the stages of the product life cycle. The works on improving the level of flight safety play an important role in the duration and cost of conducting pre-project research and are a crucial part of the general problem of creating a product as a whole.

A set of advanced works on promotion of flight safety contributes large-scale changes to organization management processes that affect all the designing stages and levels of organization. There appears a necessity for a set of additional investigations that include pre-project research with a large program of experimental works confirming an opportunity to get basic figures of assessment of the flight safety level.

Management of a set of calculating and experimental works aimed at advanced (with regard to the realization stage) determination of basic performance range of flight security allows to achieve the system adaptability. The essence of adaptation with regard to flight safety promotion is in more complete (with respect to the volume) and more improved (with respect to the method) accounting of information used in planning and managing, in capability of improvement in changing the environment of functioning and operation with regard to global purposes.

Advance assessment of flight safety promotion is aimed at causing the effect on the assessed value for managing this value purposefully, timely, efficiently. To organize the process of this assessment a system of figures, criteria, methods, models, algorithms and programs of comparative analysis of design variants of the product relating to the flight safety promotion is needed.

In the work the choice and number of the assessment figures of flight safety are determined by the level of designing stages relating to certain implementation conditions. The changes occurring in external environment or in industrial organization system that influence the assessed value of flight safety promotion are taken into account as well. The formalized process of forming the assessment figures of flight safety promotion includes:

- enlarged forming of the structure and kinds of flight safety works carried out along the life cycle of the product;
- classification of parameters and procedure of forming the flight safety assessment figures at designing stages.

Figure values of flight safety are determined according to the given basic structural and operational characteristics of a product and conditions of operation and management as well. They are used in the choice of general project solutions, alternative variants on the product as a whole providing fulfillment of the target task.

Advanced works on promotion of flight safety are interpreted in the study as a multilevel assessment method of project variants formed by operative sequence of basic design and implementation stages and the corresponding figures of flight safety assessment, forming a program at all the stages of its life cycle.

The model of hierarchical flight safety assessment system may be presented as a simple multipurpose system with a set of flight safety assessment parameters; a set of basic structural and technological parameters as well as reliability parameters and also parameters of predicted limiting values of the expected operation conditions for providing efficiency of a product as a whole.

At the first stage of assessment – technical proposal (avant-project) substantiation of priorities and ways of fulfilling the requirements for flight safety is conducted basing on structural solution schemes and data of predicted assessment of the flight safety level as well as entering corrections based on analysis. A set of technical, technological and organizational economic parameters form an area of permissible variation of flight safety level using the criterion “cost-effectiveness”.

At the second level – a draft design of the system architecture, preliminary safety analysis of different projects is conducted on the basis of development of technical solutions on meeting the requirements for reliability figures, flight safety and consequences of predicted constituent failures using the data of methods, analogues, suppliers’ messages [11].

At the third assessment level – the stage of engineering development, every incoming element of subsystems is characterized by its parameters of flight safety promotion, value of permissible structural technological parameters. Assessment of flight safety promotion is based on experimental research of flight simulators, modeling sets, simulators on safety analysis of the system. Assessment of the extent of special situations caused by constituent and unit failures is conducted.

Stratification of the system of assessing the flight safety level into independently functioning systems (projects) are determined on condition that:

- every project by its structure is a part of a larger system (a system of a top-level product) and the purposes of every project (system) are under the control of higher-level systems and serve as a means of its achievement. The hierarchy of systems is a reflection of hierarchical purposes;
- the condition of stratification should be considered observing the principle of integrity for every system that means having characteristics that is not a simple sum of characteristics but where every system constituent is connected with others. A change of this

constituent may trigger changes in certain elements and the system as a whole.

Thus, it is suggested observing the hierarchical system of assessment of flight safety level on condition that all the systems cooperate to achieve the only purpose of optimization of superior system efficiency figures and that at every hierarchical stage homogeneous by structure organizational and mathematical support is used.

At the same time, the extent of information specification at different hierarchical levels must be various. At the first level the information on flight safety promotion of the product as a whole is necessary. At the second level, the information about certain projects and their constituents must be present. Although, at all these stages one should take into account the perspective of forming a constantly functioning system of informational data provision of flight safety promotion in full.

4. Classification of parameters and procedures of forming flight safety assessment figures along designing stages

The model of hierarchical system of flight safety assessment may be presented as a simple multipurpose system with a set of flight safety assessment parameters; a set of basic structural-technological parameters including the safety parameters; as well as assessment parameters of developing organization functioning and predicted limiting values of expected operating conditions for providing the criterion “cost – time – efficiency” of a product as a whole – S. Mathematical model of hierarchical system of assessment may be represented as a functional dependency of a simple multifunctional system

$S = \{X_p^q, Y_p^q, C_p^q L_p^q\}$, where:

X_p^q – is a set of basic constructional-technological parameters;

Y_p^q – a set of parameters of flight safety assessment;

C_p^q – a set of assessment parameters of developing organization functioning;

L_p^q – a set of predicted figures of expected operation conditions;

p- a number of levels of hierarchical system of aircraft designing from top downwards,

q- a number of a system (subsystem) at the given hierarchical level.

A set of the given assessment parameters is assessed by a system of quantitative and qualitative figures of flight safety promotion along design stages, including mutually supplying generalized and single figures.

A system of figures of aircraft flight safety is controlled in accordance with the requirements of regulatory documents where general aircraft systems designing requirements are given. [All Union State Standard 56080-2014 “Aircraft. Flight safety, reliability, testability and maintainability programs. General requirements.”].

The basic figures of flight safety promotion include: an average number of crashes for 10000 flight hours; probability values of aircraft damage absence and incidents during the flight; incident danger coefficient etc. But these quantitative flight safety figures can be assessed only after the first aircraft flight.

The probability of occurrence of a certain situation on flight safety is interconnected with the level of providing a set of structural-technological parameters of product assessment. At the early designing stages, it is possible to identify probable aircraft failures and assess their consequences taking into consideration the flight stage by possibly advanced works, for instance, by figures of safety, inspectability, operation and repair performance, the accordance with which will be the basis for flight safety promotion validation at the stages of aircraft designing. The following parameters pertain to safety figures: probability of trouble-free operation; average failure interval; average flight failure interval; failure flow parameter; failure rate; average flight failure and damage interval (during the flight) etc.

A set of developing organization functioning figures is aimed at assessment of organization-technical designing level, a state of designing systems, interconnection of processes and works as well as planned changes in the system of designing and introduction of new procedures. Relating to the promotion of flight safety level the following quantitative figures of functioning assessment are pointed out: by completed safety inspections; conducted risk assessments; the crew having completed flight safety training; the necessary time to elaborate measures on an aircraft incident. In addition, qualitative figures are taken into account: the crew’s feedback on quality of flight safety functioning, crew’s recommendations on system work optimization etc. [7, 9].

Hierarchical structure of the process of forming the promotion of flight safety figures allows:

1. To determine figure values of a set of advanced design works on flight safety promotion by initial structural-technological parameters of aircraft systems and predicted values of expected operation conditions.
2. To form single figures for assessment of the certain systems (designs, subsystems) taking into account the organization and management of the set

of advanced works on aircraft flight safety promotion.

3. To combine local figures of system elements and to proceed to generalized project assessment figures on the basis of flight safety promotion.

Further specification of the expected level of flight safety assessment is conducted at the stage of factory certification tests. The analysis of causes and consequences of dangerous failures, revealed at the test stages, elaboration of necessary measures continue at the stages of batch manufacturing and operating. The calculation of quantitative flight safety figures and the results of works on project stages are confirmed by report documents on meeting the requirements for promotion of acceptable level of flight safety.

Therefore, the peculiarity of advanced works on promotion of flight safety at the stages of product designing is the iterative nature of managing processes, which assessments are being corrected and updated at developing and forming the basic product systems as a whole. The assessment and management of a set of advanced works on promotion of flight safety are always aimed at accordance with the changes in the external environment due to changing the state of internal environment and constituents of flight security assessment or redistribution of connections and interactions in the product and figures of flight safety assessment.

5. Risk management for flight safety

Integration of management processes in developing organization is expected to give synergistic effect in issues of flight safety promotion particularly in the field of risk management. It is supposed that the core element of the system of managerial procedures on introducing and operating aircraft flight safety in developing enterprises is the process of risk management. But for risk management a completely functioning system of collecting and analysis of data on flight safety as well as a system of promotion of flight safety efficiency control and assessment are needed. The main problem of risk management in aircraft systems is an opportunity to reveal dangerous factors and their elimination/ acceptable minimizing the consequences of their appearance.

The approach to risk management for a developing enterprise slightly restricts the problem, it is aimed at forming managerial procedures on assessment of structural production drawbacks or their potential influence on other constituents of the system “crew – product – environment” to know what the real risk for flying operation of the product is created by these system elements. Risk management is also aimed at forming the information on expected frequency of

appearing initiating cases (by the developer's fault) and assessment of the level of protection from the possible case.

Under the conditions of increasing and integration of modern aircraft the necessity to observe functional characteristics of developing systems and to assess their risks as early as at the initial designing stages rises. While advancing along the life cycle stages there are created and accumulated arrays of heterogeneous interconnected information about the properties of the product, characteristics of its constituents, also dangers are being revealed, safety cases that allow to classify the risk of the case. The database provides the opportunity to conduct frequency, trend analysis, identify the safety problems and then to assess the risk of the problems.

However, in practice it is a relatively low level of IT use that turns out to be critical. Partial automation of accounting functions, fragmentary use of isolated automatic management on systems of flight safety promotion including risk assessment does not contribute to creating competitive products. The crosscutting information technologies along the product life cycle stages as a necessary requirement for the production quality increase, advance of reliability and safety of aircraft flights are needed.

The changes of organization and promotion of flight safety management processes at the stages of designing aircraft systems are also connected with the necessity of not only updating and modernization of management systems but also with changing the processes of organization with external product/technologies developers and operative enterprises.

The condition of systems of organization and management at designing aircraft systems as well as the perspectives of their development evolve new ideas on improving the management processes of these systems. A peculiarity of management becomes a variety of product creation models.

Model of "Vdesign process" that can be adapted to domestic developments on promotion of flight security of sophisticated aircraft systems is based on the theory of system engineering and the theory of sophisticated aircraft engineering systems. It includes a sequence and interconnection of management and control processes along the life cycle of product creation; forms systems of requirements for designing, control, examination and testing the product along the management levels.

6. Conclusion

The suggested developments are aimed at improving the in-house managerial processes of design aircraft enterprises with regard to activation of horizontal interconnections along the stages of the life cycle of product creation. They allow to select a system of advanced managerial procedures and assessments of designing taking into account the choice of strategic priorities in flight safety promotion on the basis of multilateral solution aimed at increasing the safety level of aircraft engineering, its competitiveness and reducing the period of the product entrance to the market.

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