APPLICATION OF THE THEORY OF COMPLEX SYSTEMS IN STUDIES OF THE FUNCTIONING OF AIR TRANSPORT SYSTEMS

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A complex system is a system that consists of elements of different types and has heterogeneous connections between them, so the air transport system consists of a set of jointly operating aircraft, a complex of ground facilities for flight preparation and support, personnel engaged in flight operation, maintenance, and repair of aircraft and ground facilities, as well as subsystems for controlling the process of flight and technical operation.

Structurally, ATS includes the following elements: crew, aircraft, flight and technical operation system, flight support system, ATS. Further applying a systematic approach to considering the problem of flight safety, individual elements of the ATC or their combination, in turn, can be considered as an independent system, for example, "Crew - Aircraft".

Complexity is understood as both an objective and a subjective phenomenon. Objective complexity is inherent in systems regardless of the subject who cognizes them, subjective complexity is due to the nature of the perception of the system by the subject, depends on the lack of knowledge and intelligence. These two types of complexity closely interact with each other, especially when this or that system is only included in the cognitive process. But the basic basis is the objective complexity of the system.

Establishing the complexity of a system is extremely important for practice. In science, there are four approaches to understanding complex systems [1].

According to the first approach, complex systems are systems with poor organization. These include the so-called diffuse ones, with a large number of variables, between which it is impossible to install partitions that delimit the components. Diffuse processes are constantly going on in them. This is characteristic of innovative diffusions in technical and economic systems. Systems are also considered complex if their functions depend on the environment. The latter constantly influences the system. Therefore, these systems resemble a boat in a stormy sea, which predetermines the complexity of its route to the saving bay.

In the second approach, complex systems are understood as such systems that cannot be accurately described mathematically (here the cognitive, epistemological and even instrumental aspect of complexity manifests itself), but it also has an objective, ontological cut, since variable, stochastic multi-level systems cannot be described. The disadvantage of this approach is that the world of complex systems turns out to be very large, because there are very few strictly mathematically described systems.

In the third approach, systems of purposeful behavior are considered complex, i.e. social. In this case, complex systems coincide with a person, his social organization, which is not always justified, because complexity is not identical with purposefulness.In the fourth approach, complexity is interpreted from the position of set theory as an element of the set where it acts as a set. Here complexity is equated with the concept of "many", which is applied to elements, structures, properties, functions, etc. ATS can be viewed as a complex system, each element (subsystem) of which includes machine and human links, that is, it is a typical human-machine subsystem with its specific properties. For almost all elements of the vehicle, general factors can be named that determine the reliability of the operation of these elements, and, consequently, affect flight safety [2].

With regard to models of complex technical systems with a discrete nature of functioning, it is proposed to distinguish two directions of the hierarchy:

1) a vertical hierarchy, in which the division of models by levels is carried out depending on the structural and functional features of the system;

2) a horizontal hierarchy, in which the division of models by levels is carried out depending on the methods of their study.

The main advantage of simulation is its versatility, i.e., the ability to study systems of virtually any complexity with any degree of detail. As applied to the modeling of priority systems, this universality manifests itself in the possibility of studying the properties of systems under any laws of distribution of random variables, describing, in particular, the time intervals between the customers entering the system and the duration of customer service. However, in practice, it turns out that simulation modeling also has certain limitations, due to both the capabilities of computer technology, with the help of which the simulation model is implemented, and the disadvantages inherent in simulation modeling [3].

For example, to study the optimal distribution of aircraft in transport directions, based on the supply and demand of transported goods, the following model can be built:

Objective function:

$$L = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \to min;$$

Subjects to:

$$\sum_{j=1}^{n} x_{ij} = a_i, \qquad j = \underline{1, n};$$

He also knows many models for the study of processes by the method of their imitation and optimization of air transport systems.

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