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Structural Modeling of the Electronic Educational Complex for Studying the Legislative and Regulatory Documents of Civil Aviation

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Abstract. The results of research in the field of digitalization of methodical support of training process of aviation dispatchers are presented. As a subject area of research, the development of an electronic educational complex for the study of civil aviation documents of the Republic of Uzbekistan and ICAO, regulating the processes of organization and maintenance of aircraft flights are considered. The structure of the electronic educational complex for the purpose of development of software and algorithmic means is formalized with the help of the multiplicity theoretical approach, which allowed to carry out on the computer the construction of various variants of educational tasks on legislative and regulatory documents, which are issued to students for study and mastering. The educational complex allows to raise essentially efficiency of training by granting unlimited time for independent work on study of documents of civil aviation. At structural modelling the necessary more theoretic and multiple statements which have formed a basis for construction of various kinds of occupations are formulated.

Keywords: civil aviation, aircraft, legislative document, normative-legal document, educational system, training of aviation dispatchers, educational process, methodical support, digitalization, electronic-educational complex, structural modeling, theoretical multiplicity method.

The civil aviation (CA) system is an important segment of the global economy. It plays an important role in the mobility of people, cargo, mail, etc. The unquestionable requirements to its activities include flight safety [1], compliance with which is regulated by various technical, organizational, legal, economic and other types of documents having the status of a separate state or ICAO status. Annex 19 of the Chicago Convention [2] and a number of ICAO documents, e.g. [3], are the fundamental documents defining the methodology of flight safety management in international CA.

The technical condition of the aircraft plays a major role in flight safety, the level of which is more related to the human factor [4]. The flight safety level is directly affected by the quality of organization and service [5]. There is quite a lot of analytical reasoning to do with this. However, the human factor always remains in the field of special attention, as many aircraft accidents are mainly related to human activities. Thus, the quality of training of aviation specialists, including air traffic controllers, has relevance that cannot be justified. Regarding the requirements for training of aviation specialists, there are a number of ICAO documents, which specify the policy [6], rules and recommendations to be observed. In particular, manuals on training [7] and knowledge assessment [8] have been published for the training of air traffic controllers.

The system of training specialists for CA is unevenly developed within individual states. Some countries have the necessary and sufficient teaching and methodological tools that fully meet the requirements of the time, while some countries need to create or develop them, as confirmed by ICAO studies [9].

Digital educational technologies are currently being developed in terms of improving the educational process and broadening the educational system to include not only classroom but also non-attendant classes.

Digital educational technologies are associated with the analysis and mathematical formalization of complex organizational and functional systems and processes, and further development of appropriate software and algorithms.

Many scientific and methodical works are devoted to the modeling of complex systems and processes [10-17]. In the context of the subject they concern not only general issues of modeling systems and processes, but also the modeling of specific processes [17].

For maintenance of efficiency of processes of preparation of air traffic controllers, it is actual to develop subject-focused electronic educational complexes (EEC) of training of students of legislative and normatively-legal documents (LaNLD) of CA. On this basis, the article deals with the theoretical foundations of modeling the structure of EEC " LaNLD ". This complex was developed in the context of the educational process of training air traffic controllers for the State Aviation University of Uzbekistan in Tashkent State Technical University named after Islam Karimov. The conceptual structure of EEC " LaNLD " is shown in Figure 1.

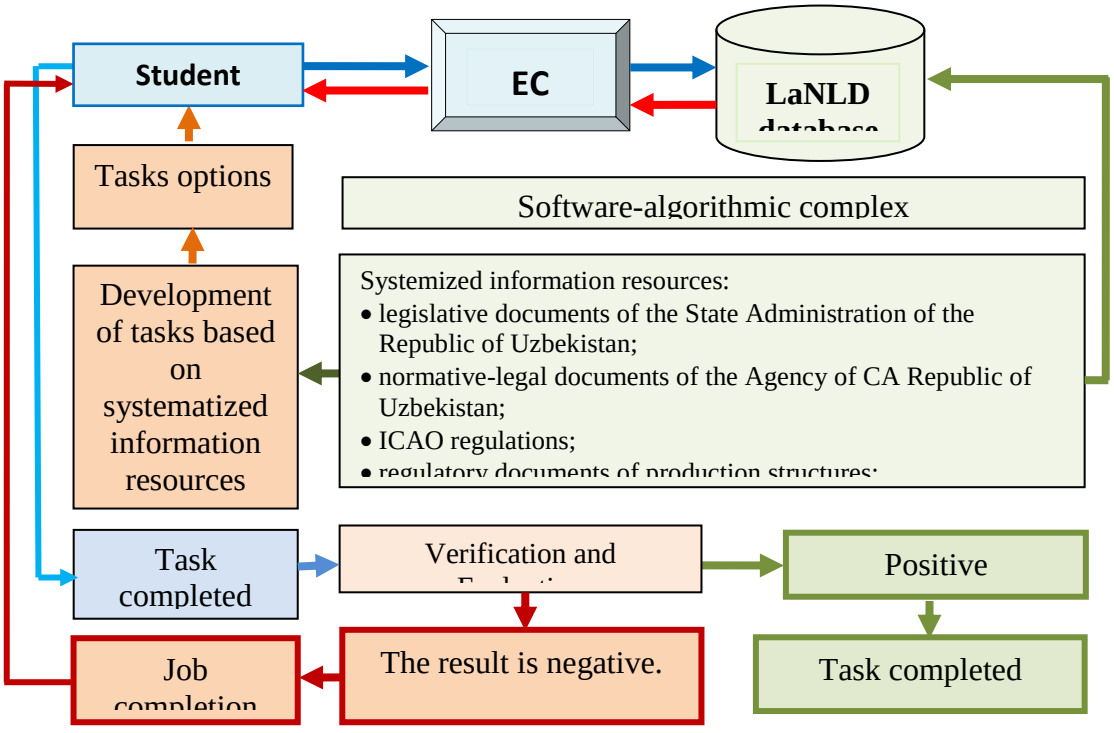

Fig. 1. Conceptual structure of EEC " LaNLD "

Digitalization, i.e. the conversion of a complex system, including an educational system, into electronic format requires the development of necessary mathematical models reflecting the essence of its structure and functional relationships between its components (elements).

The conversion of some training process into electronic format is connected with the implementation of the model of three basic actions: mathematical formalization of the system structure ⟶ development of information support in the form of a database (DB) ⟶ development of software and algorithmic software.

For mathematical description of discrete systems, to which EEC refers, with simple structure and functional-parameter links, as a rule, it is possible to carry out by means of the theoretic-multiple method of modeling [11; p.182] with application of logic algebra. This will give quite adequate results. At the same time, there are no paradoxes in the modeling of this training complex, because the process of formalization and synthesis of the structure is based on the use of elements with unambiguous and specific-oriented content. Their identification is based on the concepts of logic algebra.

In this article the main part of EEC is considered, where the process of synthesis (building) of variants of tasks for training students of LaNLD CA on practical lessons in a classroom or by remote access to a complex, when it is necessary for independent studying of materials is formalized.

The construction of variants of practical tasks will be carried out according to the content of the LaNLD, which together represent an information field formed in the form of the Database.

To streamline the process of modeling, the conceptual structure of EEC " LaNLD " includes autonomous blocks - Block 1 (B_1), Block 2 (B_2) and Block 3 (B_3), which have a separate purpose and objectives (Fig. 2), but in the aggregate implement the functional essence of the educational complex. Based on this approach, let's express this level of EEC " LaNLD " state by many:

$$EEC = (B_1, B_2, B_3). \quad (1)$$

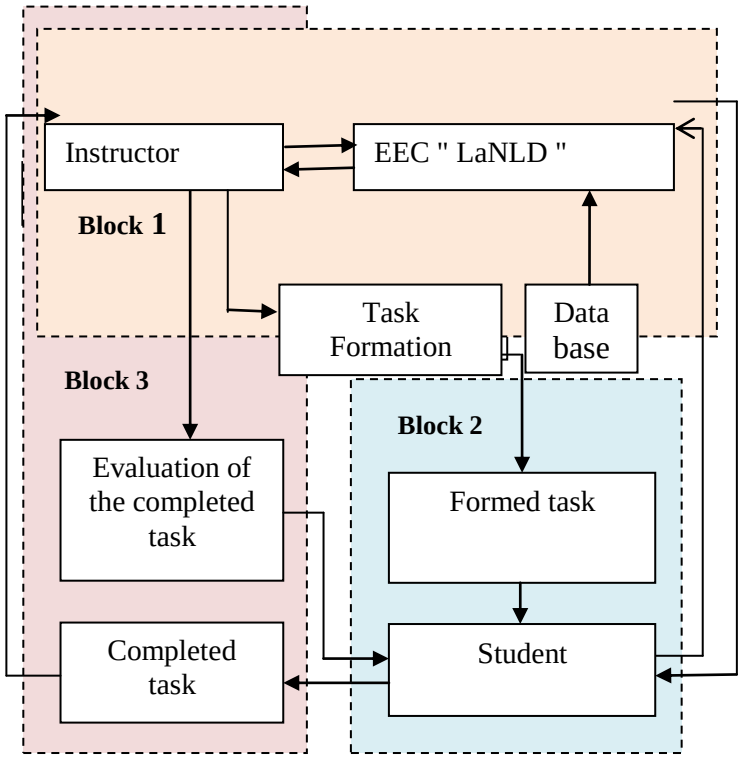

Fig. 2. Blocks of the main functional tasks of EEC " LaNLD "

Expression (1) can be taken as a basis for the formation of the principal structural model (SM) of EEC and presented in the form of the next set of tuples:

$$K = (K_1, K_2, K_3). \quad (2)$$

Each type of tuple - K_1, K_2 and K_3 will be represented with corresponding expressions.:

$$\left.\begin{array}{l} K_1 = < N_1, S_1, P_1 >; \\ K_2 = < N_2, S_2, P_2 >; \\ K_3 = < N_3, S_3, P_3 >, \end{array}\right\} \quad (3)$$

where: N_1, N_2, N_3 – B_1, B_2, B_3 model carriers, respectively.

Each of the carriers N_1, N_2 and N_3 possesses a certain subset of the basic elements N_{K_1}, N_{K_2} and N_{K_3} on the basis of which the formation of the structure B_1, B_2 and B_3, the system (EEC) at the considered level, respectively, and a certain subset of the auxiliary elements $N_{K_{I\alpha}}$, $N_{K_{2\beta}}$ and $N_{K_{3\gamma}}$, which are used to identify, respectively, the basic elements of the structures listed above system blocks. The following appropriate expressions can be used to describe what has been said:

$$\left.\begin{array}{l} N_1 = < N_{K_1}, N_{K_{I\alpha}} >; \\ N_2 = < N_{K_2}, N_{K_{2\beta}} >; \\ N_3 = < N_{K_3}, N_{K_{3\gamma}} >. \end{array}\right\} \quad (4)$$

In formula (3), S_1, S_2 and S_3 are signatures of the models of blocks B_1, B_2 and B_3, respectively. Signatures are represented by the following expressions:

$$\left.\begin{array}{l} S_1 = < S_{N_1}, S_{K_1} >; \\ S_2 = < S_{N_2}, S_{K_2} >; \\ S_3 = < S_{N_3}, S_{K_3} >, \end{array}\right\} \quad (5)$$

where: $S_{N_1} = \{s_r, s_p\}$, $S_{N_2} = \{s_\delta, s_\varepsilon\}$ and $S_{N_3} = \{s_\vartheta, s_\mu\}$ – subsets of predictors, setting types of relations on the sets $N_{K_1} \cup N_{K_{I\alpha}}$; $N_{K_2} \cup N_{K_{2\beta}}$ и $N_{K_3} \cup N_{K_{3\gamma}}$, respectively;

S_{K_1}, S_{K_2}, S_{K_3} are subsets of predicates that establish types of relationships in the environment of N_{K_1}, N_{K_2} and N_{K_3} subsets, respectively.

P - the rules for the formation of a generalized SM taking into account the syntax of the formed structure of the elements. The rules are based on compliance with the statements that clearly regulate the process of identification of elements in the SM.

Initially, we should note that elements of EEC can be understood as a separate indivisible word or a set of them with a semantic content, and the exclusion of any component in it can lead to loss of meaning. On this basis, the level of detail is essential. Excessive detail can lead to complication of formalization, algorithms and programs of logical procedures of SM synthesis.

Therefore, the subset N_{K_1}, N_{K_2} and N_{K_3} represents some finite set of elements extracted from the LaNLD database. It should be noted that these elements have no limitations. They are unchangeable and carry strictly defined substantive information. From this information, they are identified for inclusion in the SM when it is synthesized. In the end, SM gets one of the types of the LaNLD task variant, allows to carry out the performance of this task from the student's side by analyzing the content of the task with information in the database, a comparative automated analysis and teacher's assessment of the completed task, if necessary, in this mode. In this case, the synthesis is carried out by means that do not belong to the SM itself.

Description of the elements and their relations during the formation of a SM signature is carried out by the syntactic rules P_1, P_2 и P_3. The rules are formal logical procedures allowing to identify elements of N_1, N_2 and N_3 sets. On the basis of identification, their belonging to the N_K subset is established and their identification in the same subset with the help of the N_L carrier accessories.

In terms of the use of theoretical-multiple method of structural modeling, there is a fact that it is impossible to ensure the full correctness of the content of formed SMs based on syntactic rules, as their use involves abstraction. However, this gap will be completely filled by the standard and installed word constructions available in the ready form in the content of the LaNLD.

Synthesis of SMs, which represent a certain training task on the LaNLD, issued to a student for study, is based on the implementation of the following formulated statements, compliance with which leads to the effective completion of the synthesis process.

Synthesis of SM takes place within the framework of the above three blocks B_1, B_2 and B_3, each of which represents an independent subsystem, but in the aggregate, it solves the common goal of EEC " LaNLD ". The independence of these blocks is characterized by the composition of tasks to be solved. Functioning of blocks in the complex is carried out by transfer of control according to the logic based on the process of training and control of knowledge of the student.

The ideology of synthesis of the structure of blocks is in principle the same, on this basis, the theory of logical procedures considered below is applicable to all blocks.

Logical operations in the formation of the SM are based on compliance with the statements that clearly and unambiguously determine the correctness of the SM content. In this respect, the following statements are formulated and introduced. Formal representations of statements use common to all blocks of designation.

Affirmation 1. A subset of the basic elements of the carrier of the generalized structural model N_K is considered syntactically given and on the basis of identification in the set N appropriate, if on the set

$$N = N_K \cup N_L,$$

where $N_L = \mu \cup N_L'$, a $\mu \in N_L$ – some element of the set standard, a two-seat s_μ predicate is set, at which the following condition is met

$$\forall_{n_i} \in N_K \ \forall_{n_j} \in N_L' (s_r(n_i, p) = 1 \ \& s_r(s_j, p) = 0). \qquad (1)$$

Affirmation (1) is a syntactic rule that formally confirms the belonging of $n_i \in N_k$ to a subset of the basic elements N_K describing the elements of the modeled structure.

Affirmation 2. Each master element of an SM carrier $n_i \in N_k$ is considered to be identified in subset N_K if the subset $N_K \cup Z \subset N$, where Z⊂N is a subset of elements of a set reference, specifies a 2-seater predicate of s_μ, so that

$$\forall_{n_i} \in N_k \forall_{n_j} \in Z \backslash Z \exists z_k \in Z\left(s_f(s_i, z_k) = 1 \& s_p\left(s_i, s_j\right) = 0\right). \quad (2)$$

Affirmation 2 defines a rule according to which the main carrier element of $n_i \in N$ is considered to be a given one if the value of the set reference Z corresponds to it.

Therefore, the syntactic rules for describing SM elements are defined according to statements 1 and 2.

Conclusion. The stated approach to formalizing the structure of practical training options for studying the legislative and regulatory documents of the CA on the basis of theoretical and multiplicity modeling, as it was said above, formed the basis for the formalization of EEC " LaNLD ". The value of this complex lies in the fact that it can be used for practical and theoretical classes in all major disciplines of the training process for air traffic controllers, as a rule, they are always present the study of legislative and regulatory documents. This provision is conditioned by the fact that aircraft traffic maintenance processes are based on compliance with relevant regulatory, technical and legal documents.

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