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Some Theoretical Aspects of the Air Traffic Controller Training Group Formation, in Accordance to Obtain a Certain Level of Professional Qualities

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***Abstract* – A technique is proposed to enhance the professionally important qualities of air traffic controllers at the stage of training on the basis of training group formation. The methodology is based on cluster analysis. The proposed criteria are based on the measure of the similarity of student qualities.**

***Keywords* – Air traffic controller (ATC), cluster analysis, professionally important qualities, training.**

I. INTRODUCTION

The source of air traffic controller's activity is a stream of events that require management along with the change of situation in airspace. An air controller detects an emergence of events requiring management by means of available methods of obtaining information on airspace condition. The results of air controller's activity concerning flight safety are estimated by a faultlessness and timeliness of decisions made by him/her in certain situations. In the analysis of the reasons of aviation incidents in air controller's activity of a traffic department, the following violations of flight safety conditions are noted [1]–[5], [20].

Errors in the assessment and prediction of airspace condition, provision of incorrect or contradictory commands, violation of separation between aircraft, straightening routes without taking into account the safety requirements, violation of rules for the use of radio and lighting equipment, the phraseology of radio exchange, leaving the workplace without replacement, violation of instructions and other regulatory documentation [6], [7]. Thus, an analysis of the ATC personnel errors [8], [9] showed that in all cases that have occurred during this year in terms of aviation events, the requirements of legal documents regarding the observance of separation standards, manifestation of technological negligence and lack of discipline were violated, when dispatchers did not completely fulfill the requirements of work technique, etc. It is possible to avoid such errors and violations in the air controllers' activities only by meeting two related conditions:

Creation of a certain level of important occupational qualities of ATC personnel, which will allow to ensure the necessary speed, accuracy, reliability and efficiency of decision making by air traffic control in a required area.

ATC work, life, moral and material encouragement organization, that fully depends on the service authority. This direction is not the subject of our study.

II. NECESSITY OF CREATING A CERTAIN LEVEL OF IMPORTANT OCCUPATIONAL QUALITIES IN THE STRUCTURE OF AIR TRAFFIC CONTROLLERS

The professional qualities of aviation technical personnel are being developed during the process of ATC training in educational organizations, subsequent work in aviation companies, internships, etc. Thus, a modern aviation technical specialist should possess strategic thinking, initiative, high level of intelligence and culture. This requires the continuous development of working staff, i.e. carrying out events contributing to the full disclosure of specialists' personal potential and enhancement of their ability to contribute to the airline. Such activities can be organized for an individual or a group and can be conducted at the workplace, and they may be focused on the development of general or specific skills and abilities. Each of these qualities is a complex feature representing generalized, most stable characteristics of an air traffic controller, which has a decisive influence on the quality of performance of duties by an ATC. This is very sophisticated knowledge in terms of professional and psychological education, depending on a variety of factors. However, its foundation is laid during the period of studies at an educational institution. At the same time, the results are largely determined by students' personal qualities. In the aggregate, this determines the professionally important qualities of an air traffic controller, which will develop and improve during the next stages of his/her activities. Therefore, one of the most important factors to improve the efficiency and quality of training of an air traffic controller is taking into account the individual characteristics of each student at all stages of training. The latter is successfully implemented in conducting individual sessions on the basis of simulators for various purposes [10], [11]. However, a significant part (50 % to 70 %) of the training is occupied by group classes, in which it is often not possible to use a unified methodology due to significant differences between students in such characteristics as speed of thinking, level of initial knowledge, memory, etc. Thus, the transition to learning, considering the individual characteristics of the trainees, requires more careful selection and distribution of trainees by training groups at the stage of professional selection. Only the case of the correct configuration of the training group (for example, the similarity of its members) depends on the possibility of using the teaching methodology suitable for the whole group of students. [12] The latter circumstance is usually not taken into consideration when trainees are distributed into groups. This task is solved intuitively, and often is preceded from the erroneous position: to make all groups uniform in composition (that is, people who have similar test scores are divided into different groups). [13] As a result, a lot of modern methods cannot be implemented, and the entire learning process adapts to the weak part of the group, while strong, creative individuals are left out. At present, various methods are used to solve such recognition problems. And there is no such method, which in all cases has advantages over others in terms of given performance criteria. In the general case, the process of solving the grouping problem independently of the method involves 3 main stages [14], [15].

1. Selection of source data used for recognition purposes. This task is connected with the verification of the independence of the data used; it is solved before exposing the results of trainee testing to the relevant statistical processing.

Formation of uniform groups.

Evaluation of the quality of grouping results based on the selected criterion.

To implement these stages, the authors use the methods of cluster analysis. Cluster analysis is used directly for the ordering of objects into relatively uniform groups based on the selected characteristics, which are related to the specialty of students, and for determining the uniformity of the elements before any statistical method is applied [3], [8], [9].

III. Development of a Method for Formalizing the Process of Forming Training Groups for a Given Set of Trainees (Cadets and Air Traffic Controllers), Which Satisfies the Principle of Their Uniformity

To formulate the problem, let us introduce the group of sets characterizing the complex of trainees: D is a set of trainees with the power of n, where n is the number of trainees; The element of the set $d \in D$ determines a particular trainee; U is a set of characteristics of the trainee, influencing the learning process, with the power k, where k is the number of considered characteristics. The element of the set $u \in U$ determines the competitive characteristic of the trainee. Then each student $d \in D$ is characterized by a vector $\boldsymbol{P_i} = \{p_{1i}, p_{2i}, \ldots, p_{ki}\}$, defined on the set of initial characteristics U. The set of trainees D determines the matrix P – "object-attributes". The process of assigning each trainee to a certain group, clarifies in which class of objects belongs the *i*-th recognizable object of *D* set, while the class represents a certain set (sub-set) of trainees with similar properties. The grouping is performed on the basis of the decision rules according to a certain criterion of "proximity", in accordance with some hypothesis about the nature of the set *D*.

As a hypothesis, the assumption of "compactness" of data is used, that is, the objects assigned to the corresponding classes are located in a given characteristic space "compactly". This means that the distance between objects assigned to a given class must be no more than specified. In the general case, it is required to determine *T* – the set of object's partitioning variants of the set *D* into classes that are uniform in some sense. According to the task, the aggregate of the set of air traffic controllers *D* determines the matrix *P* – "object-characteristics":

$$\begin{pmatrix} P_1 & p_1^1 & p_2^1 & \dots & p_k^1 \\ P_2 & p_1^2 & p_2^2 & \dots & p_k^2 \\ \dots & \dots & \dots & \dots & \dots \\ P_n & p_1^n & p_2^n & \dots & p_k^n \end{pmatrix} \quad (1)$$

The initial information about the classified objects $d \in D$ can be presented in one of two forms. The first form is displayed in the form of the matrix *P* "object-characteristics" (1), where p_j is the value of the *j*-th statistically inspected air traffic controller. The second form is displayed as a matrix *p* of the pairwise distances (proximity) of objects.

$$\begin{pmatrix} P_1 & p_1^1 & p_1^2 & \dots & p_1^k \\ P_2 & p_2^1 & p_2^2 & \dots & p_2^k \\ \dots & \dots & \dots & \dots & \dots \\ P_n & p_n^1 & p_n^2 & \dots & p_n^k \end{pmatrix} \quad (2)$$

Where p_j characterizes the mutual remoteness (or proximity) of the *i*-th and *j*-th objects. In the general case, it is required to determine *T* – the set of object's partitioning variants of the set *D* into classes that are uniform in some sense. We assume that the $t \in T$ partitioning variant defines a set of classes:

$$A1 = \{ A^t{}_1, A^t{}_2, \dots, A^t{}_m \}. \quad (3)$$

Defined type of matrix:

$$\begin{pmatrix} A_1 & d_1^{(1)} & d_2^{(1)} & \dots & d_{\mathrm{f1}}^{(1)} \\ A_2 & d_1^{(2)} & d_2^{(2)} & \dots & d_{\mathrm{f2}}^{(2)} \\ \dots & \dots & \dots & \dots & \dots \\ A_n & d_1^{(\mathrm{m})} & d_2^{(\mathrm{m})} & \dots & d_{fn}^{(m)} \end{pmatrix} \quad (4)$$

where $\forall\, d_j^i \in D$,

m – the number of division classes.

For these classes, the following relations must hold:

$$\begin{gathered} A_1^t \cap A_q^t = \varnothing, \\ U^m A_q^t = D, \\ q = 1 \\ \Sigma fr^m = n, \\ r = 1, \\ \forall\, fr \geq 1,\ r = 1, \dots, m, \\ g = 1, \dots, m, \\ q = 1, \dots, m, \\ q \neq g. \end{gathered} \quad (5)$$

From the set T, preference is given to that variant of the partitioning $t_{\text{opt}} \in T$, at which an optimum is reached by a certain quality function R, depending on the compactness of the data specified by the characteristics vector in the obtained groups:

$$R_{\text{opt}} = \text{f}[R(A^t, P)] \tag{6}$$

Implementation of this method can be provided on the basis of cluster analysis methods. Cluster analysis is used directly to organize objects into relatively uniform groups and to determine the uniformity of the elements before any statistical method is applied. Various applications of cluster analysis can be found in [15]–[17].

IV. Selection of the Proximity Criterion (Measure) of Trainee Qualities for the Optimal Formation of Groups

In order to establish the proximity of the objects under consideration to form the corresponding uniform group, it is necessary to introduce a quantity that measures this property of two objects. The choice of a measure of similarity between objects, each of which is characterized by a multitude of features, is the focal point of the study. There are various indicators that can be used to solve this problem: correlation coefficients; distance measures; associative coefficients and probability coefficients of similarity [18], [19]. We assume that for the purposes of investigating the formulated problem, the best criterion for the measure of similarity is the Euclidean distance defined as Δ_{ij}.

$$\Delta_{ij} = \sqrt{\left(p_1^i - p_1^j\right)^2 + \left(p_2^i - p_2^j\right)^2 + \cdots + \left(p_q^i - p_q^j\right)^2}\ , \tag{7}$$

where Δ_{ij} – is the distance between objects i and j;

p_q^i, p_q^j is the q value of the characteristic for the i-th and j-th air controller.

The choice of this particular measure of proximity is explained by the following reasons:

Observations are extracted from the general set of objects under study characterized by a set of characteristics described by a multidimensional normal law, the components of which are:

1) p_q^i, p_q^j are mutually independent and have one and the same variance;
2) Components p_q^i, p_q^j of the observation vector are uniform in their physical meaning and they are all equally important for solving the problem of classifying an object;
3) The feature space coincides with the geometric space of human existence and the concept of objects proximity distributed among groups coincides with the concept of geometrical proximity in this space.

V. Conclusion

The general task of grouping trainees into uniform groups for the purposes of training is formulated.

The effectiveness of the application of cluster analysis methods for solving this problem is shown.

The methods of initial data selection for the purposes of recognizing trainee characteristics are proposed.

The criterion for estimating the measure of similarity in terms of characteristics is formulated for the distribution of trainees to groups.

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