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FORMING OF RESCUE SUBDIVISIONS BASED ON THE LEVEL OF TRAINING AND PSYCHOLOGICAL COMPATIBILITY WITH THE USE OF MULTI-AGENT APPROACH

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Abstract. The article deals with the problem of formation of rescue subdivisions based on the level of training and psychological compatibility. Analyzes the problem, statement of a problem, is being developed mathematical model and approach to the decision based on the application of multi-agent systems technology.

Keywords: multi-agent technology; agent; forming of rescue subdivisions.

INTRODUCTION

According to the Federal target program "Risk reduction and mitigation of natural and man-made disasters in the Russian Federation up to 2015" [1] in the last decade, the number of natural hazards and major technological disasters in Russia is growing every year. The risks of emergency situations (ES) arising in the process global climate change, industrial activity, complexity of the infrastructure of settlements, are a significant threat to people, objects, economy and ecology of the country. In order to save the lives and health of people, protection of the natural environment, to ensure constant readiness to respond rapidly to emergency situations (different types of accidents, incidents), and work to eliminate them in the established and operated emergency rescue formations.

Emergency rescue formations (ERF) (including all kinds of rescue squads) – it is an independent or a member of the rescue service structure designed to carry out emergency rescue work, basis of which is rescue subdivisions equipped with special equipment, facilities , equipment , tools and materials.

Rescue works (RW) is action to save lives , material and cultural values, protect the natural environment in the area of emergencies, disasters and localization suppression or bringing to the lowest possible level of exposure to their inherent hazards. Rescue works are characterized by the availability of factors endangering the life and health of the people conducting these activities, and require special training, equipment and outfitting. Lifeguard is a citizen trained and certified to conduct rescue operations [2].

The effectiveness of RW depends on the qualifications of the personnel of the subdivisions, on the degree of development and diversity of professional knowledge and skills of rescuers, skill to work in a team and coordinated action by all members of the subdivision (which is not in the least defined the moral and psychological climate in the team). Thus, for effective work of rescuers is the correct formation of ERF subdivisions.

Simulation of collective action is difficult formalized problem. Here, in an indissoluble unity must take into account not only formal but also substantive aspects of the activity. Solving this problem in a large number of works, both domestic and foreign scientists: T. Buzan, R. Khanat, E. Jordan, F. Brooks, R. Tomseta, V. A. Wittich, Y. M. Plotinsky, E. V. Popov, V. B. Tarasov, D. A. Novikov, P. O. Skobelev and others.

Questions of multi-agent systems for various industries involved in many Russian and foreign scientists V. I Gorodetsky, V. F. Khoroshevsky, R. Munday, C. Kolsky, P. O. Skobelev, I. Demazo and others. In this case, the issues related to the formation of teams of rescuers, are insufficiently studied, while they are an actual problem. And the use of the multi-agent systems technology to solve the problem is, to a certain extent, a new area of research.

1. THE TASK OF FORMING RESCUE SUBDIVISIONS BASED ON THE LEVEL OF TRAINING AND PSYCHOLOGICAL COMPATIBILITY

The basis of the emergency rescue formations consists of four emergency rescue subdivisions (ERS), they intercede on duty alternately on schedule "day after three." Typical structure of ERF is presented in Fig. 1.

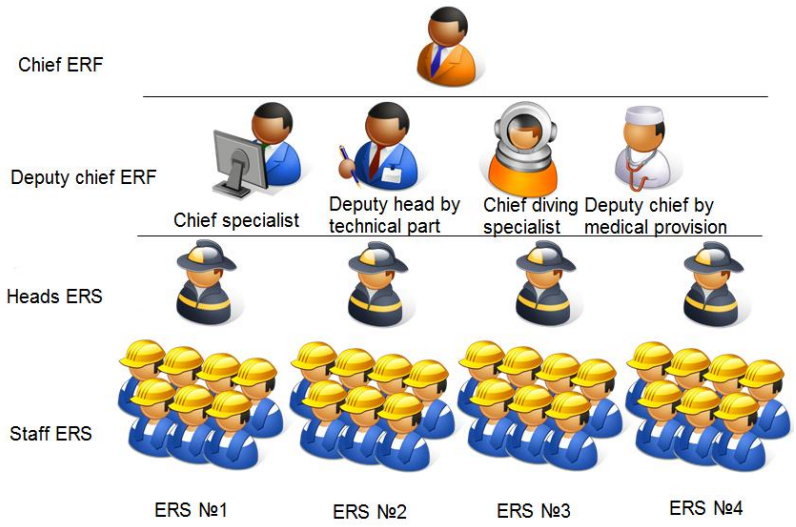

Fig. 1. Typical structure of emergency rescue formation

Table 1

Distribution of rescuers by u subdivision, which is part of ERF*

Rescuer №	ERF			
	ERS № 1	ERS № 2	ERS № 3	ERS № 4
1	Ivanov I I.	Petrov P.P.	…	Sidorov S.S.
2	…	…	…	…
…	…	…	…	…
8	…	…	…	…

* Names rescuers are fictional

Each subdivision (in this example) is listed eight rescuers, including the shift supervisor (see Table 1).

Rescue workers belonging to the ERS differ class skills (lifeguard, lifeguard third, second, first, international class) and with the additional professions (working professions), such as a driver, an industrial climber, diver, slinger, mechanic, etc. In that some working skills are also a gradation level (for example, a diver third, second, first class; different categories of driver, etc.). That is an additional specialty divided by type and level. The same can be lifesaver owner several professions (see Table 2).

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Thus, for the efficient operation of the squad as a whole is necessary that each of the four ERS were present rescuers with a variety of specialties (to ensure that the subdivision was able to perform the full range of possible ERW) and the level of preparedness of rescue each subdivision would be about the same (should not be a situation in which one subdivision consists of top-notch professionals, and the other of inexperienced newcomers). Taking into account the fact that the ERS is a collective of people, among whom there are interpersonal relationships, it is proposed to take into account their formation and rate of psychological compatibility (eg, based on the survey results rescuers). This will help create a favorable psychological climate in the team and, as a consequence, more efficient work subdivision. This is to avoid conflicts between salvors, because of their teamwork lives depend.

In this case, one is not enough time to form a well-balanced subdivision. The task reallocation of personnel occurs often. This is due to the departure of rescuers leave, sick leave, leave for a business trip, alternately passing training courses, dismissal or acceptance of the service recruits. In the absence of any of the rescue subdivision may lose the necessary specialist. It is necessary to find a temporary replacement (transfer to its place the rescuer of another division). Thus another ERS should also not lose functionality and effectiveness. Package subdivisions can also vary depending on the season. For example, during summer months (during the summer season), the priority is the presence in the duty shift enough drivers, navigators and divers.

Table 2

Characteristics of rescue subdivisions of the class skills and specialties

Name rescuer	Qualification	Specialties
Ivanov I. I.	rescuer I class	1) diver II class; 2) driver category «B»; 3) Slinger; 4) Minder
Petrov P.P.	rescuer II class	1) diver III class; 2) driver category «B, C»; 3) Industrial climber 5th grade
…		

The distribution function for rescue subdivisions entrusted with the leadership of ERF. During the formation of ERS should take into account many factors, the characteristics of rescuers, sometimes with in a limited time (the problem of forming multiple subdivisions to work in large-scale emergencies). For prompt and accurate solutions of the problem need to use the power of modern technology Intelligent Decision Support.

2. MATHEMATICAL MODEL OF RESCUERS SUBDIVISIONS FORMING

One of the first steps in implementation of decision support system is the construction of mathematical model of the problem.

Let's N is a number of rescuers; M is a number of subdivisions; L is a number of rescuers professions; $R_i = (r_{i1}, ..., r_{iL})$ is a profile of rescuer i. The rescuer profile is a vector. Each component $r_{il} \in [0, 1]$ ($I = 1, \ldots, N$, $l = 1, \ldots, L$) corresponds to the degree of qualification for profession l of rescuer i (this can be a class qualifications, rank, category, etc.). Matrix $X = (x_{ij})$, the elements of which $x_{ij} = 1$ if rescuer i is in the subdivision j and $x_{ij} = 0$ else. $RP_j = (rp_{j1}, ..., rp_{jL})$ is a profile of subdivision j. The structure of subdivision profile coincide with the rescuer profile structure. The components of subdivision profile can be determined by the formula:

$$rp_{jl} = \max_i (r_{il} x_{ij}), i = \overline{1,N}, j = \overline{1,M}, l = \overline{1,L}.$$

Let's introduce the function

$$D(RP_j, RP_k) = \sqrt{\sum_{l=1}^{L} (rp_{jl} - rp_{kl})^2}, \; j,k = \overline{1,M}$$

as the distance between the profiles of the j-th and k-th subdivision.

It is required to minimize the difference in the degree of knowledge of the specialties between subdivisions:

$$\max D(RP_j, RP_k) \to \min, j,k = \overline{1,M}.$$

It is important to take into account the moral and psychological climate in the collective when rescuers are allocated into subdivisions. To do this, we introduce: $PS = (ps_{is})$ is a matrix reflecting psychological compatibility i-th and s-th rescuers (the data can be obtained using questionnaires); PSP_j is a quantity that characterizes the moral and psychological climate in the j-th subdivision (depending on the psychological compatibility of rescuers, members of the j-th subdivision).

Then PSP_j value must be greater than a predetermined lower limit ($PSP_j \geq \delta$), and, ideally, it is required to maximize the value of PSP_j for each subdivision.

3. MULTI-AGENT APPROACH TO RESCUER SUBDIVISIONS FORMING

To solve this problem it is suggested to use an approach based on multi-agent technology [3], and develop a multi-agent system prototype for subdivisions of rescuers forming. Multi-agent system (MAS) is a system formed by several interacting intelligent agents that interact with each other through communications. Each agent acts in accordance with its goal and model behavior. Solution of the problem with the use of multi-agent system is constructed as a result of this interaction.

Multi-agent systems have been successfully used in particular for tasks such as online trading, disaster response [4], social structures simulation, etc. It is proposed to use the following classes of agents in the developing multi-agent system:

- rescuers is a class of agents that has information about its experience, working professions, psychological compatibility with other rescuers;
- the agent responsible for a specialty within the subdivisions, its goal is to get to his subdivision a top-level rescuer;
- agent-coordinator decides whether enough rescuers in the subdivision, calculates subdivision profile and tries to maximize it.

The problem will be solved in two stages. The first stage will be the initial formation of rescuers

subdivisions in accordance with the requirements in specialties.

In the second stage will be the redistribution of rescuers in order to minimize the differences between the levels of training (profiles) of subdivisions, taking into account the moral and psychological climate in the subdivision.

Thus, developing a multi-agent system prototype will give the opportunity to form well-balanced in terms of training and skills of rescuer subdivisions, taking into account the moral and psychological climate in the collective.

CONCLUSION

It is proposed to use multi-agent technology to solve the problem of rational distribution of rescuers by subdivisions. The classes of agents are identified, the mathematical model and a common approach to solving the problem are developed.

The next stage of research will be developing algorithms and software that allows forming rescuers subdivisions taking into account the level of training and psychological compatibility. Previously, we have developed the software for operational data collection and analysis of statistics on work of urban rescue squad [5–7]. One of the functions of this software is the maintenance of records of data on rescuers, and their qualifications, specialties. Thus, the software development for the forming of search-and-rescue subdivisions will be a logical continuation of the work started. And it will integrate with existing software.

Using these researches it will be possible not only generate balanced search-and-rescue subdivisions, but also to properly plan the schedule of holidays, business trips, passing the training courses of all employees. The results of research can be used in different areas in which you need the rational allocation of employees in shifts, for example, in the medical institutions, police, etc.

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