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Modeling of dangerous processes of natural and man-made disasters

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Summary

The article presents the results of the development of scientific and methodological systematic approach to assessing the effectiveness of the organizational and technical system of emergency rescue operations during the elimination of emergencies of natural and man-made origin. Based on the obtained results, there is an increase in the integrated efficiency of the resource potential of the organizational and technical system of rescue operations by increasing the functional (systemic) or corresponding economic effect.

Introduction. If we consider the dynamics of the concept of emergency, then (Trofymchuk et al., 2021), (Trysnyuk et al., 2020) we find the following definition in regulatory sources, such as an emergency is a violation of normal living conditions and activities of people on the site or territory, caused by an accident, catastrophe, natural disaster, epidemic, epizootic, large fire, the use of means of destruction that have led or may lead to human and material losses. In (Anpilova et al., 2020) it is specified that the emergency situation means the situation in a certain area, which has developed as a result of a catastrophic event and is associated with human casualties, damage to the environment, and human health, with significant material losses and disruption of living conditions. In (Azimov et al., 2019), (Gomilko and Trofimchuk, 2021). it is emphasized that this is an unexpected situation, as it occurs suddenly and is characterized by a rapid disruption of the sustainable process.

The authors (Okhariev and Trysnyuk, 2019), (Karpenko et al., 2020) call an emergency a sudden situation characterized by significant socio-environmental and economic damage, the need to protect the population from harmful factors (chemically aggressive and radioactive substances, microbes, viruses, rickettsia, hypothermia and other overheating, traumatic and psychogenic factors), rescue, emergency medical and evacuation measures, as well as the elimination of negative consequences (Horoshkova et al., 2020).

Nowadays in The Code of Civil Defense of Ukraine, the following definition is given: Emergency - the situation on a separate territory or business entity on it or a water body, which is characterized by the violation of normal living conditions caused by a catastrophe, accident, fire, natural disaster, epidemic, epizootic, epiphytosis, use of means of destruction or another dangerous event that has led (may lead to) a threat to life or health of the population, a large number of dead and injured, significant material damage, as well as the impossibility of living in such an area or object, conducting economic activities on it (Trofymchuk and Vasyanin, 2015), (Trysnyuk et al., 2019).

Narrowing the range of causes of emergencies, we will consider emergencies that are caused by the destruction of potentially dangerous objects or accidents at these objects (Myrontsov et al., 2020).

During the crisis, rescue measures are conducted to localize the effects of the threat and increase the viability of regional components in the affected areas (Volkov et al., 2019).

Rehabilitation measures carried out in the post-crisis period are designed to eliminate the consequences of the manifestation of sources of danger and increase the rehabilitation of regional components in the post-crisis areas (Trofymchuk et al., 2019).

In the context of the introduced concepts, we will define natural and man-made security as a state of components of the region, characterized by the availability of necessary protection resources for possible or real recipients of damage in each period of development of any emergencies of military-man-made origin (Trysnyuk et al., 2019), (Horoshkova et al., 2020).

Territorial distribution, heterogeneity, multi-connectedness and dynamism of impact and protection measures significantly complicate the management of natural and man-made safety (Trofymchuk et al., 2019).

The purpose of the research is to develop a mathematical formulation of the problem of eliminating the consequences of natural and man-made disasters in Ukraine.

Method

Presenting the main material. Analysis of the man-made security management problems in the region where the Joint Forces Operation is conducted leads to the logical conclusion that the object of study is to choose a system of man-made safety and civil defense (Trofymchuk et al., 2015) (governing bodies and executive bodies with subordinate resources), the objects of which are:

- ☐ objects that represent a source of man-caused hazards - potentially dangerous objects (PDO) and objects of increased danger (OID);
- ☐ objects to which the action of harmful factors applies in case of realization of dangers (recipient objects or objects of protection and restoration).

The socio-economic system of the region and the environment is external to the organizational and technical system under consideration.

You can get a mathematical description of the studied system and its environment, using the principles of a systems approach. According to these principles (Trofymchuk et al., 2013), (Trysnyuk et al., 2020) (Lukianova et al., 2020) by a system, we mean a set of objects (system components) with a set of relationships between them and between their properties (Horoshkova et al., 2020).

When describing the components of the system, their properties and relationships should take into account the main feature of the system approach, which is that all components of the system function as a whole for a common purpose (Gomilko et al., 1991). The operation of the technogenic safety system is carried out continuously in order to prevent emergencies or eliminate their consequences (Horoshkova et al., 2020). This allows the analysis of the system to highlight only certain properties of objects and relationships that are relevant in this context. Therefore, first of all, it is necessary to define the concept of an emergency (Kaliukh et al., 2019).

When searching for the optimal plan for the use of forces and means of the military-technogenic security system at the stage of emergency response, it is advisable to use a program-targeted approach to planning. The initial (Korchenko et al., 2020), (Trofymchuk et al., 2014) stage of the planning cycle is the development of the purpose of the program (goal setting). We consider the main system goal of the program of works on liquidation of consequences of emergency situations to increase their target efficiency (Greben et al., 2020). The second indicator of the effectiveness of the program should be considered the cost of budget resources B , which reached the value of the first indicator. Then the effectiveness of the target program is evaluated by the ratio:

$$E_{tp} = \frac{F}{B} \quad (1)$$

Statement of the problem of development of the optimal program of works on liquidation of consequences of emergency: on set of plans of use of budgetary resources $\{R\}$ for the program, each of which R satisfies system of restrictions on use of resources (Myrontsov, 2020) (that is belongs to the area of admissible decisions):

$$G(R) < G_o \quad (2)$$

find such an (optimal) R_o plan that maximizes the effectiveness of the program

$$E_{tp}(R_o) = \frac{F(R_o)}{B(R_o)} = \max E_{tp} \quad (3)$$

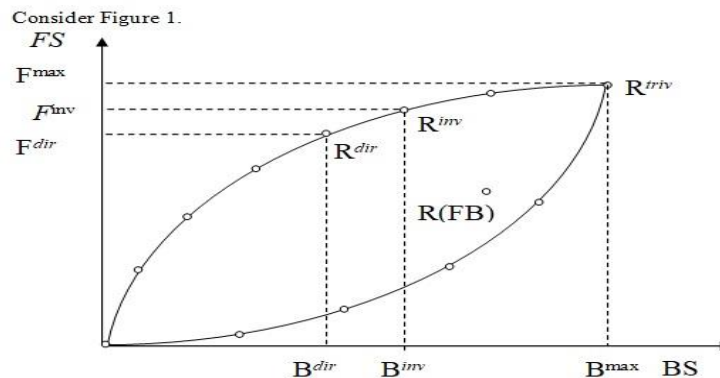


Figure 1. The area of acceptable solutions and "concessions" on the Pareto functions of the system.

Here BS - budget costs for the program, FS - the target effect achieved by the costs of BS . Naturally, there are many possible plans $\{R\}$, each of which is represented by a point with coordinates $R(F, B)$ (Figure 1). Obviously, for each point of the domain of admissible solutions, F is completely determined by the plan R of the use of resources B . It is easy to see that the set of "effective" plans for which the ratio (F/B) is best is the left upper bound of the domain of admissible plans. prevails in F equivalent to his plans in B or inferior in B equivalent to him in plans F . The set of effective plans is called the Pareto set, and if the Pareto set is a continuous line, then the Pareto function $F(B)$ is formed.

Since the desire to increase the efficiency of the system is limited to the point $R^{triv}(F^{max}, B^{max})$ as a trivial plan of "absolute perfection" of the system, the required budget funds B^{max} may not be enough, and it is necessary to slightly "yield" the target effect F . If the costs of B^{dir} are possible, then they correspond to the value of the Pareto function F^{dir} , which is the result of solving the "direct" problem of optimal planning of the use of limited resources, which maximizes the effect. If the value of F^{dir} does not satisfy and it can be increased to F^{inv} then the new F^{inv} corresponds to the new value of the

budget expenditures B^{inv} , which is the result of solving the "inverse" problem of optimal use of resources, which minimizes the required budget (Myrontsov et al., 2021).

Conclusion. In the case of solving the problem of optimal management of man-made safety resources in the aftermath of emergencies, the provisions for finding the optimal plan are implemented in the process of ranking the objects of restoration work. When solving the inverse problem, the selection of objects is carried out to achieve a specific level of system effect, which accumulates in the selection process.

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