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INFORMATION SUPPORT OF THE DECISION-MAKING SYSTEM IN EMERGENCY SITUATIONS

232.01. CONTROL SYSTEMS, COMPUTERS AND INFORMATION NETWORKS

ABSTRACT

of doctoral Thesis in engineering science and technology

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The dissertation and abstract can be found in the Library of the Free International University of Moldova and on the official website of the university (https://ulim.md/doctorat/sustinerea-tezelor-de-doctorat/) and the National Agency for Quality Assurance in Education and Research (http://www.cnaa.md/).

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CONTENTS

GENERAL CARACTERISTICS OF THE RESEARCH

The topicality and importance of the research topic. Since the beginning of the new millennium, a steady increase in natural and man-made disasters has been observed in the Republic of Moldova and around the world. The growth of such emergencies, in turn, leads to the economic weakening of the affected territorial units, inhibition of the development of the state economy.

The effectiveness of response operations aimed at eliminating emergencies and their consequences depends not only on the quantitative and qualitative composition of response forces and means, but also on the availability of a platform information system that will ensure the processing of large volumes and complex data.

To an important extent, the efficiency and timeliness of making an adequate decision leads to a reduction in response time, minimization of the risk and detrimental consequences of emergency situations, both in the short and long term.

The relevance of this work is justified by the eternal problem of choosing the best optimal adequate management decision at the initial stage of an emergency. The complexity of making such a decision is due to the multitude of emerging exceptional characteristics of the development of the situation that has arisen, and its development itself occurs in conditions of uncertainty. This is primarily due to the fact that in order to formulate and select a solution, it is necessary to process a huge flow of various information in the shortest possible time, as a result of which it is realized what unexpected events will have to be faced, what forces and means, in what volume, are necessary for a quick effective reaction.

That is why, the objects of scientific research should be not only the emergency situation itself with its individual, specific characteristics, but also the process of formation and prioritization of the decisions made, control algorithms and control of ongoing processes embedded in the corresponding software package. This approach will reduce the time for decision-making and response in the face of a large amount of initial information, as well as provide comprehensive information support for the decision-making system in emergency situations.

Despite the presence of various theoretical analyzes and practical experiments, the range of unsolved problems in this area remains wide. The analysis and experience gained allowed the author to combine developments in the following areas of research, due to the following three factors: systematization of emergency situations and their characteristics; study of territories, forces and means of response; platform information systems.

In this area, it is required to determine a clear boundary of interactions between ongoing processes, while fixing the optimal results of emergency response, in this zone the best solutions are determined in the minimum time intervals, maximizing its effectiveness, which reduces the reaction time, thus reducing the degree of negative impact.

Degree of study of the research topic at the present time in the Republic of Moldova, there is a lack of any research work and practical developments in this subject area. In other countries, some results on the subject under study, indirectly related to the latter, were published by such authors as I.U. Yamalov, E.Z. Arifullin, R.V. Sharapov, V.A. Plotnikov, O.K. Golovnin, A.S. Suprun, A.B. Kusainov, B. Paklin, N. Steiner, R. Andriciuc, M. Romano, T. Onorati, I. Eado, Ch. Reuter, A. Marx, N.N. Brushlinsky, S.V. Sokolov, E.M. Alekhin, P.M. Wagner and others. In particular, the available publications refer only to certain types of emergencies (fires, natural and man-made disasters). From the standpoint of the research, the main drawback of the available publications is the complete lack of integration of the material and information resources of a single management process implemented with the help of information technology tools and technologies, which is the main content of this work.

The aim of the research is to develop a conceptual framework and practical implementation of a set of measures to restructure and improve the efficiency of the proposed management system by introducing a science-based approach to optimizing business decision-making processes.

Research objectives, solved in the dissertation, comes down to building models and developing methods that are the basis for improving the processes of managerial actions in the mode of emergency situations. Within the framework of this general task, a number of the following **scientific problems** were posed and solved in the work:

- Identification of the existing and possible composition of emergency situations and consequences, their comparative analysis based on relevant criteria and their characteristics.
- Comparative analysis of the existing system of operational control of the response forces and statistics of the consequences of emergency situations.
- Analysis of the algorithm of actions of decision makers.
- Development of a unified standard for given commands for emergency response units.
- Development of a graphical model to determine the dependence of the values of the main time criteria from the moment of receiving a message to the end of rescue operations.
- Optimization of response time by reviewing response zones for rescue units.
- Development of a method for testing decision makers on minimal information indicators.

The research hypothesis. The working hypothesis of the dissertation research is the assumption that the development of business process algorithms based on the improvement of information technology contributes to the efficiency of the decision-making system in emergency situations. This will optimize the decision-making process, reduce response time and increase the efficiency of decision-making. Also, within the framework of the hypothesis, the author assumes that the best result will be achieved in the zone of contact of the following main three factors: systematization of emergency situations and their characteristics; study of territories, forces and means of response; platform information systems**.**

The synthesis of the research methodology and justification of the chosen research methods. The methodology used in the work was independently formulated by the author in the form of research, it consists in establishing the current state of the functioning of the action management system in the event of the occurrence and elimination of emergencies and their consequences. Based on the results of determining such a state, a comprehensive analysis of its occurrence is subsequently carried out and appropriate information technologies are developed to assess the real situation and make decisions.

The research in the doctoral work is based on the current legislation and legal acts regulating actions in the field of emergency situations of the Republic of Moldova; the historical statistics; the scientific works and researches of foreign authors; a set of studies carried out by the author to collect primary information.

The short summary of the chapters of the doctoral dissertation, based on the conducted research and the reflection of their necessity for achieving the research goal. The doctoral work consists of an Introduction, three Chapters, a Conclusion, a List of References and Applications. Its total volume is 143 pages. The work is illustrated with 52 figures, contains 7 tables and 3 annexes. The list of references includes 133 titles.

The **introduction** argues for the relevance and degree of study of the research topic, defines the goal, objectives, hypothesis, methodology and object of research, reflects scientific originality and novelty, and summarizes the chapters of the dissertation

Chapter I, “Conceptual framework and analysis of the current emergency management system in the Republic of Moldova”, consisting of four sections, analyzes the main components for performing urgent work in case of emergencies. The key parameters that affect the time indicator for making an adequate decision at the initial stage of their occurrence are determined.

Chapter II, "Optimization of the emergency management system in the Republic of Moldova" contains four sections, which substantiate an effective variant of rapid response based on the analysis of data models. An optimal classifier of given commands has been developed. The concept of cross-platform information system is presented. A methodology for assessing the damage caused by natural disasters and the possibility of its reduction is disclosed.

Chapter III, "Development of methods for developing and making optimal decisions in the emergency management system", consisting of six sections, which define the stages of an effective response and the structure of control points of a single risk management cycle. The construction of spatial geographic models of distance reduction using the geomodelling method is proposed and the composition of emergency response zones is determined. It is optimized the interaction of functional workers who make decisions when responding to emergency calls.

The **conclusions** summarize the results of the conducted research, in accordance with the purpose of the given topic of the dissertation research.

MAIN CONTENT OF THE WORK

The introduction justifies the relevance of the dissertation work, here the goals and objectives of the study are formulated, the novelty and practical significance are determined.

The first chapter, consisting of four sections, analyzes the main components for performing urgent work in case of emergency. The key parameters that affect the time indicator for making an adequate decision at the initial stage of their occurrence are determined.

The experience and available guidance material confirms that, regardless of emerging emergency situations, in order to accelerate the adoption of the only adequate decision, at the initial stage it is necessary to be guided by the following calculation. In a general sense, regardless of the nature of the emergency, at the initial stage, it is enough to receive three components in order to make the right decision.

$D = \{C_{type}, L_{location}, T_{time}\}$

where:

D – decision made,

C_{tipe} – a set of data characterizing each type of emergency;

$L_{location}$ – a set of factors describing the location of the response, the exact address or geographic coordinates;

T_{time} – elapsed time since the beginning of events.

From this position, the paper analyzes the main characteristics of emergencies, allowing you to combine the latter by class, by the dynamics of manifestation, by type of damage, by the scale of manifestation etc. A complete list of possible emergencies that may manifest themselves on the territory of the Republic of Moldova has also been determined, presented in Appendix 1. As a result of the analysis, it has been found that all types of emergencies can occur in the studied area, with the exception of tsunamis and volcanoes, the absence of which is due to the geographical location of the country.

The analysis of the main parameters of the territory has been carried out, the method of creating passports for response zones has been considered. A multi-level approach to the description of the territory is presented, where the lowest level is the certification of objects at the local level, and the highest is the national state level. In the latter, in quantitative terms, indicators of the lower levels are combined. Territory characteristics predetermine the magnitude of surrounding values and form the basis for risk assessment. Also, according to the values of this parameter, it is possible to rationally distribute or increase the available forces and means necessary for a successful response. The evolution of the response forces in the Republic of Moldova demonstrates the constant reorganization of the latter in connection with the emergence of new threats, the delegation of new powers and the development of technical means involved in the response. This process continues up to now, as evidenced by the fact that the last change in the organizational structure of the General Inspectorate for Emergency Situations of the Republic of Moldova dates back to February 27, 2019.

The extreme organizational structure allowed to improve operational processes by combining and grouping all departments in three fundamental areas: prevention, response and logistics.

With the development of technological progress, the requirements for specialized technical means used to eliminate fires and emergencies have changed. An analysis of the latter and systematization by type of work performed make it possible to redistribute their number and distribution by territorial units. With this approach, weaknesses in the equipment with technical means are clearly identified, which directly affects the increase in the speed and quality of emergency response services in case of untimely replacement of obsolete equipment or technology.

Due to the fact that the Republic of Moldova has its own state structure, internal legislative acts, uses different approaches to organizing the flow of information and decision-making, and various forces and means are used in emergency response, as a result of the above, it is impossible to fully apply the experience of European countries.

Also, the analysis of software systems in 112 European countries demonstrates the distinctive features in the choice of a software manufacturer, the ability of the created platforms to expand and introduce new modules. The above analysis demonstrates that the software package for emergency services cannot be a commercial product in view of the structural features of the structure of states.

At the same time, such experience, as well as the study of emergency situations and the analysis of the territory, forces and means of response, contributed to the need to develop and apply in everyday practice appropriate information support for the creation and operation of a decision-making system, That is, it contributed to the construction of models aimed at optimizing the process decision-making, improving the efficiency and quality of decisions made, followed by the solution of more optimal, targeted tasks by emergency response forces.

An important factor affecting the quality of decisions made is the environment and conditions in which they are made. In this paper, an optimal model of an emergency command center is presented. Three main zones are defined in which the movement of information takes place and three auxiliary zones necessary for the life support of the command and control center.

Such structuring is an important factor influencing the increase in the efficiency and quality of managerial decision-making.

Due to the fact that the design and command centers are the presence of a stationary complex, which is located at a considerable distance from the place of rescue operations, incoming information tends to be delayed or disappear. In this regard, it is planned to participate in the meeting of the control center for decision makers directly at the scene. The presented mobile and stationary command centers, in their turn, must support the technological process of exchanging up-to-date information in real time. The stability of the functioning of data exchange and communication channels should be ensured by the following rule: channels are organized by two different operators using two different technologies, which increases their reliability.

For both centers, it is necessary to improve and introduce information and switching technologies, ensuring the implementation of the following goals: quick access to professional and reference information; processing large amounts of information; timely response to changing situations; forecasting the development of the situation; implementation of the analysis of accumulated experience, etc.

To make prompt and adequate decisions and actions, it is necessary not only to organize access to significant amounts of information, but also to have an information platform technology that allows timely processing of such a large database. Therefore, in such centers, software modules for registering incoming information and a module for managing the forces and means belonging to the response service itself are mainly being introduced.

The official owners of information are various state structures of any level, private enterprises that have a monopoly on the provision of services in a certain territory, in addition, these structures operate according to different organizational principles, at this stage there are difficulties in ensuring interconnections due to the fact that each system has been built for individual narrowly focused tasks. The lack of a unified policy for building information technologies and communications creates difficulties in ensuring interoperability with other databases and state information systems. Relationships between different ministries form the basis for the creation of procedures and methods for the exchange of collected and processed data.

The second chapter, which consists of four sections, substantiates an effective variant of rapid response based on the creation of an optimal command classifier and the effective cyclicity of a unified emergency management process.

The results of the analysis of the dynamics of the manifestation of emergency situations in the zone of intersection of the relationship between the area of the Classification of Emergency Situations and the area of the Territory, Forces and Means (Figure 1.) allows us to state with confidence that due to their instant manifestation, not all emergencies can be responded to overnight. As a rule, a greater degree of response occurs to the consequences of emergency situations, such as an explosion, a transport or industrial accident, earthquakes, or the fall of objects from space. Also, there are no technologies that allow curbing the natural phenomena that have begun - strong winds, thunderstorms, cyclones, landslides, mudflows, tsunamis, etc. As an example, we can cite the advance into the territory of a cyclone, accompanied by strong gusty winds, a large amount of precipitation with lightning discharges. In such a situation, the forces and means will not react in any way, they will remain at their combat posts, waiting for a message about a violation of the normal living conditions of the population. Under the current conditions of this natural phenomenon, the following reports are likely to arrive: a strong wind destroyed the roofs; a building caught fire from a lightning strike, a fire broke out; water floods living quarters;

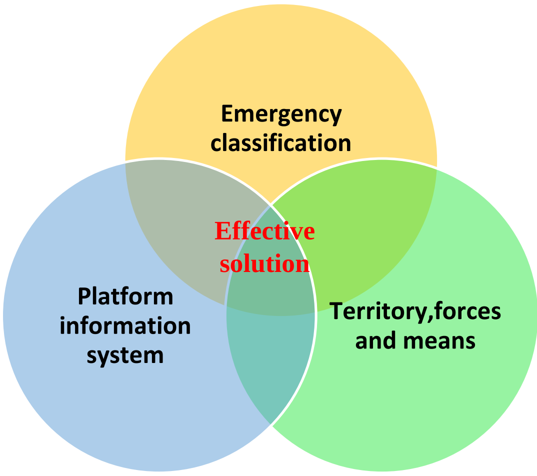


Figure 1. Composite factors influencing effective decision making [developed by the author]

a tree fell on some object or on the roadway; due to poor visibility on the road, an accident occurred, there are victims, it is necessary to remove the victims; etc., the list goes on.

For all of the above listed messages, to provide qualified assistance, various means of response are required, that is, equipment for various purposes may be involved, as well as personnel with skills in working with various specialized modern equipment. Consequently, there is a demand for the development and creation of a new unique classifier of the submitted emergency response commands, which will be operated by decision-makers to transfer more accurate point tasks to special forces. Such a classifier will allow the dispatcher to minimize the likelihood of errors, increase the efficiency and quality of decisions made, and help reduce the time for selecting commands to be given.

The teams in the classifier must be built in such a way that the decision maker and the rescue team understand what needs to be responded to, what means are to be used. Structurally, the new classifier, presented in Appendix 2, is built on three levels according to the decimal coding system (Figure 2), the lower the level of the classifier, the more accurate the command given, which allows the response forces to understand what exactly they are responding to and what technical means they will have to work with.

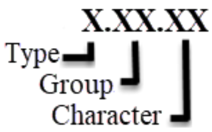


Figure 2. Structure of the response command classifier code [developed by the author]

An effective rapid response option based on the analysis of data models. The studies and practical experience presented in the paper demonstrate that there is no single, universal method for risk assessment. From these positions, it has been established that under such conditions, when there is no completeness of the picture of the impact of emergency situations, it is necessary to rely on several methods of analysis, which allows obtaining the most accurate averaged result of the study.

Proceeding from this, a method for describing the cyclicity of risk management is considered, which describes four main fundamental stages planning, preparation, response and recovery (Figure 3). Currently, there is a lack of clear transition boundaries between these stages,

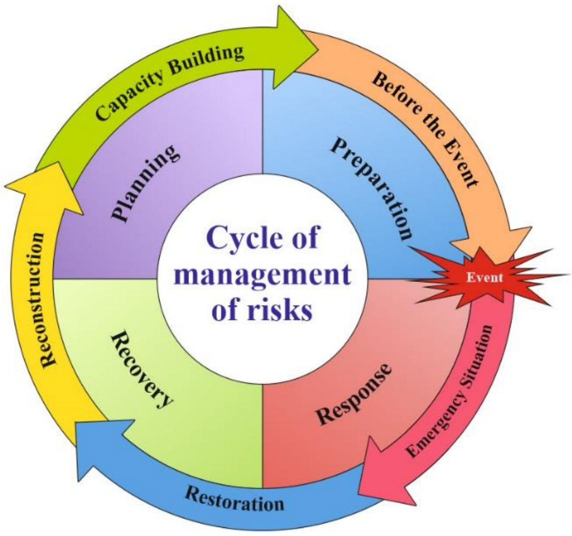


Figure. 3. Composition and sequence of implementation of a single risk management cycle

a smooth transition from one to another. The only exception in this cycle is the moment of the onset of an emergency, where there is an exact time boundary that separates the two states: before and after the emergency.

In terms of improving and increasing the efficiency of the emergency management system in a short period of time, a single integrated linear risk management system is of decisive importance. Figure 4 shows the linear structure of the risk management cycle depending on the redistribution of time and human resources, before the event, during and after the event in a short period of time (on the verge of an analog mode of operation).

The linear form of management allows you to visually redistribute resources and actions in the time period for those aimed at preventing and eliminating an emergency.

In this context, the risk management cycle approach has been developed and proposed for use as a state program, which will help distribute funding aimed at reducing the consequences of emergencies at various stages of the risk management cycle. A methodology for calculating the total damage caused by emergency situations has also been compiled. Application of the Pareto

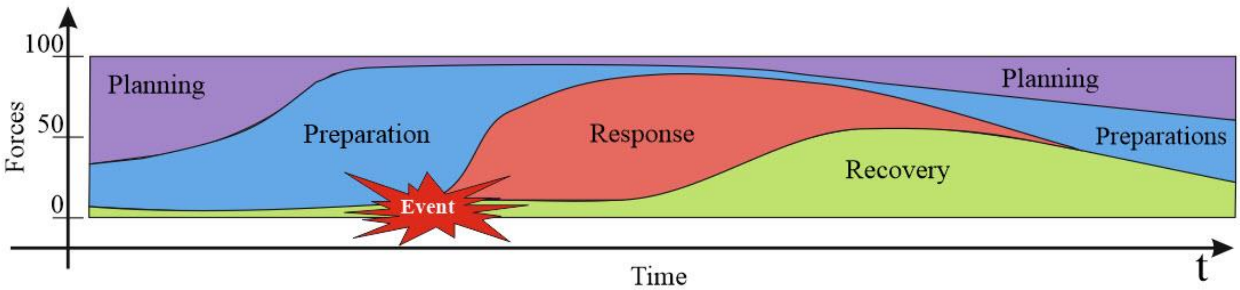


Figure 4. Linear risk management over a short period of time [developed by the author]

law for this methodology, will allow planning funds allocated from the state budget for the prevention of emergencies, which should be 20% of the total damage over the past period, which will reduce the amount of total damage by 80% in the current period of time.

For the economical use of the funds under consideration, as well as the achievement of positive socio-economic results, it is necessary to allocate funds for the next period for the development and maintenance of forces in the amount of at least 20% of the total material damage for the previous period. This amount should not include payroll and mandatory state taxes.

Such an approach should form the basis for the preparation of the annual budget aimed at protecting citizens and territories from natural and man-made disasters, as well as establish the necessary amount to finance emergency response services.

Of considerable scientific interest is also the task associated with the development of effective methods, algorithms and programs for predictive research into the functioning of the emergency management system.

The platform approach will allow access to significant amounts of data. But initially, the received data must be cleaned, organized into standard formats, and only after that they can be used. At the initial stage, manual input of training machine algorithms into the most powerful infrastructure system will be required, then a smooth transition to teaching artificial intelligence to work correctly, which, in its turn, will provide a competitive advantage, allowing you to coordinate user work, optimize business processes, and make them more flexible.

It should be noted that one of the important criteria that is not visible at first glance when working with a platform information system is that the system creates, controls and manages the rules of the game, which, in turn, leads to systemic management in the structure of the state.

At the moment, there are five types of information platforms: advertising, cloud, industrial, product and so-called thrifty. From the point of view of public administration, it is necessary to create a trans-platform information structure that will be a kind of intermediary between all existing types of platforms, structural databases organized at the state level, as well as social networks, creating new raw data products, thus raising decision-making to a new improved level. As government agencies begin to implement and use newly created components, the next important key task is to create and establish common communication standards, ensuring the compatibility of components of old working systems with new technologies. In the future, it is necessary to create fundamental industrial platforms that will connect sensors and gauges, enterprises and suppliers, manufacturers and consumers, the infrastructure of the state and citizens, software and technical equipment.

The third chapter, consisting of six sections, is devoted to solving the problems of reducing the duration of the response period to an emergency. This indicator represents the time interval between an incoming call and the arrival of the first emergency response team at the scene.

The response stage is decisive and short-term out of the four fundamental stages (planning, preparation, response, recovery) of a single risk management cycle. As a rule, this stage is discussed at the management level, and is also covered by the press, recorded in the form of photos and videos, and commented on according to their own ideas about its effectiveness. Since this approach is not standardized, it leads to a distortion of the reality of the real events taking place and carries a significant error.

One of the main criteria for responding to an incident or emergency is the quality and accuracy of management decisions, as a result of minimizing the response time for which specialized units will arrive at the scene, as well as the period from the start of rescue operations to their full completion. Therefore, the smaller the size of such a period, the more optimal the value of the response criterion. In this case, any response period is characterized by two main parameters, the start time and end time of the response.

$$T_r = t_f - t_s \tag{1.1}$$

Where:

T_r – response time;

t_s – response start time;

t_f – response end time.

Using only these two time parameters, it is not possible to fully assess the level of effectiveness of the actions taking place within the response phase. This is due to the fact that there are no obvious, clear boundaries of areas of responsibility between the various units directly involved in the response.

To this end, the use of a universal time scale of checkpoints has been developed and is proposed to allow monitoring the main time stages of the response, as well as determining the areas of responsibility for all units involved in the elimination of an emergency. It should be noted that in the Republic of Moldova three main groups of participants are involved in the response process: 112 service operators; dispatchers of three emergency services (rescuers, police, ambulance); emergency response forces.

Experience and emerging conceptual assumptions suggest that, in order to gain a more detailed understanding of the current situation, it is necessary to divide the response process stage into 11 intermediate temporary sub-stages that are part of the twelve temporary response checkpoints (Figure 5). The stages, in turn, are combined into the following three time phases.

1) The phase of response time of specialized services to emergency calls from citizens. This includes the reaction time between the time the first call is received by the emergency operator and the time the first emergency response crew arrives at the scene of the emergency. In this interval, all time characteristics are subject to mandatory fixation and normalization.

2) The phase of the time of the rescue operations. For this period of time, the values are fixed, but not normalized, due to the specificity of the ongoing processes.

3) The phase of the time to return to the base or determine the moment of readiness to continue the service. This option allows the controller to set which emergency response forces are available for the following missions.

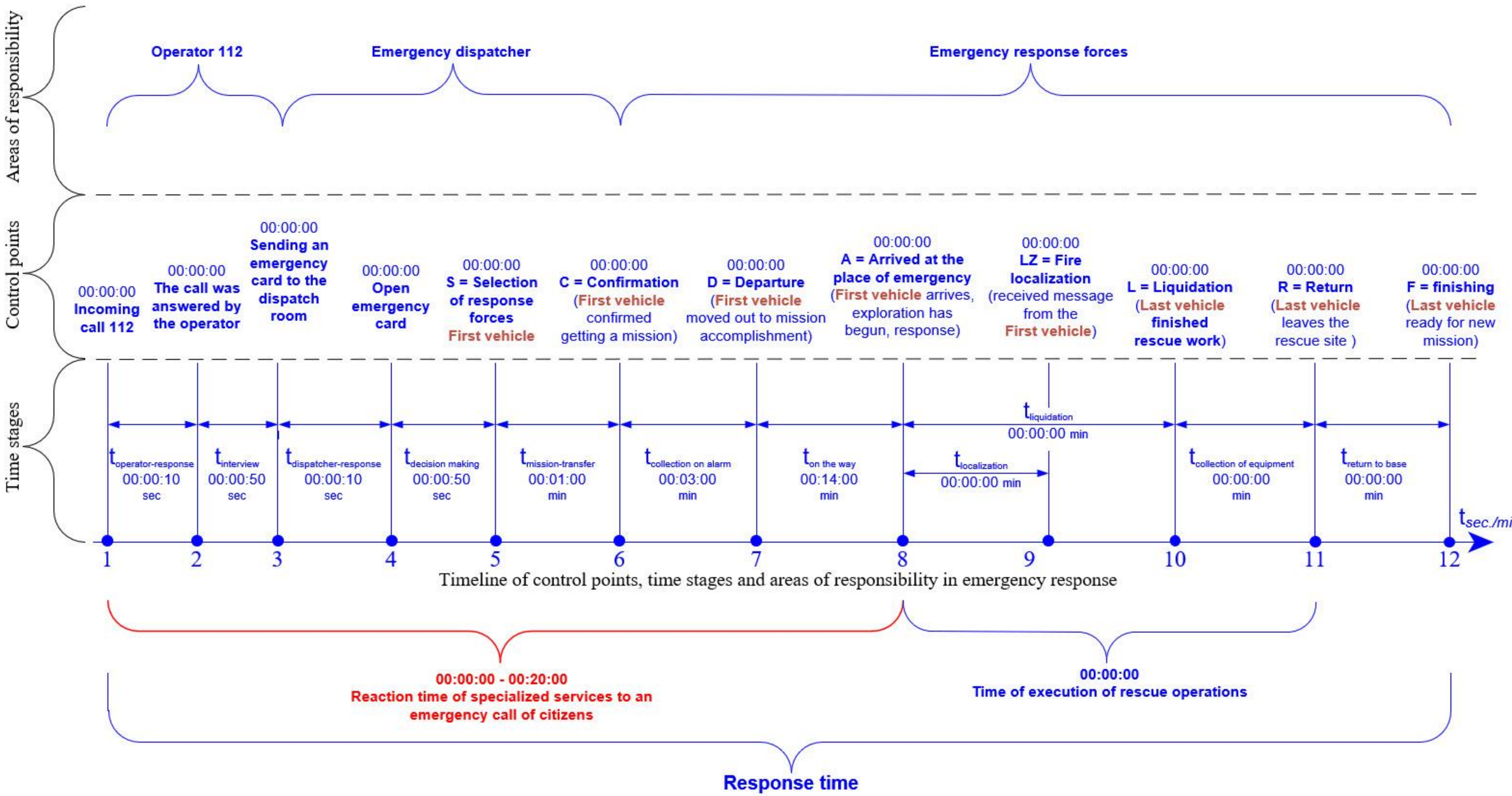


Figure 5. Graphical emergency response time model [developed by the author]

In this regard, the work describes in detail each time point, as well as the rules for calculating the size of the time steps of the response. Calculations have been made both for one unit and one response team, and for two or more units and emergency response teams. As a result of the introduction of this approach, all participants in the process began to be guided by the same unified standards, which made it possible to establish a clear boundary of areas of responsibility.

Also, its use made it possible to theoretically systematize and reduce the mission transfer time to three minutes, and on the basis of the results obtained from the database, to reduce the value of this indicator to two minutes. Analyzing the calculation of response time to an emergency call, in which all time stages of the response are subject to mandatory rationing, demonstrates that only one stage has a variable value, the rest are determined by the maximum time indicator approved by the internal documents of the response services.

Such data include the validity periods in the area of responsibility of the operator and the dispatcher, where the response time is recorded in seconds (Figure 5):

$t_{operator\ response} = 10_{sec}$, $t_{interview} = 50_{sec}$, $t_{dispatcher\ response} = 10_{sec}$, $t_{decision\ making} = 50_{sec}$ and $t_{mission\ transfer} = 60_{sec}$.

Temporal interval $t_{turnout}$ equals two minutes - this is a constant value, determined by an internal order. Includes the time of gathering on an alarm, putting on specialized equipment, the time of boarding the rescue team in the car.

$$T_{rc} = 10_{sec} + 50_{sec} + 10_{sec} + 50_{sec} + 60_{sec} + 2*60_{sec} + 15*60_{sec} = 1200_{sec} \text{ or } 20_{min}, \quad (1.2)$$

where: T_{rc} – emergency response time.

Temporal interval $t_{travel\ time}$ – variable value, depends on the speed of movement and distance. The internal standard establishes that the speed of the vehicle should not exceed 60 km/h. Therefore, travel time is directly proportional;

$$t_{id} = \frac{d}{s} \quad (1.3)$$

где: t_{id} – travel time, d – distance, S – speed

The accumulated experience shows that in order to reduce the reaction time and increase the response zone, one should also keep in mind the revision of the processes that take place on the way to the scene. According to international standards, the reaction time should not exceed 20 minutes, if the route is calculated to be no more than 15 km long.

Under ideal standard conditions, the response zone of one unit is no more than 15 kilometers in a straight line. This indicator can be attributed to the radius of the response zone. And the maximum distance between two rescue units should be no more than 30 kilometers. In Figure 6, a scheme for determining the distance to two units "A" and "B" is developed and shown, and the minimum distance between units, which should be no more than 30 kilometers, is also indicated. Units are located on opposite sides of the alleged emergency (ES), where D is the distance between two rescue units.

The conditions shown in Figure 6 have no real application, since in reality it is not possible to achieve them, due to the obvious presence of other variables. They have their constant values, and significant financial resources (investments) are needed to change them. To meet the established standard, it is necessary to increase the speed of movement or reduce the distance from the deployment of rescue units to the place of emergency. The first indicator depends on many parameters, among which, for example, the engine power of the car, which can support movement up to 90 km / h, this indicator allows you to increase the response distance from 15 km to 22.5 km. At the same time, this will increase the risk of traffic safety. Especially, this can take place when the roads are winding with different types of road surface - asphalt or concrete, crushed stone or just a field road, which becomes impassable in bad weather conditions, as well as with a long slope in the event of an ascent, which leads to a decrease in the speed of movement on the site. Provided that the road sections are even, with good coverage, it is possible to travel at a speed of 90

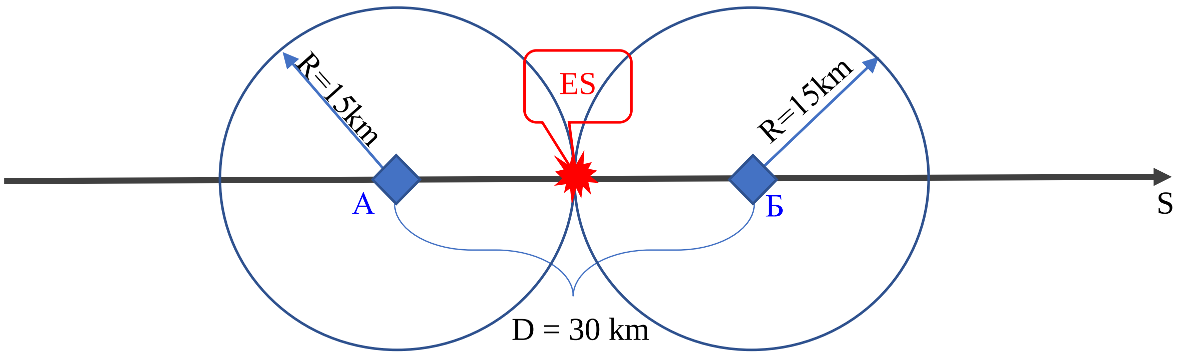


Figure 6. Graphical interpretation of the definition, the optimal size of the distance, the radius of the response zone [developed by the author]

kilometers per hour, which reduces the reaction time to 10 minutes. If this time remains unchanged, then it becomes possible to increase the response distance from 15 to 22.5 kilometers. In any case, it is required, first of all, to choose such a speed of movement of the transport, which would ensure the safety of the crew.

The second criterion for influencing the efficiency of reaction time is road congestion, the possibility of traffic jams (congestion) on the route, especially at the entrance to the place of emergency. Also, in an urban environment, it is necessary to keep in mind and follow the schedule for switching traffic lights. In this case, the best option is to introduce a green corridor system for the passage of specialized equipment.

An important factor that must be taken into account is the culture of behavior of all participants in the movement on the way of the response teams to the place of the emergency. There are other, unforeseen factors on which the speed of movement depends.

The third criterion for influencing reaction time is distance. At first glance, it is generally impossible to change it, since this approach requires a revision of the location of the rescue units, for the further arrangement of new units or the deployment of rescue teams. This approach is financially costly and long-term.

As a result of the research, it has been established and proposed to stop at the method of reducing the distance by two, and in some cases by three times, which, in its turn, will lead to a decrease in the reaction time, respectively, by the same amount, thereby increasing the number of zones departures and territories where a reduction in response time is possible. This requires the introduction of the following basic condition: the nearest unit in distance with the best road surface should go to the incident. During the study, the characteristics of the description of objects have

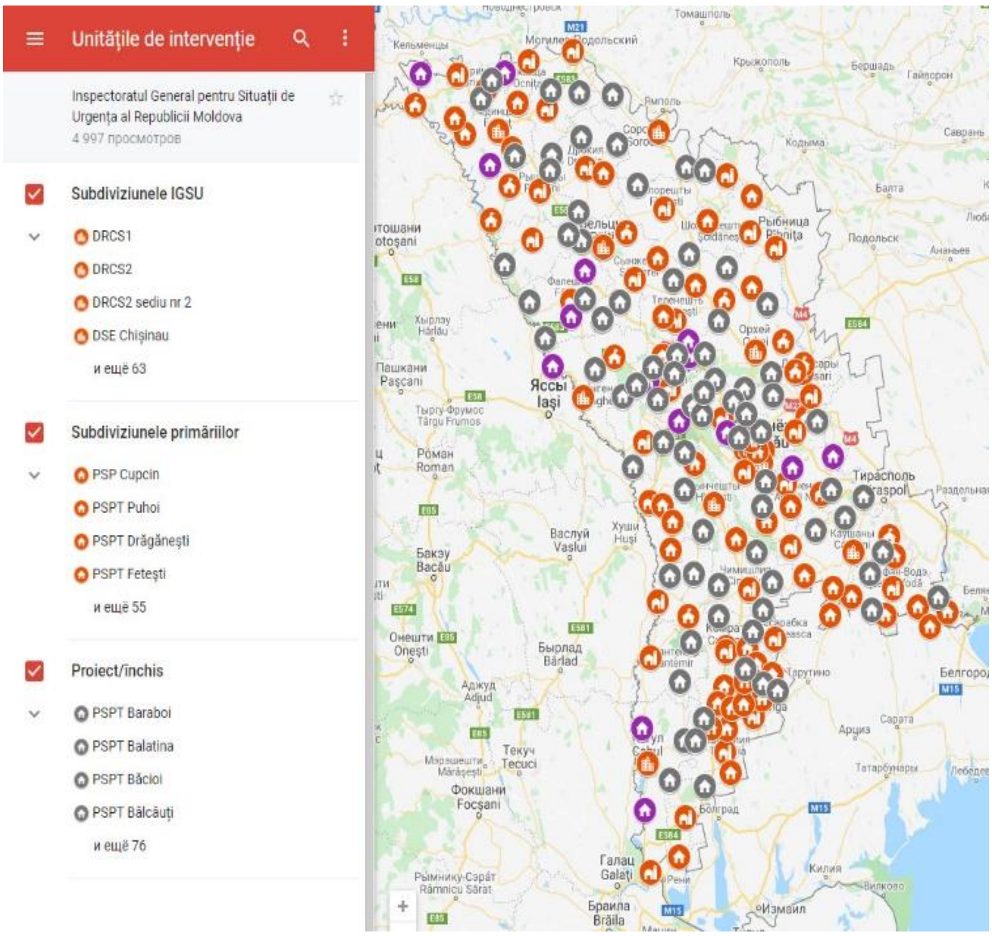


Figure 7. Map of the location of the emergency response forces of the rescue and fire departments in the Republic of Moldova [developed by the author]

been determined, the minimum requirements for the use of geographic information systems (GIS) have been established.

Of all the existing GIS technologies, the maps.google.com technology fits the requirements, with the help of which, to begin with, the geographical coordinates of the response units have been accurately determined (Figure 7). The availability of geographic data on the location of rescue units made it possible to more realistically review the possible response zones that are not tied to the administrative division of the territory, and the main approach is focused on reducing the response time along the shortest path for each unit separately.

The revision of the response zone, not tied to the administrative division, which led to a reduction in the travel route and a decrease in reaction time, can be seen in the following example: the route to the village of Reutel, Falesti district, is shown in Figure 8. The settlement is located

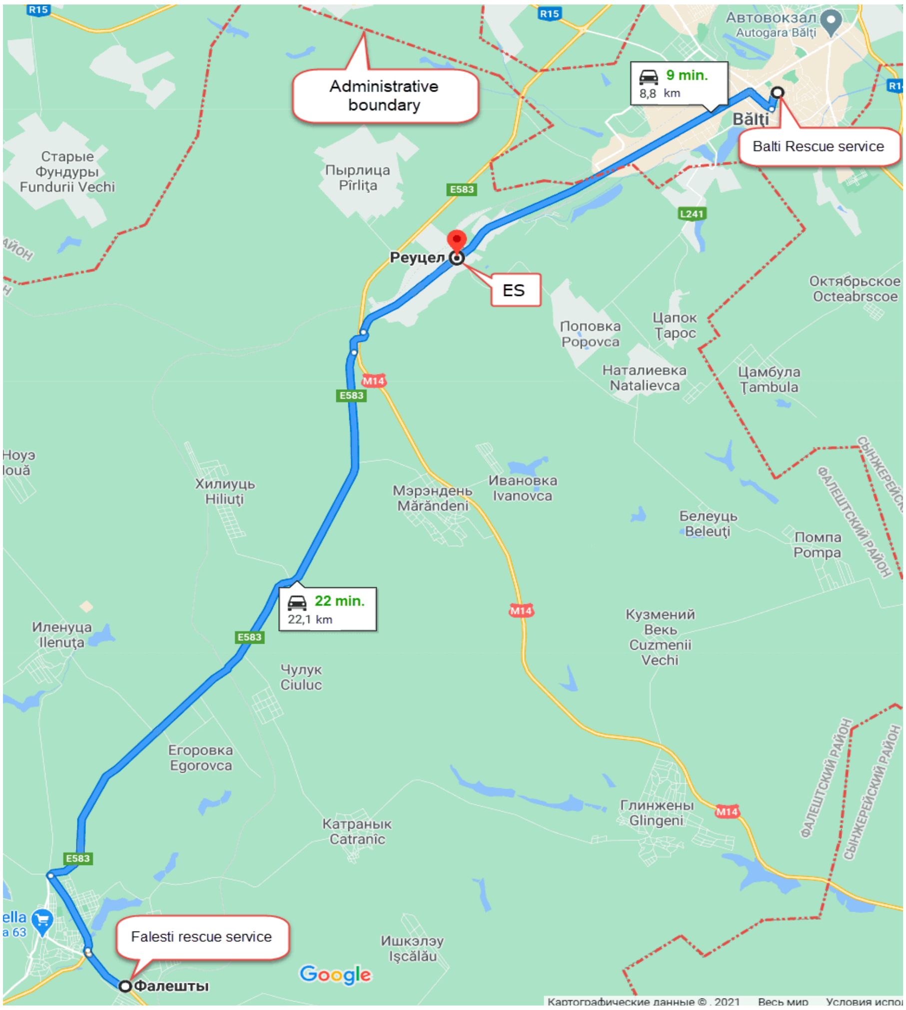


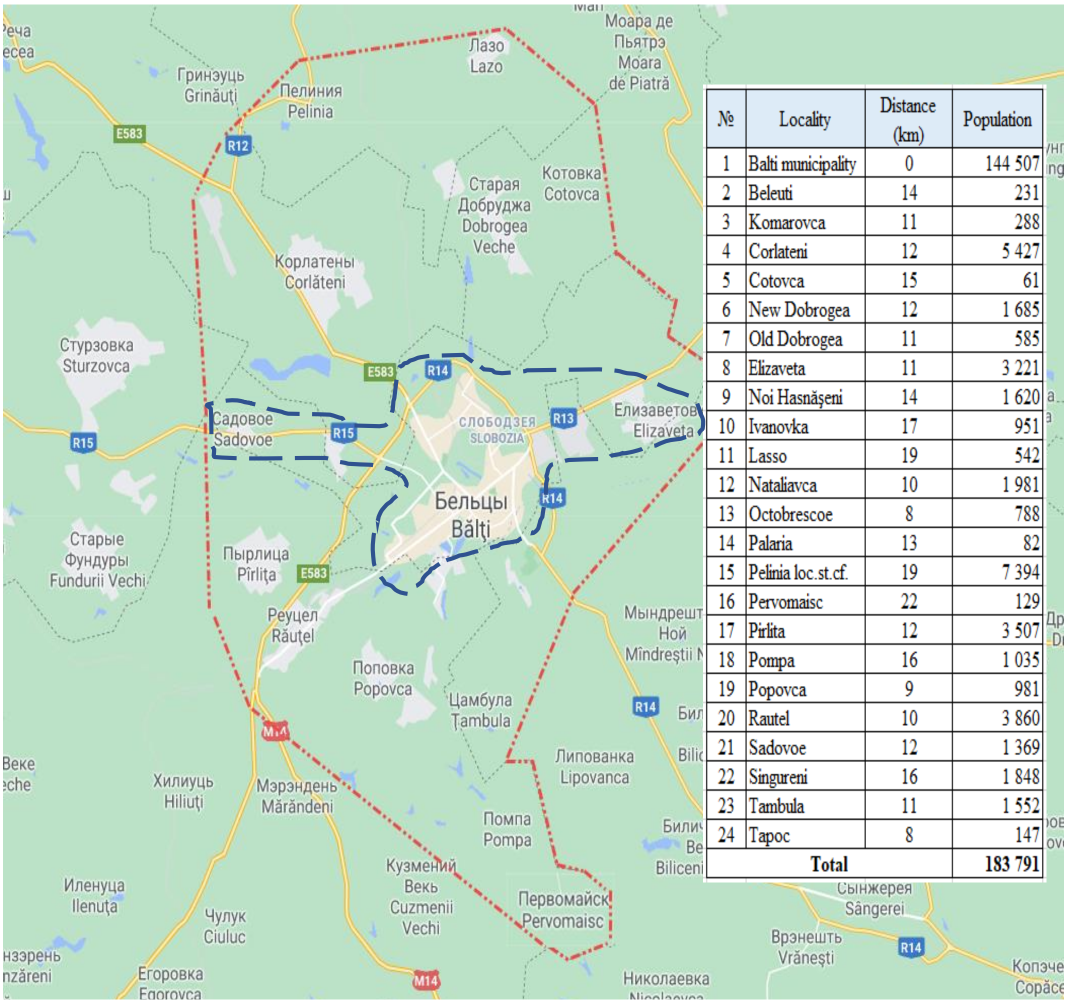
Figure 8. Map of response routes to Reutel village
[developed by the author]

8.8 km from the city of Balti. According to the approved response plan, the appropriate forces and means should leave for this settlement from the Falesti district center, which are located at a distance of 22.1 km from Reutel. By substituting the values into formula (1.2) on page 21, the average reaction time is determined.

$$T_{rc\text{-}Balti\text{-}Reucel} = T_{rp} + T_{id} = 6_{min\ \mathit{turnout}} + 9_{min\ \mathit{travel\ time}} = 15_{min} \quad (1.4)$$

$$T_{rc\text{-}\ Falesti\text{-}Reucel} = T_{rp} + T_{id} = 6_{min\ \mathit{turnout}} + 22_{min\ \mathit{travel\ time}} = 28_{min} \quad (1.5)$$

The initial response plan of the Balti garrison included only 3 settlements on an area of 78 km2, in Figure 9 this territory is highlighted with blue dotted lines with a population of up to 149097 people. The proposed methodology made it possible to increase the area of the emergency response zone to 370 km2, indicated by red dotted lines (Figure 9), and the zone included 23 settlements with a population of 183791 people.



№	Locality	Distance (km)	Population
1	Balti municipality	0	144 507
2	Beleuti	14	231
3	Komarovca	11	288
4	Corlateni	12	5 427
5	Cotovca	15	61
6	New Dobrogea	12	1 685
7	Old Dobrogea	11	585
8	Elizaveta	11	3 221
9	Noi Hasnăşeni	14	1 620
10	Ivanovka	17	951
11	Lasso	19	542
12	Nataliavca	10	1 981
13	Octobrescoe	8	788
14	Palaria	13	82
15	Pelinia loc.st.cf.	19	7 394
16	Pervomaisc	22	129
17	Pirlita	12	3 507
18	Pompa	16	1 035
19	Popovca	9	981
20	Rautel	10	3 860
21	Sadovoe	12	1 369
22	Singureni	16	1 848
23	Tambula	11	1 552
24	Tapoc	8	147
	Total		**183 791**

Figure 9. Map of the response zone of the Balti garrison according to the proposed methodology. [developed by the author]

The modification of the ideology and conception of the considered plan, carried out by the author, allowed 34694 citizens from 20 localities to receive assistance in a standardized period of up to 20 minutes from the Republic of Moldova.

The above method has been applied to all 1540 localities in the Republic of Moldova, presented in Appendix 3. One of the most important steps in optimizing the decision-making time has been the analysis of the work of the dispatcher, it is known that the time spent by him to notify all units involved in the elimination of an emergency increases in proportion to their number.

At the moment, the notification is carried out by the method of consecutive calls. Thus, in order to reduce the total mission transfer time, regardless of the deployed software, it is proposed to supplement the existing information system with a block where the controller's action is to press the button of the selected unit, which corresponds to the control point for **selecting the response forces** (Figure 5).

As a result of this action, an alarm collection signal will be triggered in the selected department, information about the emergency will be displayed on the screen installed in the department, the information will be automatically duplicated by the printer. At the same time, the garage door will open and the lights will turn on at night. By pressing a special anti-vandal button, the rescue unit confirms that the message has been received.

All these actions are fixed in the program: pressing the button corresponds to the **confirmation checkpoint** (Figure 5). If the dispatcher did not receive this confirmation, after 10 seconds a message should appear on the computer screen in a separate window that the information has not been delivered. Having received such a message, the dispatcher starts using backup communication channels to notify the selected unit.

As a rule, when changing the methods of processing incoming information, it is necessary to pay special attention to the quality training of decision-making personnel. For this purpose, it is necessary to build and implement a system for assessing accumulated knowledge and experience. The skill of making adequate decisions with the use of platform information technologies, worked out to automatism, significantly affects the reduction of decision-making time. One of the advantages of the proposed method is the ability to create, edit and view input forms and a table of results on any device such as a mobile phone, tablet or computer, without the need for financial costs for technology.

The method is based on Google's Open Source technology, which combines Google Forms and Google Sheets, which is part of the free web-based office software package offered by Google as part of the Google Drive service.

The disadvantage of this method is that there is no way to test creative answers, essays, artwork, etc. Due to the fact that the process of assessing the quality of training of decision makers does not include a range of creative tasks, this disadvantage equals to zero.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

In this paper, conceptual models and techniques have been developed that form the theoretical basis for the practical information support of the decision-making system in emergency situations. The results of the conducted studies and their implementation in reality made it possible to come to the following general conclusions and recommendations:

1. Until recently, the existing set of minimum indicators that affect the efficiency and quality of decision-making at the initial stage of responding to emergencies and their consequences was formed as the need for them arose. Therefore, both the structure and their set have not been ordered and finally established. In this regard, an objective need arose to analyze and streamline their composition, based on their content and role in the process of formulating and making decisions.
2. As evidenced by the results of their implementation and application in everyday reality, the systematization of the considered indicators led to a decrease in the impact of the harmful effects caused by emergency situations.
3. In its turn, the reduction in the number and size of the consequences of such situations led to certain socio-economic effective results.
4. The developed conceptual models and methods are primarily aimed at determining the stages of work on the technology of responding to emergency calls, as the basis for the formation of information support for the development and decision-making. In the future, based on the decisions made and the consequences of implementation, their socio-economic assessment is carried out.
5. In the current situation of the study area, the minimum set of indicators has been considered and analyzed to improve the efficiency and quality of decisions at the initial stage of responding to the events under consideration.
6. Having and managing a set of ordered, named baselines has contributed to the opportunity and the urgent need to improve decision making. This also made it possible to direct efforts towards the development of their adequate models and algorithms, which increased the efficiency of the control system in a complex environment and large amounts of initial information.
7. Due to the continuous nature of the unified risk management process, in the event of and during emergency situations, the methods of its cyclical implementation have been studied. The redistribution of resources with a linear-finite representation of this cycle for certain categories of emergency events is demonstrated.
8. Based on this redistribution, a methodology for calculating the total material damage has been developed, which is an integral part of this category of management, taking into account

the economic component of each of its stages. It allows you to determine the composition and amount of necessary costs at the stages of planning and preparing for probable emergencies. It also becomes possible to determine the amount of material and financial damage at the stages of response and recovery.

9. According to the results of the studies carried out in this plan, it is proposed to allocate funds from the state budget for the prevention of emergency situations in the amount of 20% of the total damage over the past period. This will reduce the amount of total damage by 80% for the current time period.

10. In order to obtain the necessary information for making optimal decisions in a short period of time at the initial stage of the response, as well as due to the heterogeneity of information systems and technologies, there is an urgent need to create and implement a trans-platform system for connecting to third-party databases.

11. The technologies underlying such a system should be based on the processing of heterogeneous and varied structured data, including standard format documents, social network data, and audio and video files.

12. As a result of identification, analysis of the definition of the composition and formats, a single standard classifier of commands given for emergency response units has been developed. Such a classifier makes it possible to make an objective decision, minimizing the probability of errors, increasing its efficiency and quality, thereby reducing the time for selecting the given commands.

13. In this document, the types of response are classified in such a way that the decision maker and the rescue team are equally aware of what needs to be responded to and what means to be used.

14. In order to achieve the maximum level of responsiveness, a graphical model of the timeline of the main control points for responding to emergency calls has been developed.

15. The response technology created on its basis makes it possible to time the actions of participants, establish clear boundaries for their areas of responsibility, and follow uniform algorithms of actions, regardless of the type of emergency. The correspondence of the developed model to the existing objective reality is confirmed by the achieved results of the implementation and daily practical functioning of the response system. Ultimately, the results achieved were formalized and used as a logical module of the System of the Unified National Emergency Service 112 of the Republic of Moldova.

16. By reducing the distance, as well as the route of the emergency response forces to eliminate emergency situations, a geoinformation model and an algorithm for optimizing the territorial response zones have been compiled.

17. To develop a methodology for reducing the response time by reducing the distance, as well as the route, the method of GIS technologies has been applied for 1536 settlements of the Republic of Moldova. Thus, the revision of the schemes of the spatial arrangement of settlements in relation to the rescue services made it possible to reduce the reaction time for administratively remote territorial units by an average of 60%.

18. A methodology has been developed for assessing the actions of a manager in the course of making a decision to respond to emergency situations. On its basis, the assessment of actions by decision makers is carried out both at the stage of commissioning information systems, as well as individual algorithms, and new software modules. Also, when using it, it is possible to determine the level of training of management personnel, optimize the learning process, and devote more time to explaining problematic topics. Analysis of test results helps to speed up the identification of weaknesses in the algorithms and procedures for formulating and making decisions, with their subsequent revision towards qualitative improvement.

The scientifically based approaches to optimizing business processes, models, algorithms and methods for evaluating their effectiveness, developed and proposed in this paper, significantly increase the organizational efficiency of the decision-making information support system.

LIST OF PUBLISHED SCIENTIFIC ARTICLES OF THE AUTHOR

Articles in peer-reviewed scientific journals:

1. PEANCOVSCHII S. Organization of a mobile emergency management center. In: D. A. Tsenov Academy of Economics, Svishtov, Business management Book 3. 2020, p.71-90. ISSN 0861-6604. Indexed in databases: EBSCO, CEEOL, BASE. RePEc

2. PEANCOVSCHII S., OHRIMENCO S. Mobile center for prevention and reduction of emergency. In: Humanitas university's research papers, Zarządzanie Management, Sosnowiec 2020, ZN WSH Zarządzanie 2020, DOI: 10.5604/01.3001.0014.1230, p. 163-175. ISSN 1899-8658. Indexed in databases: BazEkon, CEON, Index Copernicus, BazHum, ERIH Plus

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1. PEANCOVSCHII S., OHRIMENCO S., SARKISYAN A. Information provision of emergency management processes. B: Collection of reports, Svishtov, October 4, 2019, "Tsenov" Academic Publishing House. C.347-353, ISBN 978-954-23-1762-3. Indexed in databases: EBSCO, CEEOL, BASE, IDEAS, EconPapers, RePec.

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3. PEANCOVSCHII S., Information support of the decision-making system in emergency situations. In: Actual problems of natural sciences and humanities in the research of young scientists "Rodzynka-2019". XXI All-Ukrainian scientific conference of young scientists. Cherkasy: CHNU named after B. Khmelnytskyi, 2019, УДК 378 (6) p.239-241.

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7. PEANCOVSCHII S., Calculation of damage from emergency situations. In: Economic Security in the Context of Sustainable Development, Online International Scientific Practical Conference 1st Edition, December 11, 2020, Chisinau, Moldova, Academy of Economic Studies of Moldova, p.322-327. ISBN 978-9975-155-01-4.

ADNOTARE

la teza de doctor în domeniul științelor inginerești și tehnologii a dlui Peancovschii Serghei
„Suportul Informațional al Sistemului Decizional în Situații Excepționale”
Universitatea Internațională Independentă din Moldova, Chișinău, 2023

Structura tezei: Teza de doctor constă din introducere, trei capitole, concluzii, bibliografie și anexe. Volumul total al lucrării este de 143 de pagini. Este ilustrată cu 52 de figuri, conține 7 tabele și 3 anexe. Lista de referințe include 133 de titluri.

Cuvinte-cheie: situații de urgență, echipe de management, daune, ciclu de gestiune a riscurilor, reducerea timpului de reacție, soluții eficiente, centru de control situațional, centru de control mobil, criterii pentru evaluarea factorilor de decizie.

Domeniul de studiu: sistemul de conducere operativă a lichidării situațiilor de urgență în Republica Moldova.

Scopul lucrării: elaborarea fundamentelor conceptuale și implementarea practică a măsurilor de îmbunătățire a eficienței sistemului de management propus prin introducerea unei abordări științifice în scopul optimizării business-proceselor pentru factorii de decizie.

Obiectivele lucrării:
- cercetarea și selectarea criteriilor reducerii timpului reacției,
- elaborarea și stabilirea standardului unitar de comenzi pentru unitățile de intervenire urgență;
- optimizarea business-proceselor prin determinarea indicatorilor - cheie de timp;
- întocmirea algoritmului optim de elaborare și selectare a planului performant de răspuns la situația excepțională.

Noutatea și originalitatea științifică: elaborarea și implementarea sistemului de elemente de bază noi, care asigură funcționarea eficientă a sistemului de formulare și luare a deciziilor.

Rezultatele obținute contribuie la soluționarea problemei științifice importante, legate de îmbunătățirea eficienței sistemului decizional în vederea asigurării optimizării și calității deciziilor luate în situațiile de urgență.

Semnificația teoretică a studiului, a tezei constă în dezvoltarea unui nou sistem de management mai eficient, bazat pe un suport informațional îmbunătățit. Noul sistem de suport include dezvoltarea unui sistem de modele, metode și algoritmi, care permit optimizarea sistemului decizional, sporind eficiența și calitatea deciziilor luate atât în răspuns, cât și pe parcursul desfășurarii situațiilor de urgență.

Semnificația practică a studiului, a investigațiilor este determinată de metodele, modelele și algoritmii performanți, utilizați în pachetul software pentru dispecerii postului de comandă al Inspectoratului General pentru Situații de Urgență al Republicii Moldova. Aceasta permite optimizarea procesului de luare a deciziilor, îmbunătățește eficiența și calitatea deciziilor luate, cu transferul ulterior de sarcini mai exacte către forțele de răspuns. Optimizarea proceselor adecvate de luare a deciziilor contribuie la reducerea timpului de luare a deciziei până la 50 secunde, iar timpul total de reacție al echipei de salvare nu depășește 20 de minute la o distanță de cel mult 20 de kilometri. Datorită abordării progresive și propuse de revizuire a zonelor de răspuns pe 90% din teritoriul Republicii Moldova, a fost posibilă reducerea timpului de răspuns și creșterea eficienței luării deciziilor.

Implementarea rezultatelor științifice. Modelele și metodele elaborate au fost introduse și sunt utilizate în Inspectoratul General pentru Situații de Urgență al Republicii Moldova. De asemenea, algoritmii au fost integrați și testați în sistemul informațional 112 al Republicii Moldova în modulul de control al forței de muncă și echipamentelor tehnice, în care activează dispecerii unităților de intervenire de urgență ale Inspectoratului nominalizat.

АННОТАЦИЯ

к докторской диссертации в области инженерных наук и технологий Пянковский Сергей, «Информационная поддержка системы принятия решений в чрезвычайных ситуациях», Международный Независимый Университет Молдовы, Кишинёв, 2023

Структура работы: Диссертационная работа состоит из Введения, трёх Глав, Заключения, Списка литературы и Приложений. Общий объём составляет 143 страниц. Работа иллюстрирована 52 рисунками, содержит 7 таблиц и 3 приложения. Список литературы включает 133 наименований.

Ключевые слова: чрезвычайные ситуации, команды управления, ущерб, цикл управления рисками, сокращение времени реагирования, эффективные решения, ситуационный центр управления, мобильный центр управления, критерии оценки лиц, принимающих решения.

Область исследования: система оперативного управления ликвидацией чрезвычайных ситуаций в Республике Молдова.

Цель работы: разработка концептуальных основ и практической реализации мер по повышению эффективности функционирования предполагаемой системы управления путем внедрения научно-обоснованного подхода оптимизации бизнес-процессов принятия решений.

Задачи работы:

- поиск и выбор критериев сокращения времени реагирования,
- разработка и определение единого стандарта подаваемых команд для подразделений экстренного реагирования,
- оптимизация бизнес-процессов путём определения ключевых временных показателей,
- составление оптимального алгоритма для разработки и выбора плана реагирования.

Научная новизна и оригинальность: Разработка и внедрение системы новых базовых элементов, обеспечивающих эффективное функционирование системы принятия решений в чрезвычайных ситуациях.

Полученные результаты способствуют решению важной научной проблемы, касающейся повышения эффективности функционирования системы принятия решений с целью обеспечения оптимальности и качества принимаемых решений в чрезвычайных ситуациях.

Теоретическая значимость исследования, работы состоит в разработке новой более эффективной системы управления на основе улучшения информационной поддержки. Новая система информационной поддержки была разработана совокупность оптимальных моделей, на основе методов и алгоритмов, позволяющих значительно улучшить систему принятия решений, повысить эффективность и качество принимаемых решений как при реагировании так и при ликвидации чрезвычайных ситуаций.

Практическая значимость исследования, определяется разработанными моделями, методами и алгоритмами, применяемыми в программном комплексе для диспетчеров командного пункта управления Главного Инспектората по Чрезвычайным Ситуациям Республики Молдова. Это позволяет оптимизировать процесс принятия решений, повысить эффективность и качество принимаемых решений с последующей передачей более точных точечных задач силам реагирования. Оптимизация процессов принятия адекватных решений позволяет сократить время принятия решения до 50 секунд, а общее время реакции спасательных подразделений не превышает 20 минут на расстоянии не более 20 километров. За счёт разработанного и предложенного подхода пересмотра зон реагирования на 90% территории Республики Молдова удалось сократить время реагирования и повысить оперативность принятия решений.

Внедрение научных результатов: предложенные модели и методы были внедрены и используются в Генеральном Инспекторате по Чрезвычайным Ситуациям Республики Молдова. Также разработанные алгоритмы были протестированы и интегрированы в информационную систему 112 Республики Молдова, в модуль управления силами и средствами, где работают диспетчеры подразделений Экстренного Реагирования Генерального Инспектората по Чрезвычайным Ситуациям Республики Молдова.

ANNOTATION

to the doctoral thesis in the field of engineering science and technology of Mr. Peancovschii Serghei, "Information support of the decision-making system in emergency situations"
International Independent University of Moldova, Chisinau, 2023

The structure of the thesis consists of an introduction, three chapters, conclusions, a list of references and annexes. The total volume of the work is 143 pages. The work is illustrated by 52 figures, contains 7 tables and 3 annexes. The list of references includes 133 titles.

Keywords: emergency situations, management teams, damage, risk management cycle, response time reduction, effective solutions, situational control center, mobile control center, criteria for assessing decision-makers.

Field of study: system of effective management of liquidation of the emergency situations in the Republic of Moldova.

The purpose of the paper is to improve the efficiency of the functioning of the decision-making system by introducing a science-based approach to optimizing business processes, for decision-makers.

Objectives of the paper:
- search and definition of criteria for reducing the reaction time,
- elaboration and determination of a unified standard of commands for emergency response units,
- optimization of business processes by determining key time indicators,
- drawing up an optimal algorithm for the development and selection of a response plan.

Scientific novelty and originality: Elaboration and implementation of new conception of development of models and technics, which ensures the theoretical base and the efficient functioning of its decisional processes optimization in the emergency situations.

The obtained results contribute to the solution of an important scientific problem related to the elaboration and improving the efficiency of the decision-making system, ensuring the optimality and quality of decisions made in emergency situations.

The theoretical significance of the study lies in the development of a new, more efficient management system, based on improved information support. It includes the development of models, methods and algorithms of optimizing the decision-making system, increases efficiency and quality of decisions made in responding to and liquidating emergencies in the Republic of Moldova.

The practical significance of the study is determined by the developed models, methods and algorithms used in the software package for dispatchers of the command post of the General Inspectorate for Emergency Situations of the Republic of Moldova. This allows to optimize the decision-making process, increase the efficiency and quality of decisions made with the subsequent transfer of more accurate, point-to-point tasks to the response forces. Optimization of the processes for making adequate decisions allows reducing the decision-making time to 50 seconds, and the total response time of rescue units does not exceed 20 minutes at a distance of no more than 20 kilometers. Due to the proposed approach of revising the response zones on 90% of the territory of the Republic of Moldova, it was possible to reduce the response time and increase the decision-making efficiency.

Implementation of scientific results: The proposed models and methods have been introduced and are used in the General Inspectorate for Emergency Situations of the Republic of Moldova. Also, the developed algorithms were integrated and tested into the informational system 112 of the Republic of Moldova, into the force and equipment control module, in which the dispatchers of the emergency response units of the General Inspectorate for Emergency Situations of the Republic of Moldova work.

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232.01. CONTROL SYSTEMS, COMPUTERS AND INFORMATION NETWORKS

ABSTRACT

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