Development of a Geoinformation Model for Effective Infrastructure Management Spatial Data on Complex Objects and Distributed Systems in Conditions Uncertainties

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***Abstract*— This article describes the method of solving the problem of security management based on the solution of the inverse problem. This method allows you to create processes with initially specified properties. At the moment, most of these problems are solved using the analysis, based on the received initial data, which does not allow you to specify the required values of the safety criterion. The synthesis method is devoid of this shortcoming and can be used to create a mathematical model of a management solution with a given value of the safety criterion. There is a need to evaluate the spatial data infrastructure (SDI) to justify and control the relationship between investments in SDI initiatives and the results obtained. Also, it is necessary to pay special attention to the identification of user communities and the identification of their evaluation of the effects derived from SDI. The document introduces a concept based on the synthesis method, which allows to evaluate the effectiveness of SDI from the perspective of the user. [1]**

Keywords— management; security; geoinformation system; spatial data infrastructure; model; graph

I. NATURAL SCIENTIFIC APPROACH TO THE SYNTHESIS OF THE MODEL OF EFFECTIVE MANAGEMENT OF THE INFRASTRUCTURE SPATIAL DATA

Use of geoinformation systems to solve the problem of managing the safety of natural phenomena using analysis based on the obtained initial data, which does not allow us to specify the required values of the safety criterion. In this case, the GIS allows you to calculate the most optimal route to reduce the time of resolution of the problem.

To calculate the effect of GIS on the safety criterion, it is necessary to solve the inverse problem of safety management using the synthesis method. The solution is the basis of management. The decision-maker creates a decision-making model. This model should take into account the main regularity of the thematic area, which is the law of preservation of integrity.

The law of preserving the integrity of an object is a stable repeated connection of the properties of the object and the properties of the action for a fixed purpose. The action is carried out on three main properties: "objectivity", "integrity" and "ability to change." Therefore, each process must be represented by three interrelated components in the form of a process: "object", "destination" and "action". [2]

1. Methodological level – determining the conditions for the existence of the management process;
2. Methodical level – development of a method that allows to ensure the conditions for the transfer of the control object from the present state to the required one;
3. Technological level – obtaining conditions for the implementation of the process of transferring the control object from the present state to the required one.

Thus, the management decision is the provision by the subject of the conditions for the realization of the purpose of the object, which he manages, in the appropriate environment. The situation is the set of factors and conditions in which the activity is carried out. [3]

From system engineering it is known that two approaches to the construction of systems are possible – analysis and synthesis. In this work, the synthesis approach is used.

Problems arise with a frequency that depends on ΔtPP – the average time of occurrence of the hazard (the manifestation of the problem) (Fig. 1a) To neutralize the hazard, the employee must be able to identify it (depends on ΔtIP – average hazard identification time) (Fig. 1b) the employee needs to neutralize the danger. Neutralization occurs with a frequency that depends on ΔtNP (Fig. 1c). [4]

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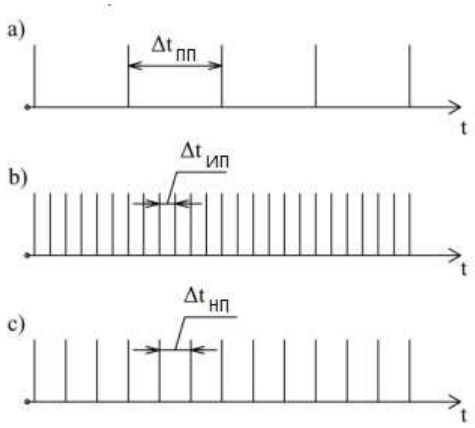

Fig. 1. The diagram of the manifestation of the basic elements of the management decision. a) the time of the problem; b) the time of problem identification; c) the time to neutralize the problem. [5]

The basic model of the management solution has three main elements, which is shown in Fig. 2.

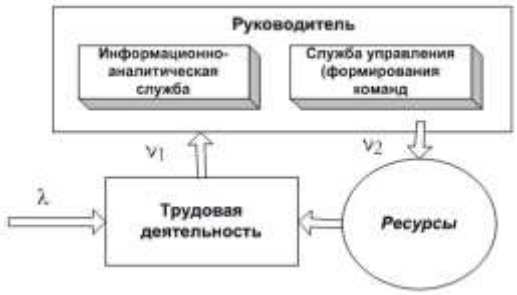

Fig. 2. Structural scheme for the implementation of management decisions

When working, there are problems with the intensity.

$$\lambda = \frac{1}{\Delta t_{ПП}}$$

These problems are identified by the information and analytical service, the intensity of identification will be as follows.

$$\upsilon_1 = \frac{1}{\Delta t_{ИП}}$$

The process for neutralizing the problem will be characterized by the intensity.

$$\upsilon_2 = \frac{1}{\Delta t_{НП}}$$

The basic equation shows the probability of finding the system at the moment of the state when the existing problem is solved, and the new one has not yet come. This indicator is a safety criterion. [6]

$$P_{00} = \frac{\upsilon_1 \upsilon_2}{\lambda(\lambda + \upsilon_1 + \upsilon_2) + \upsilon_1 \upsilon_2}$$

The basic equation shows the probability of finding a system during a state when the existing problem is solved, and the new one has not yet come. This indicator is a safety criterion. To solve the inverse problem, it is necessary to determine the intensity of manifestation, identification and neutralization of the problem. [7]

According to the National Institute of Meteorology of Venezuela, data were received for 2017, where 18 hurricanes were produced for calculations, all data are given per unit of days. Therefore, two points of view were evaluated:

1. The efficiency of the current system was evaluated.
2. The effectiveness of systems was assessed from the point of view of the proposed system.

At the moment, decisions are made by state bodies, for example, the Ministry of Emergencies, and they are affected by the human factor – when a threat arises on the territory of Venezuela, people must go to the capital to receive disks and documents with geo-data. It takes 2 days or more. Therefore, the processes of identification and neutralization of emergencies were formulated and evaluated. The average number of hurricanes is 18 per year, for identification, an average of 2 days, for neutralization – 2 days. [8]

$$\lambda = \frac{18}{365} = 0{,}049 \quad \upsilon_1 = \frac{1}{2} = 0{,}5 \quad \upsilon_2 = \frac{1}{2} = 0{,}5$$

$$P_{00} = \frac{0{,}5 * 0{,}5}{0{,}049(0{,}04\ 9 + 0{,}5 + 0{,}5) + 0{,}5 * 0{,}5} = 0{,}82$$

The leadership of the Ministry of Emergency Situations sets a task to increase the safety index by means of software and hardware. After the modernization of the decision-making process, the indicator should be at least 0.9.The platform is a compilation of reliable free software capable of performing administrative management of data and metadata, as well as providing geoservices that allow you to organize and manage data in one application, allowing any agency to concentrate, manage and disseminate geographic information about risks and disasters and do not invest a lot of time and resources in development. This study leads to the integration of multidisciplinary research efforts. Services based on the Open Web Service (OWS), with which the platform is calculated, is CSW. Unification of databases is carried out through a process called Harvesting. Metadata management is performed according to ISO 19115, the form for filling in metadata is very simple and makes it easy to publish geodata. Standardization is an important factor considering the different scales, formats and content of the data. [9]

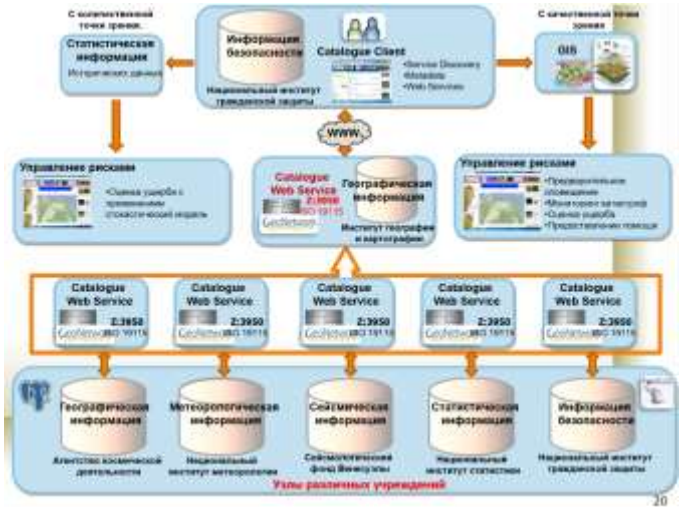

Fig. 3. Scheme of the proposed operation

It reduces the neutralization time, and the safety factor has increased to 0.92. [10]

$$P_{00} = \frac{0{,}5 * 12}{0{,}049(0{,}04\ 9 + 0{,}5 + 12) + 0{,}5 * 12} = 0{,}92$$

The effectiveness of GIS application in the interests of state management of emergencies was assessed. It was concluded that the implementation of the architecture is effective and necessary to improve the system and the time spent on average is 2 hours instead of 2 days in the current system. Time management is critical to good planning. The average time to receive information about the threat is reduced from 2 days to 2 hours, which equals a 24-fold increase in speed. In this regard, the security indicator (the probability of timely detection and localization of the threat) grows from 0.82 to 0.92. [11]

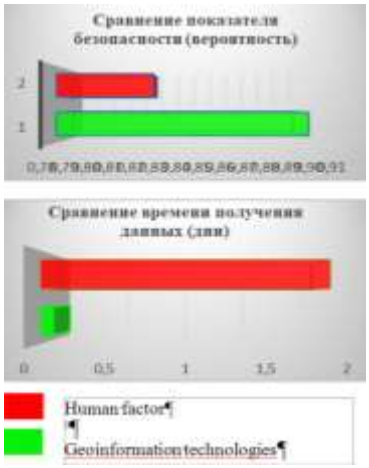

Fig. 4. Comparison between the current system and the proposed system

II. Conclusion

Using the synthesis method to solve the inverse problem allows you to model a system with a predetermined safety criterion. This is its main advantage over traditional analysis approaches. GIS provide the necessary information for modeling a safe system, and the solution of the inverse problem allows to evaluate mathematically the influence of this information on the value of the safety parameter. The application of GIS allows to increase the value of the safety criterion. [12]

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