TECHNOLOGIES OF INFORMATION SUPPORT OF TERRITORIAL SAFETY MANAGEMENT

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Abstract

The paper presents approaches aimed at solving the problems of territorial administration related to: limited availability of integrated monitoring data, the impossibility of reproducing risk calculations by independent groups of researchers; the general nature of recommendations on the composition and scope of preventive measures, formed based on the results of risk calculations and not taking into account the specifics of S-N-T systems; lack of indicators for assessing the impact on safety of the implemented preventive measures; lack of scientific substantiation of management processes, the absence of generally accepted models for forecasting the security of territories for a long-term period, which allow more systematic planning of strategic activities.

Keywords: social-natural-technogenic system, safety, territorial management

I. Introduction

Information support for the management of natural and technogenic safety is based on the results of a comprehensive monitoring of the environment state, control of technosphere objects. The assessment of territorial risks includes data on the characteristics of protected objects and sociosphere indicators [1, 2]. In recent years, the term social-natural-technogenic (S-N-T) system has been widely used to designate the object of safety research, which implies consideration of three areas and their interaction [3]. Since there is no established definition of an S-N-T system, the following formulation is used in this paper. S-N-T system - a separate territory, allocated according to administrative, geographical, economic and other characteristics, consisting of many heterogeneous elements, the dynamics of which can be determined by a system of hierarchically organized indicators that describe the normal and extreme states of the elements and are used to assess risks. On the basis of risk assessment, preventive measures are implemented to ensure the safety of the S-N-T system, and the compliance of risk values with acceptable levels is a necessary condition for the sustainable development of the S-N-T system.

From this follow the tasks of collecting and processing complex monitoring data and their application in managing the security of complex systems. For an objective assessment of territorial data, it is necessary to integrate a large amount of multi-format interdisciplinary data, most of which has signs of subjectivity. This applies to expert assessments used to bring heterogeneous data to a single measurement scale, estimates of the scale and damage from emergency situations

(ES) and other dangerous events [4]. Even data on losses are subjective, since there are no uniform criteria for classifying people as injured and dead in emergencies, and the accounting criteria change periodically. Establishing and continuing to use data collection and processing standards enhances the credibility of risk assessments, which is critical to preventive action decisions.

From the point of view of a systematic approach, the digitalization of the sphere of ensuring the security of territories, information support for management is a closed cycle. Its main elements - the collection of data on the state and characteristics of S-N-T systems, the calculation of risks, the justification and control of risk management measures, the assessment of the effect - are logically linked using analytical and situational models. In practice, most of the work is limited to the collection of fragmentary monitoring data with subsequent calculation and visualization of territorial risks [5]. The resulting risk cartograms illustrating the isotropic distribution of hazards within administrative boundaries are far from reality.

The predominance of subjective factors in the management of emergency situations, the implementation of measures to improve the safety of the population and territories in comparison with the amount of funds spent does not give the expected effect. Reasons for this situation:

− limited availability of integrated monitoring data, the impossibility of reproducing risk calculations by independent groups of researchers;

− the general nature of recommendations on the composition and scope of preventive measures, formed based on the results of risk calculations and not taking into account the specifics of S-N-T systems;

− lack of indicators for assessing the impact on safety of the implemented preventive measures;

− lack of scientific substantiation of management processes, the absence of generally accepted models for forecasting the security of territories for a long-term period, which allow more systematic planning of strategic activities [6].

The paper presents approaches to solving these problems.

II. Problems of using monitoring data to support the management of the territory’s safety

The course towards digitalization of management, which is being implemented at the federal and regional levels, has significantly changed the practice of developing and operating software systems for processing monitoring data to support management. Centralization of all developments in several systems (Risk Atlas of the Ministry of Emergency Situations of Russia, Hardware and Software Complex "Safe City", etc.) reduced the possibility of integrating third-party services. Changes in legislation require obtaining the status of state for information systems of territorial administration. This is a serious obstacle to the introduction of the developments of the institutes of the Russian Academy of Sciences into the practice of managing the safety of S-N-T systems. The results of risk assessment presented in the form of geoportals, scientific publications are “taken into account”, which has little effect on the effectiveness of risk mitigation measures. At the same time, the functionality of state information systems is aimed at collecting a large amount of information, developing dynamic visualization tools without linking with the needs of the subject area.

There is a need to integrate information resources into the federal data and knowledge repository. This will allow:

− to develop independent services for deep processing of monitoring data;

− verify prognostic models of territorial security dynamics;

− reproduce risk assessments by independent research teams;

− replicate the best management practices, taking into account the peculiarities of S-N-T systems.

The structure and functionality of the data and knowledge storage are described in different detail: the conceptual level is a system model, then the levels of architecture, functional diagrams explaining it, describing the processes of collecting, exchanging, storing and transforming information resources into management decisions.

III. System model of management information support

A systematic consideration of the tasks of information support for the management of territories is a multi-stage process of identifying elements of a complex system, followed by their detailing of elements and a description of logical connections. In this case, different design methods, rules and restrictions are used.

To describe the business processes of preparing management decisions, the information resources associated with them, the functions and technologies for their transformation, a model was developed to support the management of natural and technogenic safety [7]. Syntactically, the management information support model is represented by a tuple:

$$M = \langle T, L, R, IT, F, Y \rangle \quad (1)$$

where T – control tasks; L is the set of decision makers taking into account their interaction and powers; R - information resources; F – information processing functions; IT – information technologies; Y - representations of the results of the systems and services.

Three key management tasks $T = \{t_1, t_2, t_3\}$ have been identified: t_1 - identifying and responding to situations that require management actions (everyday management); t_2 - response to emergency situations of a critical and dangerous nature (operational management); t_3 - response to assessments of the state of territories (strategic management). From the L elements, a situational control graph is built, most of the vertices of which are decision makers with certain powers, responsibilities, and available resources. Data $R = O_1 \cup O_2 \cup O_3 \cup E \cup Des$, where O_1 is a set of factors for the implementation of events E; O_2 - protected objects that change their characteristics and functioning as a result of management actions; O_3 - forces and means necessary for the implementation of management decisions; Des is a formalized description of solutions.

The set of functions F of control support systems: $F = \{f_1, f_2, f_3\}$, where f_1 is the collection, updating and provision of access to data; f_2 - computational and analytical modeling of the current situations and their dynamics modeling; f_3 - synthesis of solutions. A variety of tasks of information support for management T leads to the need to use various information technologies, the number of which, due to the rapid development, is difficult to determine. Focusing on the functions F, we can group them by $IT = \{it1, it2, it3\}$, where it1 are data acquisition and storage technologies; it_2 - data analysis technologies, it_3 – intellectual technologies. Semantically, information support Y is the result of solving problems T using information resources R and information technologies IT that implement functions F. The implementations of functions f_{ij} for control problems t_i are presented in Table 1.

Information representations of the results of the systems Y include texts, tables; maps and graphics. Their detail depends on T and L. Common The BI-platform contains dozens of tools for displaying analysis results [8]. Ready-made solutions can be represented as a set of logically connected tuples:

$$Desi = \langle ID, Place, Period, O_3, Action \rangle, \quad (2)$$

where *Action* is an event from the list of possible ones; *Place* - venue; *Period* – work schedule, O_3, - control objects - actors; *ID* - identifier of the solution fragment for positioning it in the general process of actions performed sequentially or in parallel. This simplified form is used to record most of the decisions of the territorial commissions for emergency situations and fire safety.

Table 1: *Transformation of functions depending on management goals*

T / *F*	Identification of hazards t_1	Prompt response t_2	Strategic planning t_3
Data collection and updating f_1	f_{11} – getting monitoring data	f_{12} – input of initial data for modeling	f_{13} – obtaining additional data for safety assessment and management
Modeling f_2	f_{21} – monitoring the output of parameters beyond the standard values forecasting	f_{22} – assessing the dynamics and consequences of events	f_{23} – assessment of the security status of territories
Synthesis of solutions f_3	f_{31} – formation of solutions for the transfer to high availability modes	f_{32} – formation of recommendations for taking emergency measures	f_{33} – formation of recommendations for conducting long-term activities

Modernization of the record of decisions should be carried out taking into account the balance: on the one hand, this will allow taking into account the peculiarities of management in difficult situations, on the other hand, the complication of the forms of collection is accompanied by an increase in erroneous and unreliable information.

IV. Directions for improving the monitoring of the territory's safety

Fundamentally, the processes for solving territorial management problems have not changed since the pre-computer era. The key factor in operational decision-making is the speed of information transfer and processing, and the key factor in strategic management is the volume and quality of data. The purpose of integrated monitoring is to integrate different systems for observing the state of the environment, monitoring the functioning of technosphere objects, collecting data on events that have occurred, updating the characteristics of objects and infrastructure of territories, followed by the transformation of data into elements of management decisions. The specificity of the subject area implies the presence of a large number of hard-to-measure and probabilistic factors, the mutual influence of which can only be assessed by experts. The expansion of the scope of neural networks for test generation makes it relevant to create training samples of real solutions to various control problems [9].

The requirements for the composition of primary data and the content of the results of their processing are shown in Table 2.

They reflect the composition of the elements of the set *R*. In this form, the requirements for integrated monitoring data are presented for the first time. For example, the use of only event registers (clause 8) for assessing territorial risks does not remove the uncertainty of decision-making, and the joint analysis of E, O_2, O_3 makes it possible to form constructive recommendations for t_3.

Obtaining data on the characteristics of protected O_2 objects, collected in the form of safety data sheets for territories, is possible only through intersystem exchange. Currently, the enormous costs of duty shift operators for updating information do not increase its reliability. Decision makers under time pressure are forced to double-check the data on the consequences of the emergency situation and the forecast of the situation from alternative sources

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Table 2: *Distribution of types of integrated monitoring data depending on management tasks*

№	Primary data	Content of processing results	Task
1	Sensor readings	Assessment of the probability of manifestation of hazard factors O_1	t_3
2	Characteristics of protected objects O_2	Assessment of the consequences of the situation, justification of the scope of protection measures	t_2
3		Integral vulnerability indicator	t_3
4	Characteristics of management objects O_3	Assessment of resource costs for emergency response and protection measures	t_2
5		Integral security indicator [3]	t_3
6	Event Registry	Emergency response solutions	t_2
7		The values of dangerous factors-triggers for the implementation of situations	t_3
8	Register of preventive measures carried out	Solutions for strategic security management of S-N-T systems	t_3
9	Expert assessments	Bringing different indicators to a single scale for an integrated assessment of territorial risks	t_3

The use of the federal register of preventive measures (clause 8) in solving task t_3 will make it possible to replicate positive risk management practices. The availability of expert assessments (clause 9) will give impetus to the development of research on their refinement and replacement with multi-criteria analysis of big data. The priority of solving problem t_1 is early warning about threats and dangers [9]. Despite the large number of publications in the field of disaster forecasting, the practice of their application is limited to local models of the dynamics of a specific hazard indicator for a short period. The creation of federal cloud services should provide, in addition to organizing interdepartmental information exchange, the integration of methods for processing monitoring data.

Structural schemes for presenting complex monitoring data are described in detail in [10]. Standardization of data collection and storage processes will help to avoid wrong decisions when creating a single information space for ensuring territorial security. The process of developing services to support the management and interaction of researchers and structures that ensure the security of S-N-T systems is shown in Fig.1.

V. Conclusion

Assessing and managing the risks of S-N-T systems are among the complex unprecedented problems, the concentration of knowledge, the need to assimilate diverse information for decision-making. The practice of creating large systems developed for a long time does not work in modern conditions. Adaptive, easily customizable applications focused on the accumulation and reuse of intellectual capital are needed.

Approaches to system design, reformatting of complex monitoring, introduction of compact representations of objects and processes are essential elements of information support for management and interaction tasks. The rapid introduction of technologies into practice is hampered by administrative barriers, a weak interconnection between the digitalization of management and training of specialists. Methods for deep formalization of data, tools for accessing information resources with multi-stage control of their relevance and reliability were tested in pilot projects.

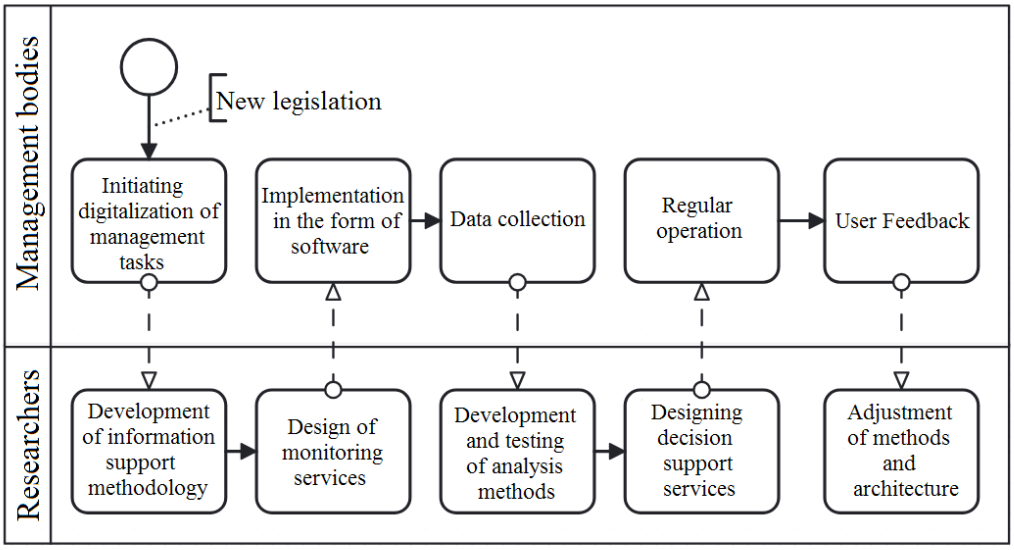

Fig. 1: *A fragment of the life cycle of information management monitoring systems*

The transformation of the monitoring system requires additional resources to collect and process new data. The release of time for the collection of constructive information at the local level of government is possible due to the systematization of business models of information support for the activities of emergency services. When organizing operational work, one should follow the rule: if the incoming information is not used directly for decision-making, then it is stored in a formalized form that allows one to extract knowledge, or it is ignored. The harmonious use of departmental control systems in combination with common information resources will minimize management errors in complex situations caused by the human factor.

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