A model for describing the administration and processing system of information generated when responding to incidents by fire departments

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Abstract. Firefighting units are a specific object of management that performs its functions in response in conditions of limited time and intensive flow of information. In these conditions, the requirements to reliability and completeness of the received information increase. Excessive flow of information characteristic at extreme information creates conditions of information overload and negatively affects the adoption of management decisions. The choice of optimum quantity and type of information in the system of management of fire protection units in conditions of limited time is the key condition of successful actions first on rescue of people and mitigation of risks in the broad sense. In the article, the formalization of information flows arising in the process of reaction by fire protection units is carried out. In grapho-analytical form the emerging information flow in the response management system is presented as an interrelation and interdependence of elements forming the volume of information and carrying out the processing (use) of information for the purposes of effective response to incidents. The ontology of the emerging information flow in the response process is presented.

1 Introduction

Development of new approaches in control systems is due not only to the emergence of new types and classes of external influences, methods of information processing and analyzing, but also to new approaches to the formation of control system structures for various systems. In a broad sense, an administration system is a set of management methods, procedures, tools and organizational mechanisms that are used to achieve certain goals within an organization or enterprise. The main theoretical and methodological basis of administration as an applied scientific section consists of the provisions of cybernetics and information theory.

Today, the most important factor in the stabilization and further effective development of organizational systems is the development and implementation of new administration

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systems at all levels. Socio-economic relations rethinking in the context of a new paradigm of a dynamically changing society makes it possible to reveal the enormous potential opportunities for national development and ensure the security of society and the sovereignty of the state.

One of the fundamental elements of society sustainable development is to ensure prevention and help to the population in emergency situations.

2 Theoretical analysis

Classification of possible potential sources of risk, incidents and emergencies by nature, scale of consequences, number of forces and means involved in the Russian Federation is determined by a wide range of both federal regulations and regulations of the Russian Ministry of Emergency Situations. For convenience in this study we will combine all operational events, incidents, fires and possible emergencies with a general term - incident

Based on the goals of the state system for the prevention and liquidation of emergency situations, the functioning of the system can be conditionally divided into two main subsystems operating in different modes: the alert subsystem and the emergency liquidation (response) subsystem. The alert subsystem operates on a daily basis in the absence of incidents and critical time constraints and includes, among other, planned activities that ensure readiness to respond. The response subsystem functions when an incident occurs, i.e., the implementation of an initiating event leading to the development of the situation into a full-fledged accident, incident, emergency and is characterized by emerging time constraints and an increasing flow of information. In various studies [1-3] this feature of the considered system is repeatedly noted.

In general terms, the functioning of the emergency prevention and response system can be represented as the formation by one of the subsystems of conditional proactive barriers that prevent the influence of various sources of risk on the formation of an incident in everyday activities and the formation by another subsystem of active barriers leveling the negative impact of the incident on the main spheres of the population life (Figure 1).

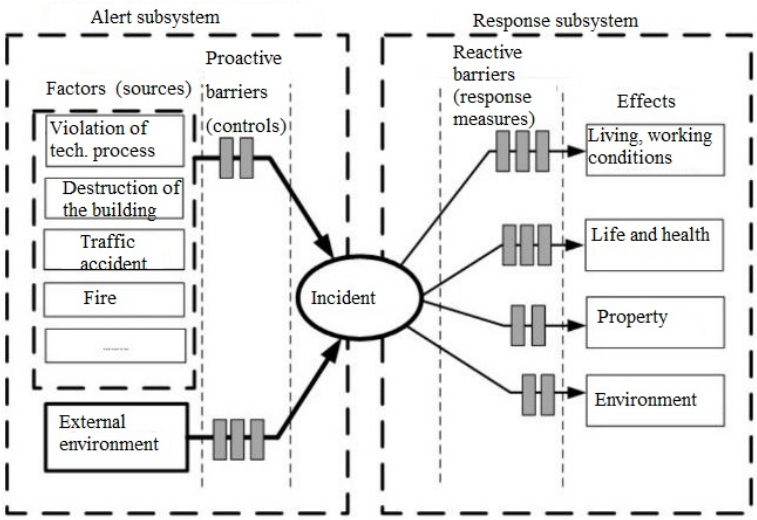

Fig. 1. Operation of the emergency alert and response system.

Active barriers that level out the negative impact of an incident are formed using forces and means specifically designed to respond to incidents. The Decree of the Government of the Russian Federation [4] refers to the forces and means of a unified state system for the prevention and liquidation of emergency situations that, within its competence, protect the population and territories from emergencies of a natural and man-made nature, including extinguishing fires (including forest fires) the forces and means of eliminating emergency situations as part of fire department.

Provisions of the fundamental Federal laws of the Russian Federation [5,6] and the analysis of the regulatory framework of the emergency prevention and response system, as an important element of national security [7-9], allow us to conclude that fire departments are not only legally are the main forces ensuring the protection of people from man-made emergencies, incl. fires, but in fact, in the vast majority of cases, they are the first to arrive and participate in rescuing people and eliminating the consequences of various accidents and incidents, while solving a wide range of non-specific operational tasks.

3 Methods

The fire department is a specific management object whose main task is to directly respond to emerging incidents. The choice of tactics to threats respond caused by an incident is aimed primarily at creating barriers to leveling impacts on the following main objects, defined by regulations [5]: Living and activity conditions; Life and health; Property; Environment (Figure 2).

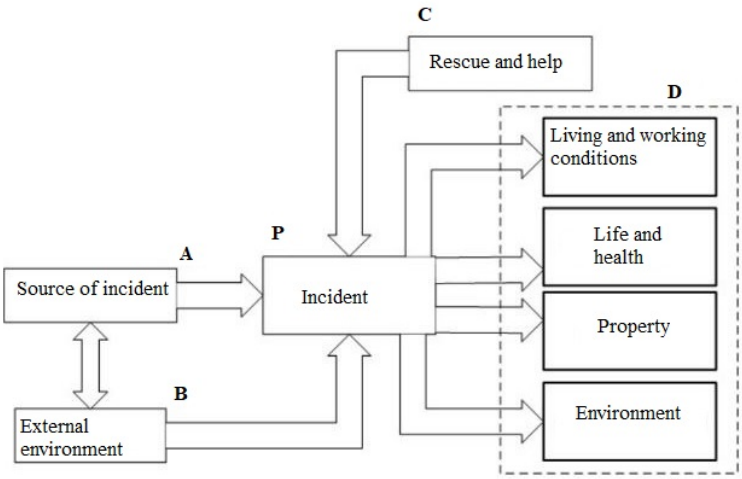

Fig. 2. Formation of active barriers when responding to incidents.

For the successful implementation of measures to protect the territory and population it is necessary to form active barriers corresponding to the magnitude of the impact on the incident, which in turn is formed by the corresponding source of risk and (or) the external environment, i.e. satisfy the relation (1):

$$P = (A, B) \leq C, \quad (1)$$

where, P - characteristics of the occurred incident; A - characteristics of the incident-indicating event; B - characteristics of the external environment; C - characterization of impacts that neutralize the impact of the incident.

Information about the characteristics of the incident is the basis for decision-making for determining the required amount of forces and means, planning the tactics of their actions in

order to neutralize the impact of the incident on the human environment. In this interpretation of the system, the concept of information becomes a key element in the implementation of measures to form active barriers and reduce the possible negative consequences of emerging incidents.

In the context of responding to emergencies and incidents by fire departments, the formation of an information flow that influences the choice of alternatives when making decisions on the magnitude of impacts (C) that neutralize the impact of the incident is determined by the type and characteristic features of the initiated dangerous situation, i.e. value: P(A, B).

Conceptualization of information resources for solving the problem of ensuring the population and territory safety from various emergency situations using various models is found in [10-12], in work [13] an example of general constructing of an ontology of information resources for solving management problems in protecting territories from flooding is given. It should be noted that despite the fact that the presented model undoubtedly makes it possible to implement situational and analytical modeling on its basis for management tasks when protecting territories from flooding, in our opinion, the generalizations adopted in the model do not take into account the specifics of the activities of fire departments and those information flows arising as a result of this activities.

4 Results

In graphic-analytical form, the emerging information flow in the incident response administration system of fire departments can be represented as the interrelation and interdependence of elements that form the volume of information and process (use) of information obtained for the purposes of effective response to incidents (Figure 3).

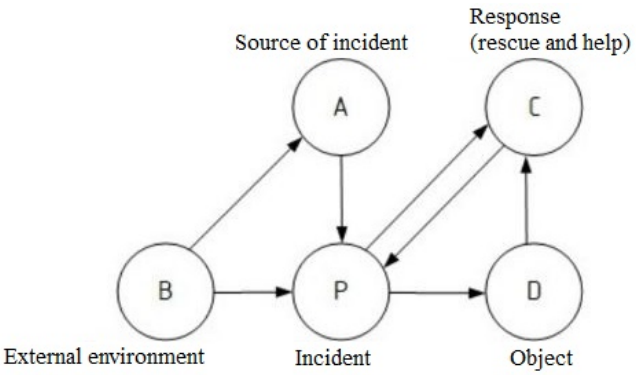

Fig. 3. Information flow in the incident response administration system.

The construction of an ontological model of the studied area is the result of the analysis. As a rule, an ontological model is understood as a representation of information about any area of reality formalized in a certain concept in accordance with the methodology [14].

Let us imagine the ontology of the information flow that arises in the process of response (Figure 3) as follows:

$$I = <P\ (A, B),\ C,\ D>, \quad (2)$$

where, A - set of information about the source of the man-made risk initiating the occurrence of the incident;

B - set of information about normal natural and climatic conditions and (or) a dangerous natural phenomenon or process in the area of the incident;

C - structure determined by a set of information about the forces and means responding to the incident and forming active barriers that level the impact of the incident on the environment;

D - set of information about the characteristics of the object at which the incident occurred that influences the scale and dynamics of the situation;

P - a set of information obtained by comparing data on normal natural and climatic conditions and (or) a dangerous natural phenomenon or process in the area of the incident (B) and a set of data on the source of man-made risk initiating the occurrence of the incident (A).

In this representation, the initiating events that form the initial (zero) information flow are elements A and B, and the relationship: B→P - at the initial initiating event assigned to element (B), it forms the characteristics of an incident interpreted as a natural incident. The relation A→P - with the initial initiating event assigned to element (A) forms the characteristics of the incident, interpreted as a man-made incident. The relation B→A - with the initial initiating event assigned to element (B) forms the characteristics of the incident, interpreted as an incident of a natural-technogenic nature, i.e. the emergence of man-made risks (formation of element A) initiated by a dangerous natural phenomenon or process.

Thus, the ontology of initial (zero) information, the total value of which makes it possible to classify an event as a significant incident requiring a response, can be described by a tuple:

$$P = <A, B>, \quad (3)$$

Activation of element (P) i.e. obtaining sufficient information to interpret an event as an incident requiring a response generates P→C relationships that form a management decision and information about sending the initial amount of necessary forces and means to the incident zone, general operational information about the incident and related threats. The C→P relationship is a feedback generated by information about changes in the characteristics of the incident after the impact of the involved forces and means on it (installation of active barriers).

The P→D relationship forms general information about the degree of negative factors impact of the incident, taking into account features and characteristics of the object on which it occurred or affects. Here, the concept of an object should be understood not only as a capital construction object, but also as any building, structure, technical facility or territory, the impact of which by the negative factors of an incident leads to a threat to life and health and a significant disruption of people's vital activity. It should be noted that, in turn, the D→C ratio generates information not just about the degree of impact, but about the state of the object affected by the incident at a specific point in time, the dynamics of the incident, taking into account features and characteristics of the object, the presence of a threat to human life and health, and material values , living and activity conditions, environment.

An intense information flow for operational purposes occurs from the moment an incident is reported to the day-to-day management body and increases exponentially until the incident is eliminated. When an incident is reported to the day-to-day management body (garrison dispatcher, dispatcher of the unified duty dispatch service of municipalities), the information is immediately transmitted to the fire department dispatcher to direct forces and means to the fire scene, provided in advance for planning documents (schedule of departure of forces and means, plans for attracting forces and resources, action plans for preventing and eliminating emergency situations). At this stage, on the basis of the primary information received (i.e., on the basis of the emerging information relationship P→C), the first management decision on the direction of forces and means to the location of the incident is made.

The moment of receiving the message is the initiating event of the implementation of a specific fundamental event, determined by the normatively established [15] event of the general algorithm: Reconnaissance. Reconnaissance in the activities of fire departments should be understood as a set of measures for the collection and further transmission to

control bodies and forces of objective data (information) about the incident, available forces and means, objects and the environment in the incident zone.

5 Conclusion

In the conditions available for making decisions when responding to incidents, time constraints increase the requirements for the reliability and relevance of information. Each piece of information must serve certain goals and objectives of management. Excessive information flow creates conditions of information overload and negatively affects management decision-making. The selection of the optimal amount and type of information in the management system of fire departments in the limited time conditions is a key condition for successful actions, primarily to save people and mitigate risks in a broad sense.

The formalization of the information flow that occurs when responding to incidents by fire departments, carried out in the presented model for describing the management and information processing system, allows us to structure the information interaction between elements that arise in the process of eliminating the incident. Unlike well-known models, the above classification of flows by response levels and normatively defined stages of incident response takes into account the hierarchy of the system and makes it possible to provide information support for making management decisions, taking into account the specifics of responding to an incident at the initial stage.

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