

Digital Economy as a Leading Factor for Ensuring Complex Safety of an Object

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Abstract The article considers the problem of automated management of complex safety systems for organizations and industrial facilities which integrated management systems for production, industrial, fire, and environmental safety and security in emergency situations. It is shown that the problems of digitalization of safety management systems at various levels can be realized through the concept of "smart city". One of the most important components of the "smart city" project is the competent integration of engineering and software complexes of safety systems of existing organizations and industrial enterprises into their infrastructure. The article presents recommendations for the design of a specialized hardware and software complex that aims to digitalize the control systems for complex safety of these objects.

Keywords: *digital economy, leading factors, complex safety, automated management*

1 Introduction

The problem of ensuring complex safety is one of the most important issues in the activities of large organizations and industrial companies, which is connected both with the need to create safe conditions for their activities, and with the regularly increasing requirements of standards and regulatory authorities at the state and international levels. In order to speed up information processing and improve the system of doing business in this area, many companies have switched to automated management of these processes, which makes it urgent to solve the problem of developing such automated management systems within the global process of digitalization of the economy.

The purpose of our paper is to develop recommendations for improving the efficiency of digitalization of control systems for complex safety of organizations and industrial facilities by designing a specialized hardware and software complex.

This goal can be achieved by solving the following tasks: i) to study modern information and analytical methods and methods for implementing complex safety management systems for organizations and industrial facilities; ii) to study the Russian and international scientific and legal experience of digitalization of certain areas of the economy; and iii) to develop recommendations for improving the efficiency of complex safety management systems for organizations and industrial facilities by designing a specialized hardware and software complex.

2 Literature review

Currently, Russia has a number of economic development strategies approved by the government of the Russian Federation and aimed at increasing the level of digitalization of the economy and the development of high-tech industries (Government of the Russian Federation 2019). In addition, in recent years, national programs for the transition to the digital economy have been adopted by such countries as Egypt (Social Responsibility Strategy in ICT Sector 2014), Israel (The National Digital Program of the Government of Israel 2017), the UAE (Federal Cabinet approves UAE ICT Strategy 2014), Finland (Service Economy Revolution and Digitalization. Finland's Growth Potential 2015), Germany, South Africa and others (Korovkin 2019; Nevskaya 2019; Teoh and

Mahmood 2017; Al-Khoury 2012; Shafqat and Masood 2016; Bukh and Heeks 2017; Luijff et al. 2013). As a rule, most programs highlight the following areas of development of the digital economy:

- legal regulation;
- formation of personnel;
- formation of research competencies, centres and technological reserves;
- development of information infrastructure and improvement of information safety;
- improvement of public administration mechanisms.

On the other hand, it is worth noting the importance of such aspects of state development as improving the level of fire, industrial, transport, environmental safety and safety in emergency situations. These areas of safety must be integrated as much as possible into the common information and economic space of each state.

In a number of countries, including Russia, the problems of digitalization of municipal and regional safety management systems at various levels are implemented through the concept of "smart cities" (Kupriyanovsky et al. 2016; The ISO/TMB Smart Cities Strategic Advisory Group (S_Cities SAG) 2014; ISO 37120:2014). As a rule, the concept of "smart cities" is aimed at improving the competitiveness of cities and regions, forming an effective system of urban management, creating safe and comfortable conditions for the population (The ISO/TMB Smart Cities Strategic Advisory Group (S_Cities SAG) 2014; Minstroy 2018).

The main tool for implementing the concept is the widespread introduction of advanced digital and engineering solutions in urban and municipal infrastructure. In international practice, the effectiveness of smart cities projects is coordinated by two specially created ISO subcommittees with the participation of the following international and national standardization institutions: IEC, ITU, IEEE, IEFT, CEN, CENELEC, ETSI, NIST, BSI, DIN (Kupriyanovsky et al. 2016).

One of the most important components of any smart cities project is the competent integration of engineering and software systems for safety systems of existing organizations and industrial enterprises into their infrastructure. Such integrated safety systems are one of the most important parts of the management structure of any object and should also cover production, industrial, fire, and environmental safety systems in a single hardware and software package. At the same time, the analysis of scientific papers shows that the use of formal methods in the practical development of software for automation of safety systems is rare. One of the reasons is the difficulties that arise in connection with the formalization of safety requirements in the field of logic (Bitsch 2001; Musaev and Sherstuk 2002).

However, many problems of complex safety management systems can be solved using automated systems that use flexible management strategies. In turn, flexible management strategies can be used by an expert management system (a program that replaces an expert in a area). These expert systems are intended mainly for solving practical problems that arise in a poorly structured and difficult to formalize subject area (Solod and Zagnitko 2013).

In addition to the above, the analysis of scientific and regulatory legal sources (Solod and Zagnitko 2013; Musaev and Sherstuk 2002 etc.) has shown that most researchers in the design of safety systems usually consider only one of the aspects of ensuring the safety of an organization or industrial object: it is either industrial, or environmental, or fire safety, or safety in an emergency.

Thus, it is worth noting the importance and prospects of further work to ensure digitalization and aggregation into a single complex of complex safety management systems for organizations and industrial enterprises.

3. Methodology

In order to develop recommendations for improving the efficiency of digitalization of complex safety management systems by designing a specialized hardware and software complex, a content analysis of the relevant legal acts and scientific papers was carried out. The study also used a systematic approach, in which the examined complex safety management system is considered as a set of interrelated subsystems of production, industrial, fire, environmental and emergency safety management.

In accordance with the existing recommendations (MCHS 2016), the hardware and software complex (HSC) should be a set of existing and promising automation tools in all areas of safety at any level of object management. At the same time, all interacting automated control and monitoring systems should be combined to create a single information space for complex control system for safety (Fig. 1).



Fig. 1. Model of a complex control system for safety of an object
Source: Own results

The recommended structure of the HSC, depending on the functional features of the protected object, consists of the following blocks:

- 1) A set of automation tools of the functional block "Coordination of services and departments" as part of the operational centre of the hardware and software complex.
- 2) A set of automated functional unit "Safety of infrastructure" including protection from fires and emergency situations of natural and technogenic character, the safety engineering and communal infrastructure of the facility, monitoring of fires and emergencies, the system of informing and alerting the staff.
- 3) A set of automation tools for the "Industrial safety" functional block, including monitoring systems for hazardous production facilities, analysis and risk management systems for accidents and incidents at hazardous production facilities.
- 4) A set of automation tools for the functional block "Industrial safety and labour protection" as part of the system for monitoring the state of the microclimate and dangerous and harmful production factors in the workplace.
- 5) A set of automation tools for the "Environmental safety" functional block as part of the environmental monitoring system and the environmental risk management system.
- 6) A set of automation tools for systems of the functional block "Coordination of work of services and departments of the object".

When creating a complex of automation tools (CAT) of the functional structures of the HSC, centralized, decentralized and hybrid schemes can be used on the object. The choice of the scheme for creating HSC and the corresponding CAT architecture is determined by the combination of socio-economic and geographical characteristics, as well as the characteristics of the information and telecommunications infrastructure of municipalities (region) of the location of the enterprise or organization.

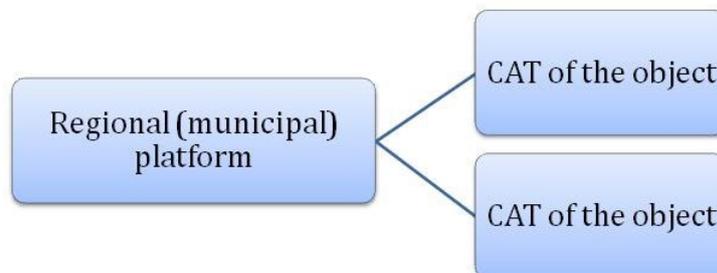


Fig. 2. Centralized scheme of HSC organization
Source: Own results

A centralized scheme for creating an HSC involves the concentration of software, management systems, and information base on a single logical platform with the possible distribution of computing power on a cloud basis (Fig.2).

The decentralized scheme for creating HSC involves an autonomous placement of computing power, management processes and information exchange for each object autonomously with aggregation of information on the basis of a regional or municipal platform (Fig. 3).

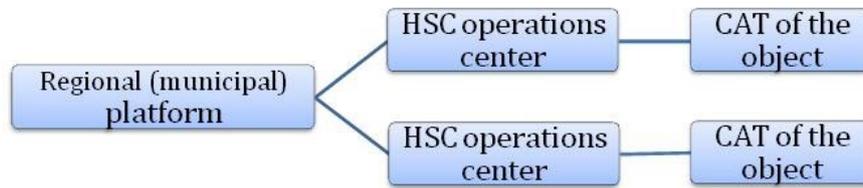


Fig. 3. Decentralized scheme of HSC organization
Source: Own results

The hybrid scheme for creating HSC is based on a combination of centralized and decentralized architectures (Fig. 4).

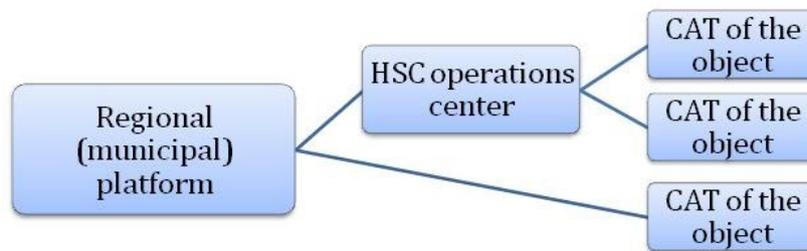


Fig. 4. Hybrid scheme of the HSC organization
Source: Own results

The general scheme of the HSC implementation is determined by the selected CAT implementation scheme and forms a general scheme of inter-system interaction. In this case, the components of other functional blocks can be implemented using different schemes (decentralized, centralized or hybrid).

When implementing the system elements of the functional block "Safety of infrastructure", it is recommended to ensure the development and modernization of smart video surveillance subsystems, fire protection subsystems and emergency situations of natural and man-made character, subsystems for ensuring the safety of the infrastructure of the engineering and utility complex of the object.

It is recommended to include development of subsystems of functional blocks "Industrial safety", "Industrial safety and labour protection", "Environmental safety", "Coordination of work of services and departments of the object" in the subsequent stages of implementation of the object's HSC systems.

It is also worth noting that it is advisable to implement the key blocks of the object's HSC on the basis of a single duty and dispatch service (SDDS) in a city or municipal (regional) entity. The practical implementation of this task is provided by:

- organization of effective work of the SDDS as a body of the situation-analytical center, with which all city and emergency services interact, as well as duty-dispatching services of other objects located on the territory of the municipality;
- computerization of the processes of functioning of SDDS, city and emergency services, as well as automation of the exchange of operational information with them and with all organizations and industrial enterprises located on the territory of specific municipal and urban entities.

4. Results and discussion

Implementation of the HSC of the complex control system for safety within the framework of the "smart city" concept should ensure:

- timely giving of the most complete, reliable and up-to-date information about the threat of emergency situations to the city or municipal administration;
- prompt preparation by duty and dispatch services of reasonable and agreed proposals for making management decisions on the prevention and elimination of accidents, incidents and emergencies and bringing them to the appropriate performers;
- inclusion of the administration of the protected object in a single information space at the municipal or regional level, their effective involvement in the processes of preparation and decision-making for the prevention and elimination of accidents, incidents and emergencies;
- improving the quality of decisions and plans made by using analytical and quantitative methods to evaluate them, as well as choosing the best option;
- ordering information flows, increasing the reliability and completeness of the data used on the basis of their regular updating according to approved regulations;
- improving the efficiency of management processes for the prevention and elimination of accidents, incidents and emergencies, reducing the total time for searching, processing, transmitting and issuing information;
- ensuring organizational and methodological, information and software-computing compatibility of the object's HSC.

The plan for the creation, implementation and development of the proposed HSC should include both the relevant planned activities of the object level, and all activities from the developed plans of regional (municipal) entities. Such a plan is necessarily formed in the context of creating and implementing the hardware and software complex in the management system of complex safety of the object.

5. Conclusions

Quite a large number of studies show that most of the private safety problems should be solved in cooperation. This implies the presence of a specialized mathematical apparatus and qualitatively new information storage systems aimed at solving large-scale analytical problems. All this leads to the relevance of the transition of information technologies to a qualitatively new class - analytical. Analytical technologies include a subclass of information technologies focused on automated decision support and predicting the state of complex dynamic systems in non-stationary and heterogeneous environments (Musaev and Sherstuk 2002).

In recent years, the most common tool for analysing and predicting the development of complex situations in safety systems has been expert analysis. Most of the well-known situation analysis centres used the same methodology: information is collected, visualized, and presented to a group of experts. However, in complex, non-stationary situations caused by a large number of various factors, experts do not always find rational solutions, their opinions are subjective and contradictory. Thus, there is a highly relevant problem of developing a qualitatively new automated decision support system (DSS), focused on solving the problems of strategic economic analysis and forecasting the development of the situation in the interests of ensuring comprehensive safety of objects and based on modern analytical technologies.

To solve this problem, it is proposed to use the Data Mining (DM) methodology as the basic platform of the HSC project. The essence of DM is automated analysis and forecasting of situations based on the analysis of ultra-large volumes of retrospective and operational information concentrated in information stores (Musaev and Sherstuk 2002).

In the end, as scientific and practical experience shows (PD IEC/PAS 62953:2015; PD IEC/PAS 62948:2017 etc.), any information system for managing complex safety must provide:

1. formalization and automation of accounting processes, collection, preparation and transmission of reporting data with a planned reduction in time for processing the received information;
2. increasing the level of accident-free and safety of the production (working) cycle, as well as improving the efficiency of production, industrial, environmental, economic and information safety systems;
3. monitoring the occurrence and reoccurrence of negative (emergency) events and analysing the their causes;
4. improving the quality of control and accounting of processed information;
5. automatic calculation of indicators and providing an objective picture of the state of all safety systems in real time.

Summing up the analysis, it should be noted that the purpose of creating a new technological basis for the development of the economy and social sphere based on the widespread use of information and digital technologies is to improve the quality of life of the population and the production efficiency. At the same time, one of the stages of creating such a technological basis in Russia can be the implementation of the concept of

"smart cities", whose projects should take into account the competent integration of safety systems of various organizations and industrial enterprises into their infrastructure by introducing a specialized hardware and software complex. For the further development of this direction, it is necessary to analyse and design all the software and hardware of the complex, as well as its functional blocks.

For a successful functioning of the HSC of the complex control system for safety of any facility they must develop, implement and periodically review the monitoring procedures, measuring and evaluating the effectiveness of safety. To do this, functional responsibilities and powers must be distributed at different levels of the object management structure.

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