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METHOD FOR TECHNICAL AND ECONOMIC ASSESSMENT OF ALTERNATIVE INTEGRATED SECURITY SYSTEM DESIGN CONSIDERATIONS FOR A POTENTIALLY HAZARDOUS FACILITY

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Abstract: The article presents a method for technical and economic assessment of security management system efficiency at a potentially hazardous facility by way of selecting a reasonable option for an integrated security system design.The subject matter of the method lies in the fact that using input data that include technical characteristics and cost indicators of protection equipment, possibility of solving the corresponding protection tasks with the help of each engineered safeguard system, weight coefficients of protection task importance, we shall first select a particular type of a system for each individual task and then define the quantity and composition of the engineered safeguard systems to be used within an integrated protection system.The method for technical and economic assessment of the ISS design considerations allows rating alternative choices for the ISS construction according to their efficiency coefficient and selecting the most preferable option for a particular asset to be protected.
Keywords: integrated security system, potentially hazardous facility, method, technical and economic assessment, threats, asset to be protected, efficiency, algorithm, system design, engineered safeguard systems, emergency situation, protection level.

Introduction

Recently we have been able to observe the tendency towards an increase in the number and scale of the consequences of emergency situations (ES), both natural and man-caused, all over the world, including highly explosive, radiation, chemical, biological and other hazardous facilities. The sources of emergency events are dangerous natural phenomena, natural risks arising in the process of business activities, terrorist acts, as well as large technogenic accidents and catastrophes.

The difficulty in solving the problem of ensuring security at these facilities lies in its complexity as it requires consideration in terms of different aspects taken as a whole, such as socioeconomic, organizational, technical, managerial, informational, personnel, psychological, etc. The development and implementation of multistage integrated security systems at critical and potentially hazardous facilities in everyday activities is one of the most important scientific problems in the event of an ES threat or occurrence.

The Integrated Security System (ISS) for potentially hazardous facilities shall be considered as a complicated dynamic mechanism. The methodology for system investigations of complicated dynamic mechanisms and management in the event of ES threats and occurrence is characterized by an ambiguity specific for each ES and requires immediate decision making with regard to the type of facility and regional aspects.

The efficiency of using such systems is essentially determined by the possibility of dynamic change in their structure and management strategy, which is a function of time and depends on the qualification of people making decisions and is based on one of the possible alternative design considerations, the selection of which has to be made amidst existing limits of system resources, as well as technical capabilities of the structural components, i.e. individual elements and subsystems.

Developing management solutions to ensure a comprehensive approach towards providing safe functioning of an asset to be protected is an issue of systematic nature and therefore, it is reasonable to use systematic analysis and synthesis methods for its solution.

Task Definition. Objectively, there exists a range of threat sources for a potentially hazardous facility $m \in \{1,M\}$, which are characterized by a vector of parameters. The following of them are relevant for this task:

- time-space characteristics of threat sources;
- degree of threat possibility for each security element as the function of time-space characteristics of a threat or its carrier and relevant parameters of the asset to be protected.

The existing threats have a combined integral impact on the asset to be protected.

The analysis of every possible threat to the asset to be protected makes it possible to create a range of tasks $z \in \{1,Z\}$, the solution of which ensures safety of the asset to be protected.

There is a range of engineered safeguard systems $n \in \{1,N\}$ that are used for constructing the ISS for the asset to be protected, which are characterized by a vector of parameters. The following of them are relevant for this task:

- the efficiency of solving each z-security task by each n-engineered safeguard system – $P_{z,n}$;
- the cost of n system (including in relation to its operating cycle) – C_n, $n \in \{1,N\}$.

The task of selecting a reasonable design option $v \in \{1, V\}$ for the ISS construction regarding the limited cost of the whole work C_{max} resolves into the choice of the most acceptable aggregate r^v of engineered safeguard systems according to the "efficiency/cost" criterion, $r^v \in \{1,R\}$.

The limited resources and multiple-choice solutions for security determine the need for motivating the structure and composition of the ISS. The comparative technical and economic assessment of management solutions on preventing threats from occurrence and selection of reasonable options for the ISS construction at an asset to be protected shall be the result of task solution.

Solution Method. Generally, as may be applied to any asset to be protected, security requirements can be restricted to the choice of the necessary level (class) of security. In this approach, each class is characterized by a particular minimal set of safety requirements. A hierarchy of requirements is maintained for all classes.

The implementation of a particular protection class is achieved through the solution of corresponding protection tasks and is ensured with a set of engineered safeguard systems and organizational measures. Each of the engineered safeguard system (measure) ensures a particular security level P_i in terms of the actual cost of this system (measure) – C_i. A set of required levels for solving each z-security task by the integrated security system are established – P_z^{req}.

Total cost of the systems at v-option of the ISS design for the asset to be protected is determined using the following formula:

$$C_v = \sum_{i=1}^{r_v} C_i \qquad (1)$$

where r_v is the total number of engineered safeguard systems and organizational measures at v-option of the ISS structure for the asset to be protected.

However, such an approach cannot be considered completely correct. If the efficiency indicator of the ISS directly depends on the efficiency of its components and "nonrecurring costs", then the total cost of the ISS shall include the installation (fitting) costs of the safeguard elements – C_i^{ins}, cost of routine maintenance (where appropriate) – C_i^{main}, and training of the management and operators – C_i^{tr}:

$$C_v = \sum_{i=1}^{r_v} C_i + \sum_{i=1}^{r_v} C_i^{ins} + \sum_{i=1}^{r_v} C_i^{main} + \sum_{i=1}^{r_v} C_i^{tr} \qquad (2)$$

Equation (2) can be used as a model of taking into account the impact of the cost index on selecting a reasonable option for the ISS design.

The index of technical and economic efficiency of an ISS design option for the asset to be protected is a value expressed as the ratio of the ISS efficiency index to the value of financial resources spent for its development and maintaining in operational condition:

$$I_v = \underline{P_v} / C_v, \qquad (3)$$

where $\underline{P_v}$ is the integral efficiency index of v-option of the ISS design for the asset to be protected.

The subject matter of the approach to assessing the impact of the chosen composition of the ISS's engineered safeguard systems providing the solution of common tasks on the value of the efficiency index lies in the comparison of integral possibilities of the ISS in equal application conditions.

Such assessment is possible through the use of a tailored method for technical and economic assessment. A simplified chart of the developed algorithm for the assessment method is provided in Fig. 1.

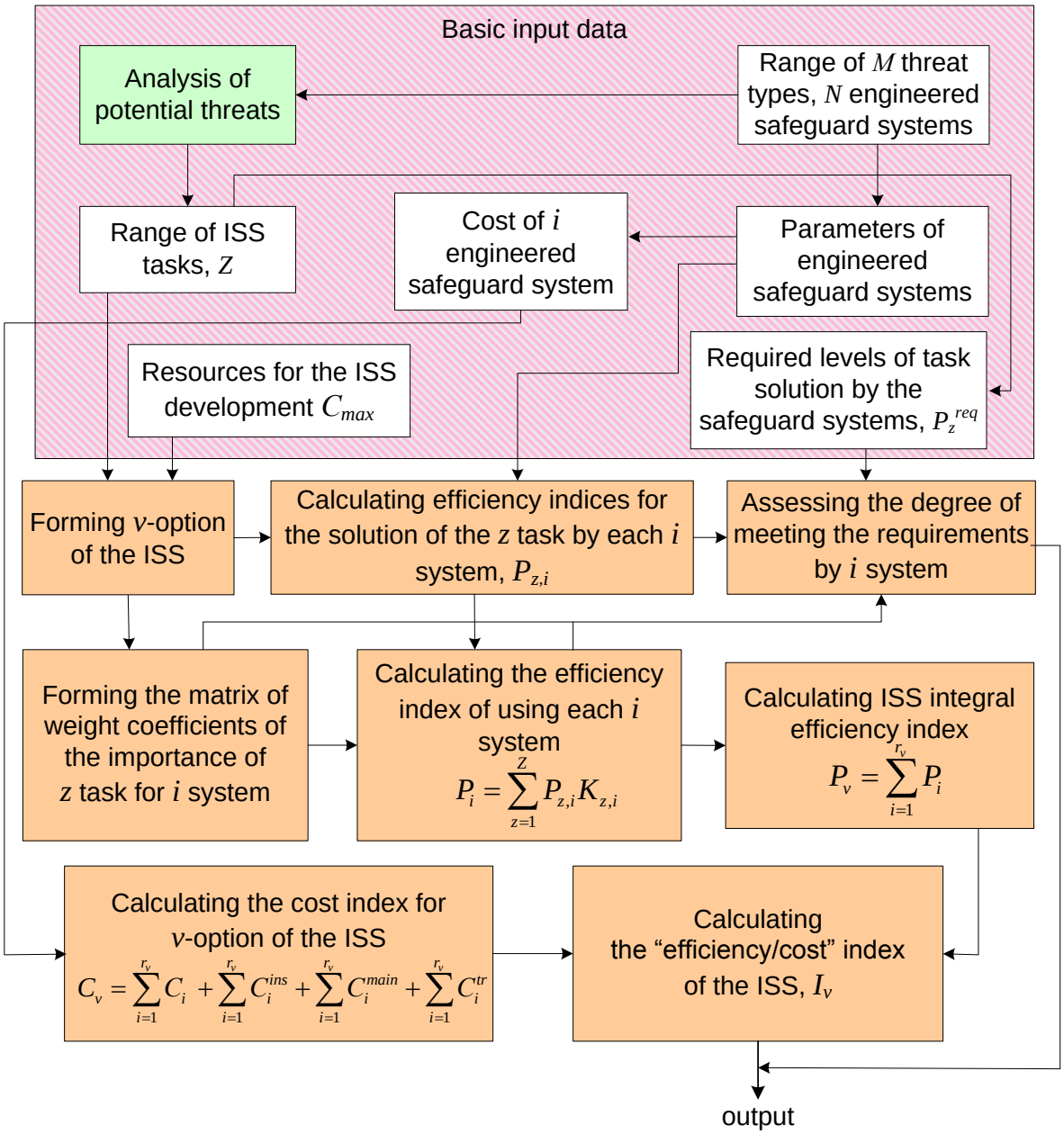

Fig. 1. Block-diagram of the algorithm for technical and economic efficiency assessment of the ISS construction options

The assessment procedure is performed through a consecutive performance of a number of steps, including:

– forming v-option of the ISS, the design of which consists of the aggregate rv of engineered safeguard systems;

– forming a matrix of weight coefficients of task "importance" for each i engineered safeguard system that is included in the ISS design. Any method that is based on a method of pairwise comparisons (Saaty's method) can be laid at the core of the method for determining weight coefficients of security ensuring task "importance".

– calculating the values of efficiency indices of applying each i-system to solve each z task – Pz,i;

– calculating the values of integral efficiency indices of applying each i -system considering the matrix of weight coefficients of "importance";

– assessing the degree of meeting by each i- engineered safeguard system of task solution requirements Pzreq.
– calculating the integral efficiency index of ISS – Pv;
– calculating the cost index of each ISS option – Cv;
– calculating the technical and economic efficiency index of each ISS option – Iv .
The calculation results are provided as a table and diagrams of the relative indices of technical and economic efficiency of each ISS option for the asset to be protected and the assessment of meeting the requirements on each security task.

Conclusion

. It is quite obvious that the types and number of engineered safeguard systems for ensuring security depend on the importance of the asset to be protected, accessibility (availability on the service market) of the necessary engineered safeguard systems and financial possibilities.
The following task definition of managing the security level at the asset to be protected is acceptable to ensure maximum possible security level with the available resources to organize security policies. However, for the most critical facilities a reverse task may be set out – motivating the volume of assignments to ensure the required security level.
The subject matter of the method lies in the fact that using input data that include technical characteristics and cost indicators of protection equipment, possibility of solving the corresponding protection tasks by each engineered safeguard system, weight coefficients of protection task importance, we shall first select a particular type of a system for each individual task and then define the quantity and composition of the engineered safeguard systems to be used within an integrated protection system.
The method for technical and economic assessment of the ISS design considerations allows rating alternative choices for the ISS construction according to their efficiency coefficient and selecting the most preferable option for a particular asset to be protected.

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