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STATE EMERGENCY SERVICE OF UKRAINE UNITS' POTENTIAL MISSION EFFECTIVENESS DURING EMERGENCY RESPONSE ASSESSMENT MODEL

The article provides the model and obtained design correlation for assessment of the State Emergency Service of Ukraine units' potential effectiveness during emergency response. These data enable comparative analysis of the units based on their mission effectiveness prospective. The model is built on modular approach where modules perform specific tasks with logical interconnection and informational sharing.

The potential effectiveness of unit as a single integral system in emergency situations depends on the potential technical capability and unit's personnel proficiency level to perform missions. The potential technical capacity characterizes the degree of staff compliance, technical readiness, resource, tactical and technical characteristics of weapons and equipment of the complexity performed tasks. The unit's personnel proficiency level characterizes its professional ability to perform missions.

Keywords: *State Emergency Service of Ukraine, State Emergency Service of Ukraine units' potential mission effectiveness, potential technical capability, State Emergency Service of Ukraine units' personnel readiness level, model.*

Introduction

Problem statement. Security defines such status of human activity when the possibility of potential danger is eliminated with definite probability. Safety and security during emergencies requires effective functioning of natural and man-made emergency response that should be relevant to the level and character of the threat [7; 2].

Emergency response – these are coordinated actions of civil protection agencies according to emergency response plans adjusted to specific kind and level of emergency. Those are: rectification of emergency consequences, emergency termination caused hazards influence, rescue and savage operations, emergency zone isolating, rectification (minimization) of emergency consequences that threaten human health or life, territories, environment or estate [11].

Civil protection forces that are allocated in the regions of Ukraine are tasked for opportune and effective emergency response and rectification of different kind emergency consequences. Each region has specific levels of technogenic, natural and social threats that specify structure and assets of civil protection units necessary for adequate emergency response [4–5].

Civil protection forces combine accident rescue services and units of central and local governments' executive branches, enterprises, institutions and organizations of all form of ownership and management. The main body of civil protection forces is Civil Protection Rescue Response Service (CPRRS). CPRRS consists of command and control body, direct-controlled accident rescue units, special purpose accident rescue units, special aviation and other units, state fire extinguishing units, training centres and support units.

Mission effectiveness of State Emergency Service of Ukraine (SESU) units as whole depends on equipment availability, its readiness for application and proficiency of personnel. Potential mission effectiveness of SESU unit during emergency response is the main reference of its mission readiness.

The latest research and publications analysis. The analysis of literary sources regarding the mentioned problem shows that most of publications consider the SESU units' mission effectiveness increase as a result of optimization and rational usage of assets for mission task performance as well as improvement of cooperation between units of different subordination during rectification of emergency consequences. The article [10] presents optimization model of Civil Protection forces allocation by the regions of the country considering stochastic nature of emergency occurrence and response and participation of Civil Protection forces from other regions in rectification of emergency consequences.

The model of rational resource allocation for successful mission accomplishment in the case of emergency is presented in the article [1].

The way of quantitative description of cooperation between units of different subordination during rectification of emergency consequences that allows assessing change of the cooperation system elements' state before

and after control action is defined based on the theory of graphs in the [9]. The [12] is devoted to increase based on opportune and reliable reconnaissance data during operations on the objects with large area with allocation of big amount of suppression forces. Particularities of Civil protection system modernization, legislation concerning Civil protection, structure, functions and tasks of government branches during rectification of emergency consequences, level of their equipment availability and staffing level as well as implementation of international experience for Civil protection system effectiveness increase, role and function of its information and analytical support are examined in the article [6].

The assessment of potential mission effectiveness during emergency response of SESU units' as whole was not covered in the last publications.

The aim of the article is to develop the SESU units' potential mission effectiveness during emergency response assessment model.

Main statement

As SESU units' potential mission effectiveness we will consider the possible efficiency of their actions during rectification of emergency consequences that means the quality of conformance of obtained results with their maximum provided technical capabilities. The potential mission effectiveness during emergency response of SESU units' as whole depends on potential technical capabilities and proficiency of personnel:

$$E = \Pi_T \cdot P, \qquad (1)$$

where E – the potential mission effectiveness during emergency response of SESU unit;

Π_T – the potential technical mission capability of SESU unit;

P – the proficiency of personnel.

The potential technical mission capability of the unit characterises the compliance of unit's equipment availability, its technical readiness for application, service life and specifications with challenges of performed tasks. The potential technical capability of specific SESU unit depends on many factors [3], specifically on availability of modern equipment, its operating factors, availability of expendable supplies (e.g. fuel and lubricants, spare parts, tools and accessories) etc.

Let's assume that each SESU unit in general can possess different kinds of equipment. Based on this the potential technical mission capability of SESU unit is calculated as [3]:

$$\Pi_T = \left[\sum_{i=1}^{k} (N_{НАЯВН_i} \sum_{z=1}^{m} \left(\sum_{j=1}^{n} \frac{A_{jzi}}{A_{jzE}} \cdot M_{jzi} \right) P_{zi}) / \sum_{i=1}^{k} N_{НАЯВН_i} \right] \cdot$$

$$\cdot \left\{ \left(\sum_{i=1}^{k} N_{НАЯВН_i} / \sum_{i=1}^{k} N_{ШТ_i} \right) \cdot \left(\sum_{i=1}^{k} (N_{НАЯВН_i} \frac{T_{0_i}}{T_{0_i} + T_{b_i}}) / \sum_{i=1}^{k} N_{НАЯВН_i} \right) \cdot \left(\sum_{i=1}^{k} (N_{НАЯВН_i} \sum_{s=1}^{6} N_{is} R_{is} / N_{НАЯВН_i}) / \sum_{i=1}^{k} N_{НАЯВН_i} \right) \right\}, \qquad (2)$$

where m – the number of groups of equipment specifications that determine the quantitative measures of its technical excellence;

k – the number of different types of equipment in the unit's possession;

n – the number of characteristics in the j group of the piece of equipment specifications;

$N_{НАЯВН_i}$ – the number of pieces of i type of equipment in the single SESU unit's possession;

$N_{ШТ_i}$ – the organic number of pieces of i type of equipment in the single SESU unit's possession;

A_{jzi} – the j specification numeric expression of the z group of specifications of the i type piece of equipment;

A_{jzE} – similar j specification numeric expression of the z group of specifications of the i type reference specimen of equipment;

M_{jzi} – weight coefficient of j specification of the z group of specifications of the i type piece of equipment that is obtained in an expert way at that $\sum_{z=1}^{m} P_{zi} = 1$;

T_{0_i} – mean time between failures resulting from i type piece of equipment exploitation;

T_{b_i} – mean restoration time resulting from i type piece of equipment exploitation;

R_{is} – service life margin coefficient relative to s bound of N_{is} pieces of $N_{НАЯВН_i}$ available i type piece of equipment.

The presented shows that the value of potential technical mission capability of SESU unit is determined with equipment condition that depends on its technical excellence and operating factors of these pieces.

The proficiency of SESU unit's personnel P characterizes its professional mission capacity.

The proficiency of unit's personnel P is determined with two components: staffing of SESU unit with experts and professional mission training:

$$P = P_{ОС} \cdot P_{ПП}, \qquad (3)$$

where P_{OC} – the probability of SESU unit staffing with experts;

$P_{ПП}$ – the probability of professional mission readiness.

If unit's manning chart foresees availability of r expert staffing positions and w are available, then the probability of staffing with experts is [8; 14]:

$$P_{OC} = \frac{w}{r}. \quad (4)$$

where r – the organic number of experts;

w – the real number of experts.

Professional mission readiness is the complex of expertise, knowledge and skills, personnel's mission proficiency and in accordance with their assignment, availability of professional experience of unit's personnel [13].

The dynamics of professional mission readiness level $P_{ПП}$ is determined with processes of obtaining expertise, knowledge and skills during institutional studies, within training and professional development system and professional experience. It can be formulated as correlation that considers results of vocational selection and effectiveness of patterns and methods of expert's training systems [13]:

$$P_{ПП}(S) = P_1(S) + [P(S) - P_1(S)] \cdot \cdot B(S) \cdot [1 - A(S)]^{-1} \left[1 - A^{q-1}(S)\right], \quad (5)$$

where q $\left(q = \overline{1,\infty}\right)$ – the number of exercises and drills that correspond with possible tasks during rectification of emergency consequences;

P(S) – the probability of infallible performance of mastered S type task;

$P_1(S)$ – the initial level of readiness;

A and B – parameters of the model that consider effectiveness of training patterns and methods.

Let's consider that for successful mission accomplishment by the unit it's necessary to perform few tasks, z in general case. Then personnel proficiency level is determined as follows:

$$P_{ПП} = \sum_{i=1}^{z} Q(S_i) \cdot P_{ПП}(S_i), \quad (6)$$

where $Q(S_i)$ – the probability of performing S_i type task during rectification of emergency consequences;

$P_{ПП}(S_i)$ – the level of personnel proficiency at performing S_i type task.

When we consider (5) the correlation (6) will look like:

$$P_{ПП} = \sum_{i=1}^{z} Q(S_i) \left\{ \begin{array}{c} P_1(S_i) + [P(S_i) - P_1(S_i)] \cdot \\ \cdot B(S_i) \cdot [1 - A(S_i)]^{-1} \cdot \\ \cdot \left[1 - A^{q-1}(S_i)\right] \end{array} \right\}. \quad (7)$$

While substituting formulas (4) and (7) into the formula (3) we will get the probability P formula as:

$$P = \frac{w}{r} \cdot \sum_{i=1}^{z} Q(S_i) \cdot \left\{ \begin{array}{c} P_1(S_i) + [P(S_i) - P_1(S_i)] \cdot \\ \cdot B(S_i) \cdot [1 - A(S_i)]^{-1} \cdot \\ \cdot \left[1 - A^{q-1}(S_i)\right] \end{array} \right\}. \quad (8)$$

Considering correlations (2) and (8) the potential mission effectiveness of SESU unit (1) formula will be written as:

$$E = \left[\sum_{i=1}^{k} (N_{НАЯВН_i} \sum_{z=1}^{m} \left(\sum_{j=1}^{n} \frac{A_{jzi}}{A_{jzE}} \cdot M_{jzi} \right) P_{zi}) / \sum_{i=1}^{k} N_{НАЯВН_i} \right] \cdot \left\{ \begin{array}{c} \left(\sum_{i=1}^{k} N_{НАЯВН_i} / \sum_{i=1}^{k} N_{ШТ_i} \right) \cdot \\ \times \left(\sum_{i=1}^{k} (N_{НАЯВН_i} \frac{T_{0_i}}{T_{0_i} + T_{b_i}}) / \sum_{i=1}^{k} N_{НАЯВН_i} \right) \cdot \\ \cdot \left(\sum_{i=1}^{k} (N_{НАЯВН_i} \sum_{s=1}^{6} N_{is} R_{is} / N_{НАЯВН_i}) / \sum_{i=1}^{k} N_{НАЯВН_i} \right) \end{array} \right\} \cdot \frac{w}{r} \cdot \sum_{i=1}^{z} Q(S_i) \cdot \left\{ \begin{array}{c} P_1(S_i) + [P(S_i) - P_1(S_i)] \cdot \\ \cdot B(S_i) \cdot [1 - A(S_i)]^{-1} \cdot \left[1 - A^{q-1}(S_i)\right] \end{array} \right\}.$$

Potential mission effectiveness of SESU unit during emergency response assessment model is presented on fig.1. The model is built on modular approach where modules perform specific tasks with logical interconnection and informational sharing.

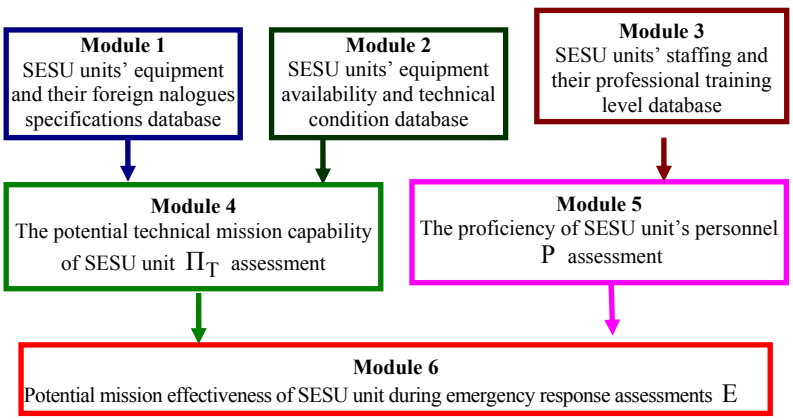

Fig. 1. Potential mission effectiveness of SESU unit during emergency response assessment model

Module 1 is SESU units' equipment and their foreign analogues specifications database. These data are used for assessments in module 4.

Module 2 is SESU units' equipment availability and technical condition database. These data are used for assessments in module 4.

Module 3 is SESU units' staffing and their professional training level database. These data are used for assessments in module 5.

Module 4 is intended for potential technical mission capability of SESU unit assessment according to formula (2). Data from module 4 are used in the sequel for calculations in module 6.

Module 5 is intended for proficiency of SESU unit's personnel assessment according to formula (8). Data from module 5 are used in the sequel for calculations in module 6.

Module 6 is intended for Potential mission effectiveness of SESU units during emergency response assessment according to formula (1).

Conclusions

Among the huge amount of factors that influence the potential mission effectiveness of SESU units the increase of potential technical capability and personnel's proficiency are the main elements that directly influence the unit's potential mission effectiveness.

The proposed model and obtained design correlation for assessment of the SESU units' potential effectiveness during emergency response enable comparative analysis of the units based on their mission effectiveness prospective.

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МОДЕЛЬ ОЦІНКИ ПОТЕНЦІАЛЬНОЇ ЕФЕКТИВНОСТІ ДІЙ ПІДРОЗДІЛІВ ДЕРЖАВНОЇ СЛУЖБИ УКРАЇНИ З НАДЗВИЧАЙНИХ СИТУАЦІЙ ПРИ ЛІКВІДАЦІЇ НАДЗВИЧАЙНИХ СИТУАЦІЙ

Г.В. Іванець, М.Г. Іванець, Г.М. Сафарова

У статті запропонована модель та одержані розрахункові співвідношення для оцінки потенціальної ефективності дій підрозділів Державної служби з надзвичайних ситуацій при ліквідації надзвичайних ситуацій, що дозволяє проводити порівняльний аналіз їх між собою з точки зору їх ефективності можливого застосування за призначенням. Модель побудована за модульним принципом, де модулі логічно та інформаційно зв'язані між собою і виконують конкретні завдання.

Потенційна ефективність застосування підрозділу, як єдиної цілісної системи, при ліквідації надзвичайних ситуацій залежить від потенційної технічної спроможності та рівня готовності особового складу підрозділу до виконання завдань за призначенням. Потенційна технічна спроможність характеризує ступінь відповідності укомплектованості, технічної готовності, ресурсу, тактико-технічних характеристик озброєння і техніки підрозділу складності завдань, що виконуються. Рівень готовності особового складу підрозділу характеризує його професійну здатність виконати задачі за призначенням.

Ключові слова: *Державна служба з надзвичайних ситуацій, потенціальна ефективність застосування підрозділів Державної служби з надзвичайних ситуацій, потенціальна технічна спроможність, рівень готовності особового складу підрозділів Державної служби з надзвичайних ситуацій, модель.*

МОДЕЛЬ ОЦЕНКИ ПОТЕНЦИАЛЬНОЙ ЭФФЕКТИВНОСТИ ДЕЙСТВИЙ ПОДРАЗДЕЛЕНИЙ ГОСУДАРСТВЕННОЙ СЛУЖБЫ УКРАИНЫ ПО ЧРЕЗВЫЧАЙНЫМ СИТУАЦИЯМ ПРИ ЛИКВИДАЦИИ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ

Г.В. Иванец, М.Г. Иванец, Г.М. Сафарова

В статье предложена модель и получены расчетные соотношения для оценки потенциальной эффективности действий подразделений Государственной службы по чрезвычайным ситуациям при ликвидации чрезвычайных ситуаций, что позволяет проводить сравнительный анализ их между собой с точки зрения их эффективности возможного применения по предназначению. Модель построена по модульному принципу, где модули логически и информационно связаны между собой и выполняют конкретные задачи.

Потенциальная эффективность применения подразделения, как единой целостной системы, при ликвидации чрезвычайных ситуаций зависит от потенциальной технической возможности и уровня готовности личного состава подразделения к выполнению задач по предназначению. Потенциальная техническая возможность характеризует степень соответствия укомплектованности, технической готовности, ресурса, тактико-технических характеристик вооружения и техники подразделения сложности выполняемых задач. Уровень готовности личного состава подразделения характеризует его профессиональную способность выполнить задачи по предназначению.

Ключевые слова: *Государственная служба по чрезвычайным ситуациям, потенциальная эффективность применения подразделений Государственная служба по чрезвычайным ситуациям, потенциальная техническая возможность, уровень готовности личного состава подразделений Государственной службы по чрезвычайным ситуациям, модель.*