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Olena PARSHYNA ©
D.Sc. in Economics, Professor *(University of Customs and Finance)*, Ukraine

Natalya METELENKO ©
D.Sc. in Economics, Professor (*Engineering educational and scientific Institute of Zaporizhzhia National University*), Ukraine

Viktor KOVALENKO ©
D.Sc. in Technical Sciences, Associate Professor (*Engineering educational and scientific Institute of Zaporizhzhia National University*), Ukraine

Marharyta PARSHYNA ©
Ph.D. (Economics), Associate Professor *(University of Customs and Finance)*, Ukraine

SYSTEM PROVIDING OF INFORMATION SECURITY AT THE OBJECT OF CRITICAL INFRASTRUCTURE

Abstract. The article is dedicated to solving a topical issue concerning the provision of information security at objects of critical infrastructure. Information security providing is a priority task and a basic precondition for the effective functioning of the objects of critical infrastructure in the current conditions.

The purpose of this article is the development of research methods, analytical procedures and mathematical models for the forming of the complex system for information security providing to the critical infrastructure object. The article presents theoretical and methodological foundations of the strategic management of information security of the objects of the critical infrastructure. Assessment of conditions for the implementation of the information security system is one of the most important principles of the critical infrastructure activity, which

© Parshyna O., 2023
ORCID iD: https://orcid.org/0000-0002-7836-0140
parschina@ukr.net
© Metelenko N., 2023
ORCID iD: https://orcid.org/0000-0002-6757-3124
natalia.metelenko@gmail.com
© Kovalenko V., 2023
ORCID iD: https://orcid.org/0000-0001-5950-4412
victor.l.kovalenko@gmail.com
© Parshyna M., 2023
ORCID iD: https://orcid.org/0000-0001-9256-1929
maggiednepr@ukr.net

provides the complex information about material, economic and financial capabilities of the object of the critical infrastructure.

System analysis, mathematical modelling, analysis and synthesis methods have been used. The main results of the research are following: the model and method for research conducting of the conditions for the implementation of the information security system to the object of the critical infrastructure have been formed; the complex index for the assessment of conditions for the implementation of the information security system has been determined; the multivariable regression model which determines the relationships at the potential estimation level of the production component has been calculated and the complex system for providing of information security to the object of the critical infrastructure has been proposed.

Keywords: *critical infrastructure, information security, complex index, mathematical modelling,*

Introduction. The intromission of Ukraine in the system of the world globalization requires solution of the complex questions on the strategic management of information security to the objects of the critical infrastructure. Ensuring the information security of the critical infrastructure objects and the security of information resources had been defined as a priority problem in the sphere of the state policy of national security of Ukraine (http://zakon2.rada.gov.ua/laws/show/287/2015).

The desire to providing of information security encourages the objects of the critical infrastructure to review the conditions for the implementation of the information security system, to assess their own capabilities and to find the additional reserves for increasing the information security of their activities.

Therefore, the importance of the information security of the objects of the critical infrastructure is growing in the current conditions of the transformational economy of Ukraine in the context of globalization (O. Parshyna et al., 2021, pp. 3-7). Issues of the quantitative assessment to determine the dominant factors which influence the level of the information security and the formation of management decisions on the scientific basis are of particular importance.

Analyses of the recent researches and publications. Modern scientists pay special attention to the prospects of the research of information security at the different systems and objects of the critical infrastructure. Plenty of modern scientists pay attention to the issue of forming, estimation and information security management as one of the most essential. The priorities for ensuring the security of the critical infrastructure in separate areas in accordance with the National Security Strategy (http://zakon2.rada.gov.ua/laws/show/287/2015) have been determined.

The conducted analysis of the priorities for ensuring the safety of the critical infrastructure requires a return to the issue of developing a national model of the functioning of subjects of protection of the critical infrastructure objects with the introduction of the experience of the world's leading countries in this field. In particular, O. Yermenchuk proposes to divide the general approaches to the protection of the critical infrastructure into two main groups and presents them in the form of "American" and "government" models of functioning (Yermenchuk, 2017, pp. 224-235). Thus, the task of creating an effective security system of protection of the critical infrastructure in Ukraine becomes especially urgent.

Analysis of transformational processes (O. Parshyna et al., 2021, pp. 3-7) and the need to solve the problem of ensuring the information security allows us to make an assumption about the relevance of studying the conditions for the

implementation of the information security systems. Based on this assumption, and also taking into account the encyclopedic approach to the concept of the capabilities of an object or the formation of favorable conditions, we consider it appropriate to use the concept of potential.

The study of evolution of the scientific concept "potential" is given by possibility to make the conclusion, that its introduction in researches was related to the problems of development of the complex estimation of the production forces of the development level in the twentieth of the last century. In domestic literature, potential, in the wide understanding is interpreted as possibilities, present forces, supplies, facilities which can be used or power-level in any relation, aggregate of facilities, necessary for anything (Big Economic Dictionary, 2002, p. 950). Also, under this concept in the dictionary of foreign words potential is understood as "the degree of power (hidden possibilities) in some relation... " (https://www.definitions.net/definition/potential).

According to the results of the accomplished research of the term «potential» we must note that scientists examine the different aspects of the potential during many years. Taking into account the main signs of the potential classification it is possible to select the basic types of the potential, in particular, production, scientific, information, innovative, marketing, financial and others. The structure of the enterprise potential has been defined in theoretical part of the research (M. Parshyna, 2015, 2020). Also, objective and subjective components of the potential have been considered.

It had been exposed that one of the debatable questions in scientific literature is the question concerning the interrelation of the concepts of information and production potentials (Karapeychik, 2012, pp. 8-12). In particular, critical analysis of different kinds of potentials on the results of analytical researches is presented (2015, 2020, 2021). I. Azhaman, O. Zhydkov, M. Hronska, N. Petryshchenko and N. Serohina (Azhaman et al., 2020, pp. 2875-2881) discuss the formation of the potential of the service enterprises involved in the repair and maintenance of vehicles. B. Murodov makes analyses of the prospects of development of innovative activity and their influence on the increase of opportunities and potential of the enterprise (Murodov, 2020, pp. 80-84). M. Shamsutdinova, E. Astrakhantseva, A. Bimurzaeva, I. Mirgaleeva, V. Ignatiev say about the creation of optimization mechanism to increase the potential of an enterprise (Shamsutdinova et al., 2022, pp. 869-878). T. Hart (Hart, 2015) says about creating the integrated system for decision-making for increasing of the opportunities and enterprise potential. Thus, scientists consider the potential of various enterprises as objects of the critical infrastructures.

The issue of the research of different approaches, methods and analytical procedures is being considered in numerous publications of the modern scientists. In particular, the intromission of Ukraine in the system of the world globalization requires the solution of complex questions on strategic management of the potential use on scientific basis (M. Parshyna, 2020, pp. 334-342).

Scientists use different approaches in the researching process. T. Hart (2015) in the article uses a systematic approach for studying the potential. M. Maghradze and D. Sichinava (Maghradze et al., 2017, pp. 311-316) provided an approach to the terms and composition of information potential of micro and macro levels of the managing system. O. Komelina, S. Shcherbinina, M. Korsunska (2019) developed the approach, which makes it possible to evaluate

the state of the enterprise, its resources, the efficiency of using the potential, as well as to determine the reserves of its use and opportunities for further growth. The Balanced Scorecard concept for defining the prospects, opportunities, limitations and methodological format of the competitiveness assessing has been considered in the article (Shamsutdinova et al.,2022, pp. 869-878).

Scientists say about the quantity estimation and use of the various information indicators for analyzing. S. Carter analyses the incidence of the portfolio entrepreneurship in the farm sector and assesses its potential in terms of the enterprise and employment creation (Carter, 1998, pp. 297-306). The analysis of the factors of innovative potential of enterprises in the context of innovation subsystems of the economy was included in the study process by Iz. Krawczyk-Sokolowska, A. Pierscieniak and W. Caputa (2021, pp. 103-124). I. Azhaman, O. Zhydkov, M. Hronska, N. Petryshchenko and N. Serohina (2020, pp. 2875-2881) identify the criteria for assessing the formation of the economic potential of the enterprise. M. Shamsutdinova, E. Astrakhantseva, A. Bimurzaeva, I. Mirgaleeva, V. Ignatiev (2022, pp. 869-878) propose to use many parameters for characterizing the economic potential of economic entities which depend and are being formed under the influence of environmental factors and financial condition.

Scientists use different methods and models during conducting research. M. Maghradze and D. Sichinava (2017, pp. 311-316) examine and analyze the points of view of the various authors in scientific literature on the concepts and compositions of economic and information potential. T. Hart (2015) in the article includes different methods of the long-term, medium-term, the current (annual), operational planning. Iz. Krawczyk-Sokolowska, A. Pierscieniak, W. Caputa (2021, pp. 103-124) propose an original methodology for the opportunities and potential. Great amount of factors of the innovative potential of Polish enterprises were identified by using this original methodology of the research.

I. Ishmuradova, A. Karamyshev, D. Lysanov, Al. Isavnin, I. Eremina (2019) develop the methodology for assessing the potential which is based on the rapid assessment by using three main components of potential: production capacity, financial potential and intellectual potential. O. Komelina, S. Shcherbinina, M. Korsunska (2019) propose the model for assessing of the enterprise economic potential, taking into account the components of its formation (production, financial, labor, information, innovation). Matrix analysis was applied to assess the enterprise performance indicators; it revealed a relationship between the enterprise's competitive position and the class of its innovation (M. Parshyna, 2020, pp. 334-342).

As a result of the research, scientists identify the dependencies in information processes and formulate proposals for the increase of opportunities for the development of the objects of the critical infrastructure. In particular, T. Hart (2015) presented a system of planning of the increase of opportunities and potential of the enterprise. Iz. Krawczyk-Sokolowska, A. Pierscieniak, W. Caputa (2021, pp. 103-124) formulated the qualitative diagnosis of the activities of Polish enterprises in terms of innovation development and implementation, and also, the economy is assessed regarding innovative opportunities and potential in a macro scale.

Thus, we consider it appropriate to explore the potential of the critical infrastructure objects as a base of the implementation of the information security

system.

However, nowadays, the positions on forming the theoretical basis for the creation of effectively functioning of the potential of the critical infrastructure object are not sufficiently defined in scientific researches. There are no works in which the questions of development of concrete methods and models of the quantitative estimation of opportunities of the critical infrastructure object would be considered in complex. Also, there are no works in which recommendations on the effective use of opportunities of the critical infrastructure object are developed. The scientific tasks on development of the management systems of information security of the critical infrastructure object are not resolved. The mechanisms of adaptation of such systems to the terms of transformation economy are not offered.

Thus, the questions of development of the methodological basics of strategic management of information security of the critical infrastructure objects remain practically unexplored.

The purpose of the article is the development of research methods, analytical procedures and mathematical models for the forming of the complex system for providing of information security of the critical infrastructure object.

Formulation of the main material. On the basis of the approaches analysis and methods of the quantitative determination of the critical infrastructure object potential had been considered that these questions need detailed research and require proper elaboration taking into account modern tendencies in forming of the information security. Paradigms of strategic management of the critical infrastructure object have been investigated and initial positions of strategic management of information security have been considered in the process of the research.

The conceptual positions on the quantitative estimation of information security of the critical infrastructure object have been determined. It is proved that it is expedient the determination of information security to be the integral estimation of potential possibilities which are represented in the resource potential of the critical infrastructure object taking into account the achievement of the economic effect.

The complex model of information security forming has been worked out. That allows not only to estimate the information security of the critical infrastructure of the object quantitatively but also to create the basis for the modeling different production situations. There has been shown that it is necessary to conduct the research of the information security of the critical infrastructure object on the basis of such model and its components depending on the change of many factors. Thus, the received dependences must make basis of the strategy forming of information security of the critical infrastructure object.

The resource concept on the basis of the complex model of the forming process of the information security of the object of the critical infrastructure has been taken. According to this approach the use of production, material, personnel and financial components have been offered. The research method of the information security of the object of the critical infrastructure on the basis of the offered conceptual positions has been developed. The method foresees the researches taking into account the terms of external and internal environment of the object of the critical infrastructure (Fig. 1).

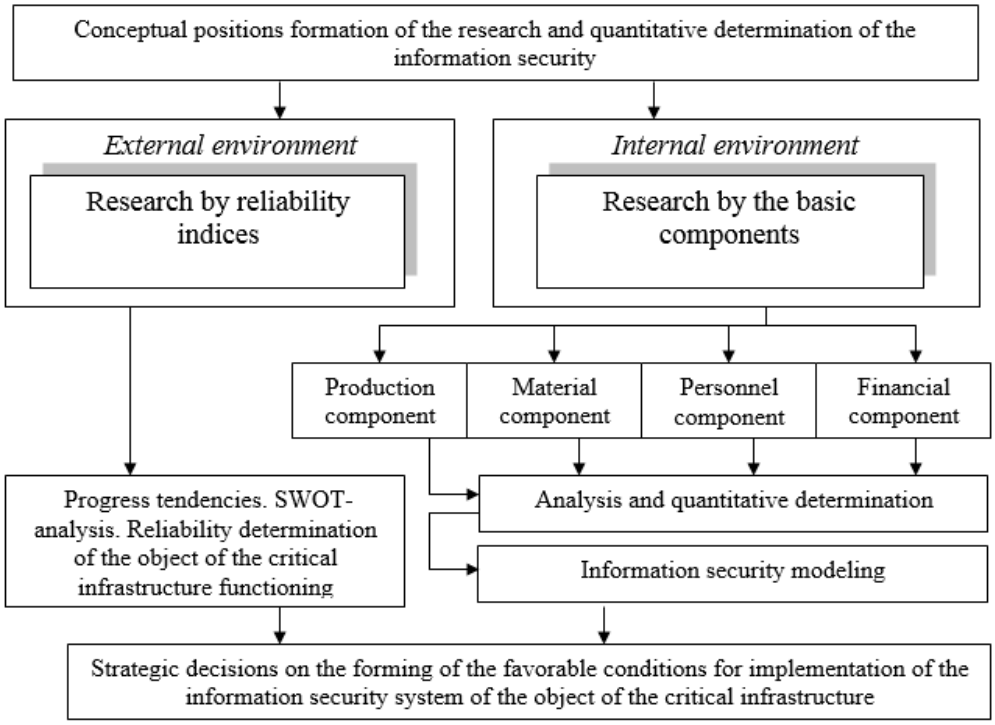

Fig. 1 – Researching method of the information security system of the object of the critical infrastructure

Source: created by authors

The system of scientific and special methods of research in the work for the purpose achievement has been used. In particular, dialectical analysis, logical analysis and system analysis have been used for theoretical and methodological generalizations, determination of essence and components of the information security, instruments forming of the quantitative estimation of the information security and improvements of mechanisms of strategic management.

Structural, calculative and comparative methods of the construction of the integral indices of the level estimation of the information security have been used. Methods of statistical and graphic analysis of the systems, expert estimations, matrix and mathematical modelling have been used for the development of the management method of the information security of the object of the critical infrastructure. Graphic method for the evident image of dynamics of the base indicators and schematic presentation of the theoretical material and results of the researches has been used. Processing of the data with the use of computer technique and modern software has been carried out.

The analysis of the functioning of the object of the critical infrastructure in the external environment is carried out by the reliability index. The offered method includes four basic stages: analysis of external surroundings of the enterprise; SWOT-analysis; analysis of the tendencies of the development of external surroundings; quantitative estimation of the chances on success.

The researches of the terms of the internal environment of the object of the critical infrastructure foresee the determination of the next levels (Fig. 2).

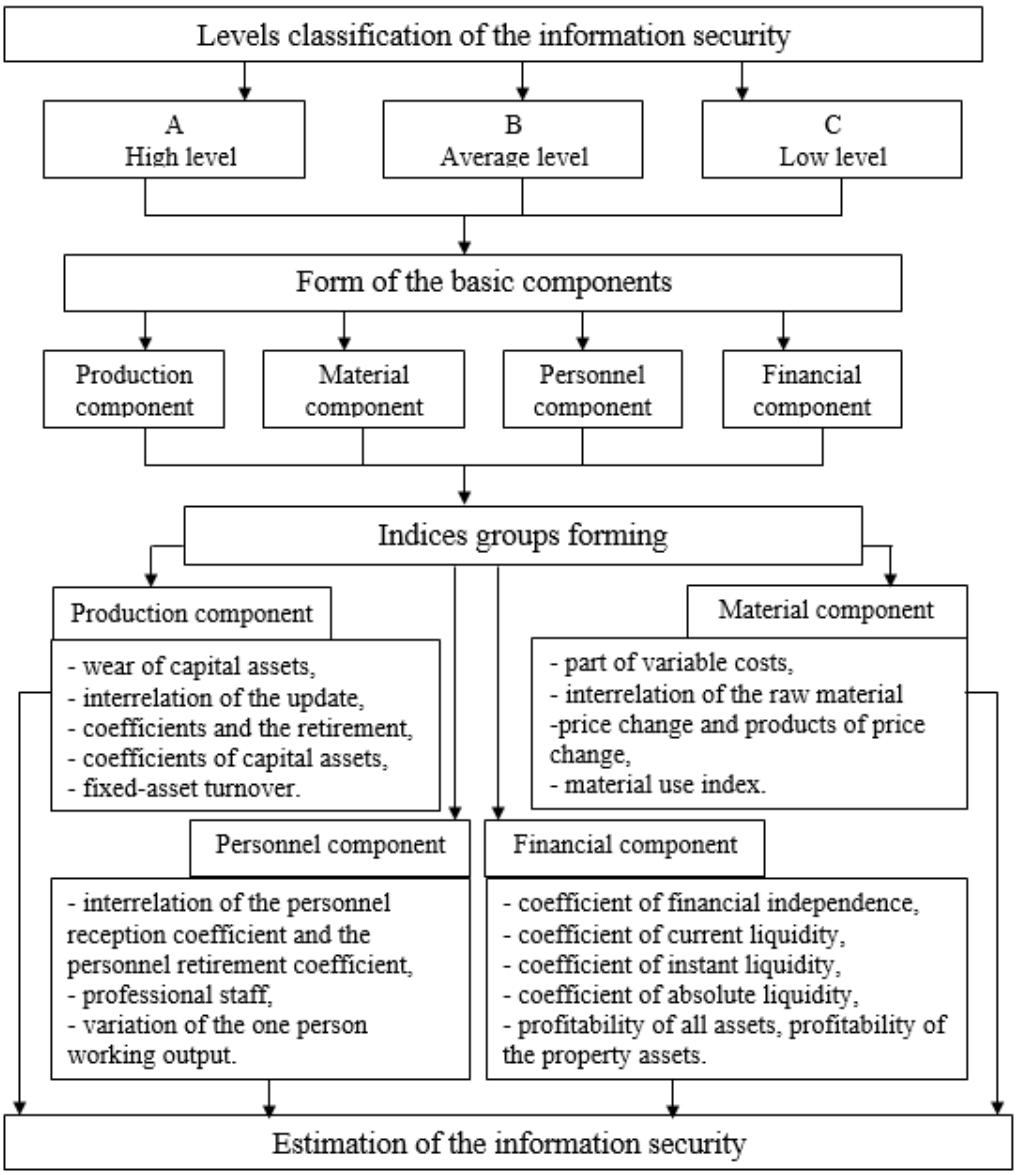

Fig. 2 – Levels classification of the information security
Source: created by authors

The critical values have been determined and the scale of the quantitative estimation of the levels of the information security has been formed (Table 1).

Table 1

Description of the levels of the information security

Levels	*Denotation*	*Short description*
High level	A	The object of the critical infrastructure is in absolute equilibrium state on all component indices in accordance with all estimation criteria
Average level	B	The object of the critical infrastructure functions successfully in business, but there are difficulties which the object overcomes because of the adaptation mechanisms work
Low level	C	Chronic violations by many parameters of all functional components: problems with raw material, information and labor resources, capital production assets and their ineffective use on the object of the critical infrastructure

The system of indices was formed for the research of the information security of the object of the critical infrastructure taking into account four components, in particular, production, material, personnel and financial components. For the estimation of the production component the following indices have been offered: wear of capital assets, interrelation of coefficients of update and retirement of capital assets, fixed-asset turnover. The part of variable costs, price change on the raw material and price changes on the products, index of the material use have been proposed for the estimation of the material component.

For the estimation of the personnel component the coefficient on the personnel reception and the coefficient on the personnel retirement have been offered; professional personnel staff; variation of the output of one person working. For the estimation of financial component have been offered coefficient of financial independence; coefficient of current liquidity; coefficient of instant liquidity; coefficient of absolute liquidity; profitability of all assets; profitability of the property assets; efficiency of the assets use for the production of goods; part of the borrowed capital in the sum of financing sources.

The formed system of indices of the quantitative estimation presents an informative base for the analytical researches. On this basis the information security of levels on production and material components have been defined. During the research statistic information of industrial enterprise (from sector of critical infrastructure) has been used (tables 2-5).

Table 2

Level estimation on the production component by first index – wear of capital assets coefficient

Original data	*2021*	*2022*
Wear of capital assets, USD	15916,67	139500,00
Original value of capital assets, USD	652166,67	652166,67
Wear of capital assets coefficient	0,02	0,21
Level estimation	A	A

Table 3

Level estimation on the production component by second index – interrelation of update coefficients and retirement coefficients of capital assets

Original data	*2021*	*2022*
Value of updated capital assets, USD	11456	133500,00
Value of capital assets in the end of the year, USD	636250,00	630250,00
Update coefficients	0,02	0,21
Value of retired capital assets, USD	15916,67	139500,00
Value of capital assets in the beginning of the year, USD	652166,67	769750,00
Retirement coefficient	0,02	0,18
Interrelation of update coefficients and retirement coefficients of capital assets	0,74	1,17
Level estimation	B	A

Table 4

Level estimation on the production component by third index – fixed-asset turnover

Original data	*2021*	*2022*
Products realization profit, USD	1094500,00	828666,67
Basic capital assets, USD	636250,00	630250,00
Fixed-asset turnover	1,72	1,31
Level estimation	A	A
Level estimation on the production component	ABA	AAA

The square of the information security to obtain a quantitative assessment of the conditions of the object of critical infrastructure have been constructed, which made it possible to present the dynamics of the constituent components (Fig. 3). This approach made it possible to quantify the information security of the object of critical infrastructure taking into account base components.

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Table 5

Level estimation on the material component

First index – part of variable costs		
Original data	*2021*	*2022*
Part of variable costs	47 %	56 %
Level estimation	C	B
Second index – raw material price change and products price change		
Raw material price change and products price change	1,25	1,19
Level estimation	C	C
Third index – material use index		
Products realization profit, USD	1094500,00	828666,67
Material cost, USD	524241,67	420758,33
Material use index	2,09	1,97
Level estimation	A	A
Level estimation on the material component	CCA	BCA

The conducted research shows that the object of critical infrastructure uses the potential in the external environment at sufficient level. On the results of the conducted research the conditions of the internal environment it is possible to establish that the level of information security on material, production, financial and personnel components has been improved in the current year in comparison with the previous year. Level of the information security of the critical infrastructure object also has a tendency to increase, however, the information security level remains at the average level. The multivariable regression models with the purpose of determination of relationships and for defining the most influential factors on the information security level of the critical infrastructure object have been developed. The degree of relationships between the factors has been calculated with the use of methods of the correlation analysis. Parameters of mathematical models with the use of the least-squares method have been defined.

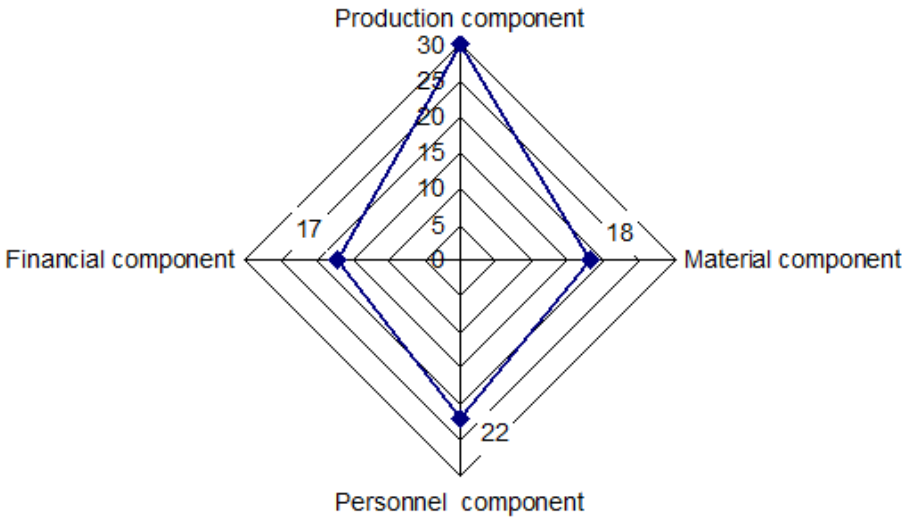

Fig. 3 – Information security of the critical infrastructure object by the graphic interpretation taking into account base components of the 2022 year

Source: created by authors

In particular, multivariable regression model has been calculated which determines relationships at the level of estimation of the information security at the object of critical infrastructure by production component:

$$Y = 11.23 – 6.17 \cdot X_1 + 13.32 \cdot X_2 + 3.69 \cdot X_3, \quad (1)$$

where: Y is the information security level by the production component;
X1 is coefficient of the wear of capital assets;
X2 is interrelation of coefficients of update and retirement of capital assets;
X3 is fixed-asset turnover.

With the purpose of determination of the relationship at the level of integral estimation of the information security of the critical infrastructure object and the basic factors by the production, material and personnel components, the following multivariable regression model has been calculated:

$$Y = 13.98 + 16.55 \cdot X_1 + 15.8 \cdot X_2 + 2.61 \cdot X_3, \quad (2)$$

where: Y is integral estimation of information security of the critical infrastructure object;
X_1 is output of the work (factor of the personnel component);
X_2 is index of the material use (factor of the material component);
X_3 is fixed-asset turnover (factor of the production component).

Coefficient of multiple determination is 0.82. Thus, the factors X_1, X_2, X_3 explain the variation of the integral estimation of the information security of the critical infrastructure object on 82 %. The influence of the other factors which are not being included in the model makes 18 %. Verification of precision of the received mathematical model with the use of Fisher's statistics has been accomplished and adequacy of the received mathematical models has been proved (Table 6).

The system structure of the strategic decisions forming on the increase of the level of the information security has been developed (Fig 4). The offered system contains the complex of analytical blocks with the use of methods of the mathematical modelling, methods of reflexive management and complex validation of strategic decisions.

Table 6

Verification of the received mathematical models precision with the Fisher's statistics

The multivariable regression model which determines the relationships at the level of estimation of the information security of the critical infrastructure object by the production component		The multivariable regression model which determines the relationships at the integral level estimation of the information security of the critical infrastructure object and the basic factors by the production, material and personnel components	
Fisher's statistics tabular value: $F(K1,K2,\alpha)=4.76$ K1=3 factors K2=10-3-1=6 $\alpha=0.05$	Fisher's statistics calculation value: F=8,28	Fisher's statistics tabular value: $F(K1,K2,\alpha)=4.07$ K1=3 factors K2=12-3-1=8 $\alpha=0.05$	Fisher's statistics calculation value: F=12.19
8.28>4.76 – the model is adequate		12.19>4.07 – the model is adequate	

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This system is a meaningful aspect of the basics of strategic management of information security of the object of the critical infrastructure and is a set of theoretical knowledge for synthesizing methods, models and tools of strategic management.

The basis for building of this management system of the information security of the critical infrastructure object is the scientific concept that takes into account on the one hand the peculiarities of the critical infrastructure object and, on the other hand, its market position and environment. The use of modern management concepts of the information security of the critical infrastructure object has been proposed.

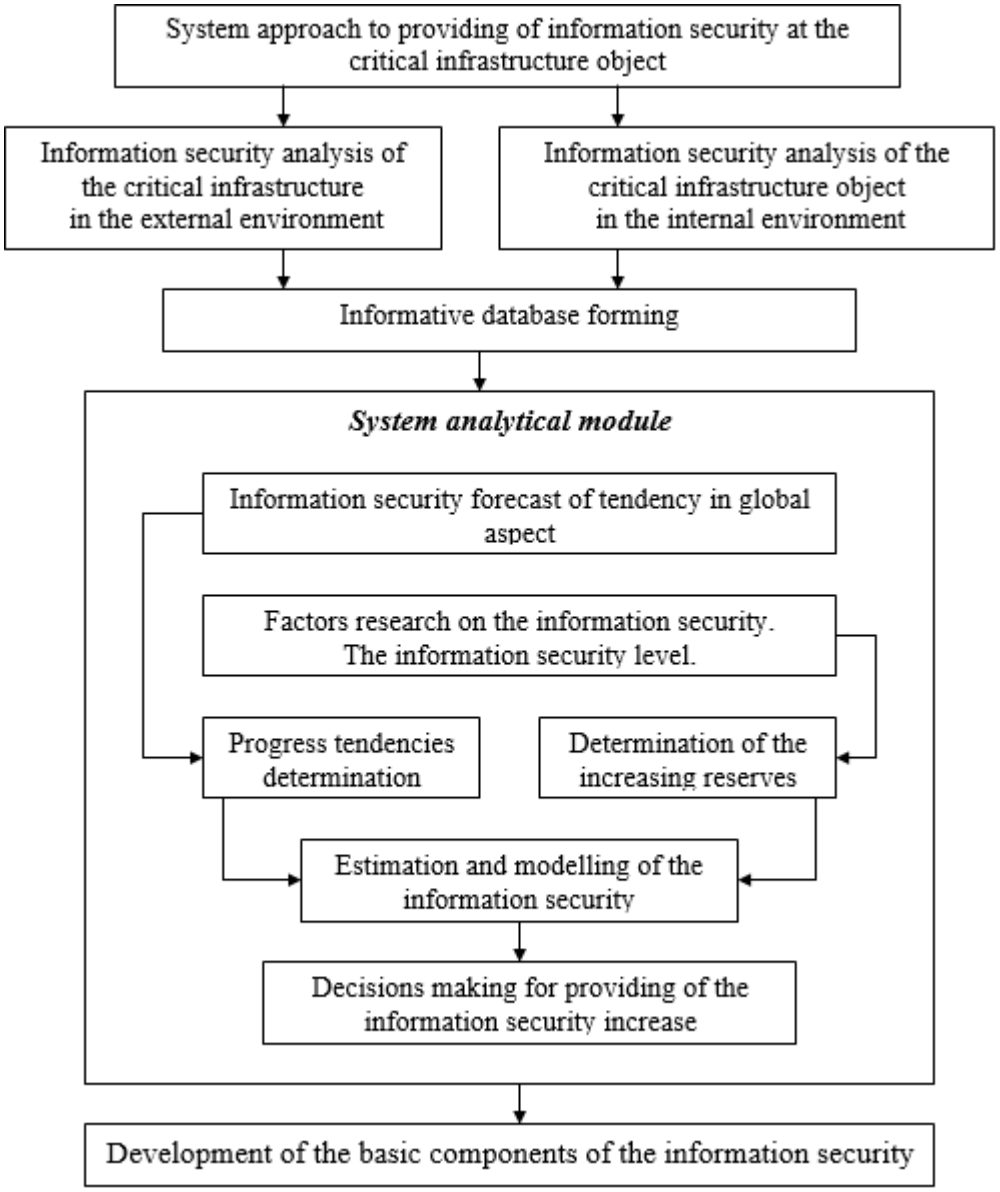

Fig. 4 – Complex system for providing of information security at object of critical infrastructure

Source: created by authors

Conclusions. Basic scientific result of this research consists in forming of theoretical and methodological positions of the providing system of information security of the object of the critical infrastructure on the basis of the offered conceptual positions on the strategic management of information security. The concept of the information security management of the critical infrastructure object determines forming processes, recreation and increase of information security on the basis of analysis and estimation of basic elements, tendencies of their changes, correlative and relationships between elements in the structure of information security.

Complex model of the forming process of information security has been developed. The resource concept has been fixed on the basis of this model taking into account production, material, personnel and financial components of information security. Methodical aspects regarding to quantitative determination of the information security level of the critical infrastructure object and its basic components have been generalized.

Multivariable regression models for defining the relationships between basic factors and exposing their influence on the information security level of the critical infrastructure object have been developed. The structure of the system of information security management has been formed. It foresees administrative decision forming on the basis of analysis, mathematical modeling, as well as reflexive methods use in the management of the information security.

Method of quantitative estimation of information security and offered management system of information security can be implemented to the objects of the critical infrastructure.

Conflict of Interest and other Ethics Statements
The authors declare no conflict of interest.

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Олена ПАРШИНА, Наталя МЕТЕЛЕНКО,
Віктор КОВАЛЕНКО, Маргарита ПАРШИНА

СИСТЕМНЕ ЗАБЕЗПЕЧЕННЯ ІНФОРМАЦІЙНОЇ БЕЗПЕКИ НА ОБ'ЄКТАХ КРИТИЧНОЇ ІНФРАСТРУКТУРИ

Анотація. Стаття присвячена вирішенню актуального питання щодо забезпечення інформаційної безпеки на об'єктах критичної інфраструктури. Забезпечення інформаційної безпеки є пріоритетним завданням і основною передумовою ефективного функціонування об'єктів критичної інфраструктури в сучасних умовах.

Метою даної статті є розробка методів дослідження, аналітичних процедур і математичних моделей для формування комплексної системи забезпечення інформаційної безпеки об'єкта критичної інфраструктури. У статті викладено теоретико-методологічні основи стратегічного управління інформаційною безпекою об'єктів

критичної інфраструктури. Оцінка умов впровадження системи інформаційної безпеки є одним із найважливіших принципів діяльності критичної інфраструктури, що забезпечує отримання комплексної інформації про матеріально-економічні та фінансові можливості об'єкта критичної інфраструктури.

Використано методи системного аналізу, математичного моделювання, аналізу та синтезу. Основними результатами дослідження є: сформовано модель та методику проведення дослідження умов впровадження системи захисту інформації на об'єкті критичної інфраструктури; визначено комплексний показник для оцінки умов впровадження системи захисту інформації; розраховано багатофакторну регресійну модель, яка визначає зв'язки на рівні оцінки потенціалу виробничої складової та запропоновано комплексну систему забезпечення інформаційної безпеки об'єкта критичної інфраструктури.

Ключові слова: *критична інфраструктура, інформаційна безпека, комплексний показник, математичне моделювання.*

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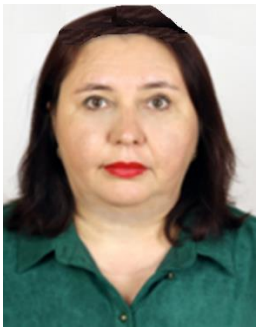
Viktor KOVAL ©
D.Sc. in Economics, Professor *(Izmail State University of Humanities)*, Ukraine



Iryna HONCHAROVA ©
Ph.D. Student *(Izmail State University of Humanities)*, Ukraine

Nataliia LYSENKO ©
Ph.D., Associate Professor, *(National University "Odesa National Maritime Academy")*, Ukraine

MANAGEMENT OF AN INTEGRATED MODEL OF INNOVATION IN MARITIME TRADE

Abstract. The article presents a model that will allow substantiating the sequence of introducing a system of innovative activities with integrated management of an integrated model of innovative activity. In order to identify the sequence of innovative activities, a study was made of indicators of maritime trade in Ukraine for the period from 2016 to 2020 according to the

© Koval V., 2023
ORCID iD: https://orcid.org/0000-0003-2562-4373
victor-koval@ukr.net

© Honcharova I., 2023
ORCID iD: https://orcid.org/0000-0003-2607-6698
cehovich2610@gmail.com

© Lysenko N., 2023
ORCID iD: https://orcid.org/0000-0001-9375-4693
natalylysenko10@gmail.com