Fundamentals of theory and methodology for the study of the transformation of systems of various origins

Основи теорії та методології дослідження трансформації систем різного походження

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Purpose. The purpose of the article is to justify the theoretical basis and methodological foundations of the systems' transformation in the context of the influence of external and internal factors.

Methodology. The results of the article were obtained through the application of such methods: analysis, synthesis, deduction, induction in the study of systems, the theory of self-organization and scientific concepts. These methods form the basis of a modern study of the self-organization of systems of living or inanimate nature of artificial or natural organic or inorganic, socio-economic, humanitarian, military, political and other origins. Systematic method – for substantiating the laws and principles of the transformation of systems, the general law of transformation of systems; modeling – for developed mathematical model of the system.

Results. The author substantiates the regularities and principles of system' transformation, determines the external and internal factors of this process, reveals their objectivity and subjectivity; the general law of transformation of systems is defined and formulated; An approach to mathematical modeling of systems is proposed on the basis of complex consideration and application of external and internal factors.

Originality. The general law of systems transformation is definite for the first time. The law objectively takes into account all existing theories and concepts concerning transformation, self-organization and modernization of systems, that is quantitative, qualitative and functional changes taking place with them. The mathematical model of the system is represented by the function of the action and interaction of objective and subjective external and internal factors.

Practical value. The obtained research results allow at the present stage of development of science to create a universal approach and the corresponding equipment for modeling, analysis and evaluation of the degree of transformation of systems of any origin. The determination of their productivity, stability, prevention of chaos, dissipation and corresponding corrective actions, depending on missions and goals, actions that are being persecuted and carried out or are taking place. According to the research, the way to the solution of this problem lies in the field of the most optimal representation of the action of external and internal factors by physical, social or any other nature by mathematical, functional, statistical, expert methods on the basis of the corresponding presented functions and qualimetric approaches.

Paper type: Theoretical.

Key words: system, theory of self-organization, transformation, thermodynamics evolution, interaction, external factors, internal factors, model.

Мета роботи: обґрунтування теоретичних основ та методологічних засад трансформації систем у контексті впливу зовнішніх і внутрішніх факторів.

Метод/Підхід дослідження: Результати статті отримано шляхом застосування таких методів: аналізу, синтезу, дедукції, індукції у вивченні систем, теорії самоорганізації та наукових концепцій. Ці методи лежать в основі сучасного дослідження самоорганізації систем живої чи неживої природи штучного чи природного органічного чи неорганічного, соціально-економічного, гуманітарного, військового, політичного та іншого походження. Системний метод – для обґрунтування законів і принципів перетворення систем, загального закону перетворення систем; моделювання – для розробленої математичної моделі системи.

Результати дослідження: Автор обґрунтовує закономірності та принципи трансформації системи, визначає зовнішні та внутрішні чинники цього процесу, розкриває їх об'єктивність та суб'єктивність; визначено і сформульовано загальний закон перетворення систем; Запропоновано підхід до математичного моделювання систем на основі комплексного врахування та застосування зовнішніх і внутрішніх факторів.

Оригінальність: Вперше визначений загальний закон перетворення систем. Закон об'єктивно враховує всі існуючі теорії та концепції щодо трансформації, самоорганізації та модернізації систем, тобто кількісних, якісних та функціональних змін, що відбуваються з ними. Математична модель системи представлена функцією дії та взаємодії об'єктивних і суб'єктивних зовнішніх і внутрішніх факторів.

Практична цінність: Отримані результати дослідження дозволяють на сучасному етапі розвитку науки створити універсальний підхід і відповідне обладнання для моделювання, аналізу та оцінки ступеня трансформації систем будь-якого походження. Визначення їх продуктивності, стабільності, запобігання хаосу, розсіювання та відповідних коригувальних дій залежно від місій та цілей, дій, які переслідуються та здійснюються чи мають місце. Згідно з дослідженнями, шлях до вирішення цієї проблеми лежить у сфері найбільш оптимального представлення дії зовнішніх і внутрішніх факторів фізичної, соціальної чи будь-якої іншої природи математичними, функціональними, статистичними, експертними методами на основі відповідних представлених функцій і кваліметричних підходів.

Тип статті: Теоретична.

Ключові слова: система, теорія самоорганізації, перетворення, еволюція термодинаміки, взаємодія, зовнішні фактори, внутрішні фактори, модель.

1. Introduction

Natural, political, social, technical, technological phenomena and events, objects and subjects of animate and inanimate nature are in some way structured formations, that are systems. That is why, perhaps, it is reasonable to admit that the macro and micro world of human activity, the functioning of the global earth's environment are represented by many systems of different origins and purposes, which generally determine the state of our planet and human activity. This gave as the reason for the search for effective and optimal research methods, synthesis of complex systems, their management. The fundamentals of such a theoretical and methodological basis became systems theory and systems analysis (tectology). For the first time a significant contribution to the formation and development of a systematic approach to the study of complex systems was made by O. Bogdanov (1913). His theoretical provisions have contributed to the development of such modern scientific fields as synergetic, management in the field of natural and social science. Further development of systems theory was the research of L. Bertalanffy (30s of the XX century). The scientist proved that the methodology of the systems approach is broader, it can be applied in various fields of knowledge and forms the methodological basis of research for all the science.

As the course of planetary, historical events, scientific research, the functioning of systems of different origins have common features, characterized by positive and negative results: development, success, decline, chaos, dissipation, etc., that is a system's formations change over time, functioning in environments under the influence of external and internal factors. At the same time, the mechanisms of change that occur in them have not found deep scientific coverage and continue to be problematic and relevant for scientists in the present time – the progress of science in the world, increasing knowledge, forming a global information space, developing and implementing new technologies in a wide range of knowledge based on innovative scientific achievements, increasing action of information, psychological, cyber, economic, military-political, terroristic, environmental, religious, migration and other global factors, the accumulation of material, technical and financial resources as tools to influence the state, stability and development of systems.

2. Data and methods

The results of the research are obtained through the use of the following methods: analysis, synthesis, deduction, induction in the study of systems, theory of self-organization and scientific concepts that form the basis of modern research of self-organization of animate and inanimate nature of artificial or natural, organic or inorganic, socio-economic, technical, humanitarian, military, political and other origin; system method is used for explaining: patterns and principles of systems transformation, the general law of systems transformation; modeling is used when developing a mathematical model of the system.

3. Analysis of research and publications

A significant number of theoretical and methodological works of domestic and foreign scientists from various fields of knowledge are devoted to the study of systems (R. Akoff, V. Afanasyev, L. Bertalanfi, I. Blauberg, O. Bogdanov, N. Wiener, G. Hegel, V. Glushkov, I. Dzhalladova, F. Engels, M. Zgurovsky, I. Kant, O. Kutsenko, V. Kremen, T. Prokopenko, W. Ashby Ross, V. Sadovsky, T. Saati, J. Takahara, V. Flashman, A. Uemov, V. Shinkaruk, E. Yudin and others), in which the general theory of systems, system approach, system analysis are thoroughly covered. Based on these studies, we can state that the meaning of the system allows us to outline a wide range of different phenomena that have something in common and create the necessary prerequisites for its transformation into a philosophical category, absorbing the

essence of such important categories as order, organization, integrity, and at the same time, not being reduced in its objective content completely to any of them.

The second important complex problem, the study of which focused the views of scientists, was to determine the stability of systems, the focus on self-organization, analysis of factors that influencing their functioning. This was promoted, according to the scientists, by two outstanding achievements in the natural sciences of the opposite direction: the scientific foundations of Darwin's evolutionary theory and non-equilibrium thermodynamics (S. Grot, N. Carnot, P. Mazur, I. Prigogine, J. Fourier and others).The first one explained the development of living matter from lower forms to higher ones, that is the complication of structural organization in the process of evolution. The second one foresees the disorganization or destruction of the original structure in the evolution to equilibrium. Both achievements are directly related to the theory of self-organization of systems because they represent its essence in two opposite forms – the creation of structures and the destruction of structures, which is characteristic of systems of both animate and inanimate nature. In the process of further development of the theory of self-organization in the natural sciences, its provisions have proved to be universal and have been successfully used in social, economic, political and other processes of human activity.

The fundamental basics of the theory of self-organization, from the standpoint of thermodynamics, are reflected in the works of I. Prigogine, I. Stengers, H. Haken, H. Forster. Some provisions of applied aspects of the theory of self-organization in the socio-economic sphere are contained in the scientific publications of V. Vasylkova, S. Kapitsa, E. Knyazeva, B. Kuznetsov, S. Kurdyumov, G. Malynetsky.

Synergetics in education in the context of anthropocentrism has become the subject of fundamental research by V. Kremen, V. Ilyin. From the standpoint of philosophy, the synergetic paradigm as a methodological basis for the formation of worldviews of the XXI century is covered in the work of V. Lutay.

Problematic issues of systems transformation have found a place in a number of scientific publications in Ukraine and abroad: methodological aspects (A. Galchynsky, [4]); Ukrainian society (M. Mykhalchenko, 2001); society, public administration (V. Tsvetkov, I. Kresina, A. Kovalenko, 2003); economic systems (V. Zhuravlyov, 2014); transformation of the UK health care system (Leading health system); study of COVID-19 for the transformation of global health care systems (D. Clawson, D. Kellar, S. Larsson, 2020).

4. Results and discussion

The subjects of the research are both closed systems and open systems of different functional origin, that is, systems that are under the influence of external and internal factors. Therefore, first of all, we will stop on certain categories and concepts that are directly related to the problem that is under consideration.

The leading place in systems research belongs to the category of "system" (from the Greek. – a whole, composed of parts; combined). The opinion of the prominent philosophers is important here. I. Kant understood the system as the unity of various knowledge united by one idea (Kant, I., 1964, p. 680). G.W. Hegel believed that any subject of study is a system that develops itself, because it is only a moment of development of the idea (Gegel, G.V., 1932). The generalized philosophical definition of the system was formulated by F. Engels: "All ... nature is a certain system, a certain general connection of bodies, understanding the word body as all material realities ..." (Marks, K. i Engels, F., p. 392). According to the International Standards of the ISO 9000: 2015 series, a system is a set of interconnected or interacting elements (DSTU ISO 9000:2015, p. 12).

Exploring the structural essence of systems, patterns, conditions and stages of their development, O. Bogdanov identified the following stages: "complexion" (the system is a

mechanical union of elements among which there are no interaction); "conjugation" (there is cooperation between the individual elements of the system); "ingression" (transition of the system to a new quality); "degression" (the process of degradation of the system, its disintegration as a whole formation) (Bogdanov A.A., 2013).The author of the general theory of systems L. Bertalanffy considered a set of elements that interact to be a criterion of any system (Bertalanffy L., 1950).

In the "Philosophical Encyclopedic Dictionary" – a system is a set of certain elements between which there is a natural connection or interaction; quality characteristics of these elements are the content of the system, a set of regular connections between elements - the internal form or structure of the system…, the nature of the elements and the character of the structure of the system are divided into material ones that exist in objective reality (inorganic, organic), and ideal ones, which are an expression of human's consciousness (concepts, hypotheses, theories, linguistic and logical constructions, mental formations, etc. (Filosofskij enciklopedichnij slovnik, p. 583).

Saatiaccentes T. the need to note the target and functional components in the system. The concept of the system, according to the researcher, can be defined in terms of its structure, functions, goals, which are laid in its construction (Saati, T.L., 1993, p. 16).

In systems research, it is advisable to present the whole array of system concepts in several groups, each of which is specific to a particular range of problems that are analyzed. According to E. Yudin (Yudin, E.G., 1978, p. 183], the whole array of such concepts should be divided into such groups:

The first group of concepts covers the description of the internal construction of system objects: element, structure, connection, relation, environment, integrity, organization.

The second group of systemic concepts provides a description of the functioning of system objects: function, stability, equilibrium, regulation, feedback, homeostasis (from the Greek – the same state), management, self-organization, and others.

The third group of systemic concepts characterizes the processes of development of system objects: genesis, evolution, formation, and others.

The authors of the dictionary manual "Vocational Education" define the system as an order determined by the correct location of the parts; a set of principles fundamental to a particular study; the form of the order; method of construction; a set of parts connected by a common function, etc. (Profesijna osvita, p. 314).

Summarizing and supplementing the views of scientists, the concept of "system" can be represented as follows: 1) the system must contain a set of elements; 2) the elements of the system are connected in some way; 3) the connected elements of the system create a kind of integrity; 4) the elements of the system are in constant interaction through energy exchange; 5) the functioning of the system is characterized by certain patterns, principles, contradictions; 6) the properties of the system are different from the properties of individual elements of the set; 7) the system is under the influence of external and internal factors; 8) the system, depending on the conditions, circumstances, influence may acquire a state of development, destruction, chaos, etc.

It was noted above that the explanation and development of the theory of self-organization are related to the theory of evolution and the natural sciences, in particular, nonequilibrium thermodynamics. It supplemented classical thermodynamics by substantiating the theory of "structure creation" as a fundamental achievement of the natural sciences.

Let's have a brief look on some basic concepts of the theory of self-organization in the context of the laws of nonequilibrium thermodynamics, the theory of evolution, as well as its conceptual foundations that are directly related to the impact on the self-organization process of external and internal factors.

Classical thermodynamics in the general sense is the knowledge of energy, which studies various natural phenomena, based on its characteristic objective laws. The range of phenomena

studied by thermodynamics is quite wide: physical, chemical, technical, physiological, biological, space, etc. For further study, in terms of thermodynamics and the extension of its laws to a wider range of systems, two provisions are important: 1) thermodynamics involves the disorganization or destruction of the original structure during evolution to equilibrium; 2) the energetic nature of thermodynamics.

The theory of evolution is a scientific theory that explains the mechanisms of change in the forms of biological organisms and the reasons for their diversity, which arise over time in the process of their historical development, functioning, existence. Based on numerous observations of the development of living and non-living biological organisms (flora, fauna), Charles Darwin concluded that changes in them occur under the influence of two factors: 1) heritable variations; 2) selection. The scientist considered variability as a factor of evolution. In the struggle for existence in the natural environment (selection), Charles Darwin identified the following three main forms: 1) dependence on the environment; 2) intraspecific struggle; 3) struggle between species. It should be noted that at the end of his extremely effective scientific work, Charles Darwin expressed the opinion about the hypothetical nature of his theory, that he did not consider a number of external factors.

At the same time scientists claim that people should distinguish the difference between terms "evolution" and "the theory of evolution". Scientists have no doubts about the term evolution as indisputable phenomenon. As for the mechanisms of the theory of evolution that lead to evolutionary change, proposing different concepts, hypotheses, approaches, scientists have not yet reached a common opinion. First of all, it concerns to nature, influence on the process of evolution, their diversity, effectiveness and priority, to which the classical evolutionary theory does not provide a complete answer, as well as confirmation.

The most confessed scientist`s view of the process of evolution is *a synthetic theory of evolution* (modern evolution theory), which is a synthesis of different fields of knowledge, especially genetics and Darwinism. This theory depends on paleontology, molecular biology, taxonomy, etc. Nowadays a synthetic theory was formed as a result of changing a number of provisions of classical Darwinism from the beginning of genetics in the early twentieth century. Many scientist's societies consider that the founder of the synthetic theory of evolution was S. Chetverikov. In 1926 he showed the compatibility of the principles of genetics with the theory of natural selection, which was a great push to the development of evolutionary genetics. In further researchers, the authors of the synthetic theory of evolution significantly disagreed with a number of fundamental problems and worked in various sectors of biology (F. Dobrzhansky, S. Wright, N. Timofeev-Resovsky, R. Fischer, J. Holden Jr., etc. At the same time all researchers almost agreed with such interpretation of the main statements of a synthetic theory (Voroncova N.N., 1980; Chetverikov S.S., 1968):

- the elementary unit of evolution is considered to be the local population (subject as a system);
- the material for evolution is mutational and recombination mobility (change in the qualities of the system under the influence of external and internal factors);
- natural selection is considered as the main reason for the development of adaptations, the formation of species and super species (factors of external influence, the transition of the system to another state – ed.);
- species is a system of populations, reproductively isolated from the population of other species, and each species is ecologically separated (isolation of the system – ed.);
- gene drift is the cause of the formation of signs of species (internal interaction of system elements – ed.);
- speciation is the emergence of genetically isolating mechanisms and takes place mainly in conditions of geographical isolation (system environment – ed.).

All processes of evolution in dialectics are reflected in *the law of transition from quantitative*

to qualitative changes. According to this law radical changes do not occur by themselves, but due to gradual quantitative increases. And together they admit the future quantitative processes. The consistence of the law is in the categories of quality, quantity, measure, and their relationship. Generally, it characterizes only the way of development of the material world, its discreteness and continuity, but not defined at the same time the mechanisms, the factors leading to changes.

All-purpose law of dialectics is the law of unity and the struggle of opposites. The effect of law is appeared in systemic structures that take place in nature, society and thinking. The essence of the law is that it explains development as a self-movement, but as the previous law it does not define the mechanisms, factors that lead to dynamic changes.

Thermodynamics of irreversible processes determines the speed of nonequilibrium processes depending on external conditions

Stationary nonequilibrium states of the system are acquired under the influence of so-called boundary conditions, in particular, external influence on the system. According to the I. Prygozhyn theorem *(on the minimum entropy production)* the production of entropy in a stationary condition is really minimal. The general theory of stability (O. Lyapunov) proves that stationary nonequilibrium states with minimal entropy production are stable. At the same time, due to external influences, there are fluctuations in such systems. In a stable system, the resulting fluctuations themselves (spontaneously) decrease over time. Such internal processes do not lead to increased fluctuations (system oscillations). Conversely, in an unstable system, the amplitude of deviations (so-called gain) begins to increase and the system spontaneously, or with a high probability, goes beyond the stationary nonequilibrium state. While analyzing such systems the theory of turbulence is used. The transition of the system to a state of turbulence is characterized by the emergence of chaos – an increase in entropy. The dissipative structures is when unstable structures over time go from a state of stationary nonequilibrium state to an irregular nonequilibrium state and unexpectedly form a new system (Prigozhin I., Stengers I.,1986).

The synergetic concept is considered to be a studying about cooperation. According to it, the problems of the emergence of order from chaos, especially the transition of the system to a new state are investigated in the systems (Haken, G., 1983; Haken, G., 1980).

The concept of deterministic chaos reflects the emergence of chaos from an order. In this case, a system that is completely in an irregular, nonequilibrium, unpredictable state is classified as chaotic. This statement is characteristic of both dynamic systems in the natural sciences and social systems that are particularly sensitive to influences. According to this concept, it is believed that the impact on social systems must be kept in mind that any invasion in them can lead to completely unpredictable, chaotic developments and consequences.

Constructivism. Constructivist theory of knowledge is mostly used in the study of the impact on social and humanitarian systems. If such systems are studied as organizationally closed and self-referential, it is concluded that direct external influence, as a rule, does not achieve the goal that was set or arose spontaneously. Admirers of constructivism believe that external influence is perceived by the system only as an obstacle and "processed" by it in accordance with its own mechanisms. In our opinion this statement may be a partial case. There are such types of constructivism: social, cognitive-theoretical (radical), empirical, communicative-theoretical.

Interpreting theory of organization (system). The essence of this theory is that scientists take account on a social factor in contrast to functionalist theory, where the system is seen as a "black box". This ignores the factor of human behavior in the system, the conditionality of its stability. The purpose of the interpreting theory is to explain human actions in organization of the system and vice versa to explain these actions (reactions) through the actions of people (staff). The idea of this theory is that all staff of the organization operate within the reality that they create for them self. The meaning of interpretive theory in the study of social and humanitarian systems is that it

provides answers to such problems as the realization of external regulations; positive or negative consequences for structural or functional changes in the system; quality of interaction of elements, subsystems in integral system; measures to improve the efficiency of the system; tendency to self-organization, etc.

Psychotherapy is the system of therapeutic impact on the psyche and through the psyche on the human body. It is often defined as activity aimed to rid a person of various problems (emotional, personal, social). In this case, the person, as a subject, is under the influence of the medical worker (conversation, discussion, cognitive, medical techniques, etc.), and due to internal neuro-energy mechanisms expects only positive results from external influences and internal self-organization.

A new ontological paradigm of human development in the personality formation system (Krutov, V. V., 2014).Based on an analysis of the latest scientific achievements of quantum physics and cosmology and also criticism of the worldview foundations of modern "scientific realism", it is obvious that the way out of the worldview crisis of modern science should be found in developing a new spiritual paradigm of thinking. In this traditional system a human is considered as a subject and object only of the material world, which in science is presented as unambiguous structure – "matter-energy". In the innovation system, a human is considered as a subject and object of two worlds: energy information, which operates within the ontological model "Consciousness – Information – Energy – Matter", and the physical world (Krutov, V. V., 2014, p. 107).

A quantum psychology (Uilson, R. A., 2016). A quantum psychology based on the quantum mechanics and a quantum physics can accurately describe through subatomic world a picture of the whole, part of which is each of us and is aimed at studying the processes of human consciousness and learning, management of their lives. The basic of this psychology is that everything in this world consists of molecules and atoms, including thoughts and people speech. Speaking, man releases an impulse into the universe, which is reflected, returns back, but no longer to man himself, but to the molecules that surround him. As a result of such a movement, the space around the individual begins to change according to the impulse sent, and at any time we can receive information that will significantly change our own model of the world.

Epigenetics is a branch of biological science. It is believed as a branch of genetics that studies hereditary changes in gene activity during the development of an organism or cell division. The human hereditary apparatus is contained in the main DNA molecule (genome). All genes are separate areas which take only a small amount of a genome (up to 3%). Most of the genome (approximately 97%) is in a state of expression – the impact on genes. *This process is called methylation*, that is the impact on genes under the influence of various factors (lifestyle, education, upbringing, physical activity, nutrition, vitamins, trace elements, stress, treatment, society, spiritual environment, etc.). The state of gene expression leads to changes in man, the acquisition of new traits, qualities, diseases, etc., which can later be inherited to offspring. The most important in the epigenetics is the influence of the external factors and changing in physiological processes due to the action and cooperation of external and internal factors. The analysis of theories, scientific directions, paradigms, concepts stated above, allows to make certain generalizations, to be defined with laws and principles of transformation of systems

The main conclusions for researching transformation of the systems:

- the synergetic concept of systems is considered to be the study of cooperation, while some investigations in such systems claims that the problems came from chaos, it means the transition of the system to a new state;
- chaos is a consequence of the transition of the system to a state of turbulence;
- a significant impact on the state and dynamics of their functioning has the human factor, as a combination of certain actions on the system;
- the system is changing under the influence of internal and external factors;

- the main statements of the theory of self-organization, which were introduced in the natural sciences, proved to be universal and are successfully used in social, economic, humanitarian, political and other processes of human activity, represented by systems or complex solutions.

Thus, it can be argued that systems change, firstly, under the influence of the environment in which they are, secondly, under the influence of factors that this environment produces, thirdly, under the influence of internal systemic interaction caused by internal factors; fourth, under the influence of internal systemic interaction caused by external factors. That is, changes in systems in certain environments occur under the influence of external factors and two-order internal factors caused, firstly, by their own internal interaction, and secondly – by internal transformational interaction under the influence of external factors.This statement can lead to replacing the concept of "self-organization of systems" to the concept of "transformation of systems", which, in our opinion, more accurately characterizes the essence of changes happening in systems and their functionality. After all, in terms of terminological definition, self-organizational processes are mainly related to the action of internal factors.

Let's define the general laws and principles of transformation of systems, inherent in one way or other systems of any origin – animate and inanimate nature (biological, technical, economic, social, humanitarian, military, etc.).

Regularities of transformation of systems are caused by:

- *factors of cosmogenesis;*
- *quantum field theory, quantum psychology;*
- *objective processes of evolution;*
- *the energy nature of systemic change;*
- *the environment where the system is located;*
- *human factor;*
- *the influence of external and internal factors;*
- *interaction of internal factors;*
- *of internal factors under the influence of external factors;*
- *the level of knowledge inherent in the environment where the system is located;*
- *phenomena of various natures.*

The principles closely connected with the laws of transformation of systems serve as a certain system of principles on the basis of which transformation processes take place in systems. The principles, following from the laws of transformation of systems, determine their general direction, process and the result that the system can get.

The basic principles of system transformation include the following: scientificity; separate autonomy; procedural system; interaction; mutual influence; functionality; objectivity; subjectivity; controllability; diagnostics; security; adjustability.

Transformation processes occurring in systems are studied mainly by constructing generalized models (mathematical, functional, hierarchical, statistical, combined, etc.) that reflect all the factors, connections, relationships of the real situation that may occur in the implementation process. changes, determined or adopted decisions, etc. that may occur. The obtained model is investigated in order to highlight the proximity of the result of one or another of the alternative actions to the desired result, to assess the degree of sensitivity of the system to various external and internal influences.

However, according to theory and practice, none of these models, which represents certain activities, processes, material substances, does not correspond to the expected or practical results that a priori relied on them. In particular, it is well known that engineering and technological models need significant adjustments over the years and numerous tests. Humanitarian, social, economic, political, military models in general can be the results opposite to those envisaged by the subjects

of actions, projects, decisions. In the context of the above, in our opinion, the model of any system is a complex, multidimensional functionality of external and internal factors, which reflects its projected practical effectiveness. Taking these factors into account as a complex functional is a complex problem that requires thorough theoretical and applied research, primarily in terms of modeling accuracy. The general statement of accuracy indicates that it should be minimal, which reflects all the important features of the system. It is believed that the departure from detail is a saving of time, resources, reducing the amount of input and output data and even increasing the reliability of the model, associated with decreasing its complexity. On the other hand, too simple a model will not convey the essential qualitative features of the system and can lead to erroneous conclusions about its behavior, as well as to the following disastrous consequences – waste of time, significant resources, decline, and so on. Finding the limit of reasonable complexity is often not easy and it is finally determined, as practice shows, in the process of adjusting the model on practical samples, the so-called refinements and adjustments of iterative nature, which have an empirical orientation. It is another matter when there are theoretical and methodological developments in various fields of knowledge that allow you to build a model of a system with a sufficiently high degree of reliability of the process, which is its basis. At present, unfortunately, the level of scientific knowledge does not allow to implement such approaches, but it should only encourage further basic and applied research in various fields of knowledge – natural, engineering, social, economic, humanitarian, military, psychological and pedagogical, etc., as reality shows, are developing dynamically. In our study, we consider a generalized process of transformation of systems of different origins, based on a comprehensive consideration of the impact on the system of external and internal factors. It is obvious that the formation of models of systems that reflect their transformation on the basis of certain factors will have differences (inherent in one or another system of types of factors), depending on which system is by nature – biological, social, economic, humanitarian, military etc. The model of the system in general can be represented by the function of action and interaction of external and internal factors:

$$M = F(Ef; If),$$

Where Ef – characteristics of the action and interaction of external factors from 1 to *n*,

If – characteristics of the action and interaction of internal factors from 1 to *n*.

In turn:

$$Ef = f(Efi\ldots\ldots Efn); \quad If = f(Ifi\ldots\ldots\ldots Ifn), \text{ where } i \text{ from } 1^* \text{ to } n^*.$$

Factors influencing the system include the following:

- natural: biological; climatic; meteorological; geographical; radiation; wave (electromagnetic, space, gravitational, etc.);

- genetic: gene drift; hereditary; species; interspecific;

- radiation: mutational; recombination;

- human: structural and personal; intellectual; medical; missionary; target; degree of use of knowledge; psychological, including - neural programming; technological; instrumental; interests; motives, etc.;

- level of scientific knowledge (theory and practice);

- resources: logistical, financial; technological; information;

- degree of interaction of components.

Factors, in turn, have an external and internal nature.

External factors: natural; genetic; radiation; human; level of knowledge; degree of interaction of components; resources. External factors can be complex, then their impact should be considered as a result of the interaction of a set of influences. In this case, the external influence, in addition to the above, acquires the character inherent in the components of internal influence, in

the first place – the degree of interaction of the components.

Internal factors: natural; genetic; radiation; human; level of knowledge; degree of interaction of components; resource.

External and internal factors on formal grounds coincide, but their action in transformational processes has its own characteristics. Some factors, in particular, natural, radiation can have a double effect. For example, the impact on the human factor, which, in turn, affects the state of the system, its stability, adaptability or dissipation.

These factors, by their nature and action, are carriers of the categories of objectivity and subjectivity.

Objective factors include the following: natural; genetic; level of knowledge; degree of interaction of components.

Subjective factors: human; degree of knowledge; degree of use of knowledge; resources.

The diversity of certain factors of external and internal influence on systems, their objective and subjective nature, interaction at the current stage of knowledge development when used for modeling structured systems, their transformation, transition to another quality and functionality, obviously, will be an extremely big scientific problem. But science does not stand still, as eloquently evidenced by the history and practice of its development. Ultimately, this problem will be resolved progressively over time. The way to solve it lies in the discovery of mechanisms that cause the transformation of systems, i.e., the most optimal reflection of the abovementioned external and internal factors by physical, social or any other nature of mathematical, functional, statistical, expert methods based on the relevant functions and qualimetric approaches, as well as in the further search for innovative tools based on artificial intelligence.

An important subject of living nature is man as a system, given its personal structural components and the role that individuals play in systemic processes and actions of different origins. What is a person capable of? What is the complex intellectual potential, its components and areas of implementation? What is the purposefulness, leadership and willpower of a person? Does a person have a systematic, critical thinking? Why and how does he change in the process of development and professional activity? How to behave in critical situations? What is the morality and sequence of human actions? How to a priori avoid misdirections and risks, which often lead to terrible consequences? Such and many other questions often arise posteriori, i.e., after gaining some experience (in our case – negative). How to prevent negative consequences in human activities? No approaches to diagnosing human qualities and intentions with the help of psychological tests, psychophysiological equipment, modern tools of artificial intelligence, education, employment, illusory success, lobbying recommendations, etc. are effective, as evidenced by numerous national and international practices, as well as use, for the most part, trial and error procedures.

The answers to the questions about man, in our opinion, are in the plane of the theory of transformation of systems, in particular, as a separate subject of this theory – man as a biological system. External and internal factors of epigenetics, synthetic theory of evolution, quantum psychology, new spiritual paradigm of human development and other mechanisms as components of the general theory of transformation of systems, i.e., instrumental researches of the person at cellular-molecular-atomic level by means of artificial intelligence should become effective tools in it, able to "read" the thoughts, intentions, actions of people in real space and time. And at the current stage of development of science we can only state that the human factor, accumulating external and internal influences, becomes a significant factor in the transformation processes occurring in various spheres of human activity, so it should be as open, objectified and controlled with evaluation, responsibilities of both the authorities and the public environment.

An almost exhaustive list of external and internal factors influencing the system, their

objective and subjective nature allow us to conclude that the transformation processes are inherent in both open and closed systems of any origin.

Based on the above, it is possible to formulate a general law of systems transformation, which objectively takes into account all existing theories and concepts of transformation, self-organization and modernization of systems, i.e., quantitative, qualitative and functional changes that occur with them.

Systems or complex structured formations of any origin are transformed (changed) in essence and functionality due to the state of turbulence under the influence of the action and interaction of external and internal factors (natural, genetic, radiation, human, knowledge, resources, degree of interaction, etc.) which are carriers of the categories of objectivity and subjectivity.

5. Conclusions and prospects for further research

The world of animate and inanimate nature of organic or inorganic, political, socio-economic, technical, humanitarian, military and other origin is a certain way of structured formations, i.e., systems. The course of globalist, historical events, scientific research shows that the development and functioning of these systems are marked by various positive and negative results, i.e., system formations change (transform) over time, functioning in the environment under the influence of external and internal factors.

Transformation processes occurring in systems are studied mainly by constructing generalized models (mathematical, functional, hierarchical, statistical, combined, etc.) that reflect all the factors, connections, relationships of the real situation that may occur in the process of implementing changes, defined or decided decisions. The mechanisms of changes that occur in the systems have not found deep scientific coverage, especially in terms of methodology, patterns, principles and continue to be problematic and relevant for scientists in the present.

The development of systems transformation theory creates opportunities to develop a universal scientific approach and appropriate apparatus (tools) for modeling, analysis and evaluation of the degree of transformation of systems of any origin, determining their stability, preventing chaos, dissipation and appropriate corrective action, depending on mission and goals, which are prosecuted and carried out or take place. The way to solve this problem lies in the following areas: 1) in the plane of the most optimal representation of actions of the external and internal factors listed above on physical, social or any other nature by mathematical, functional, statistical, expert methods based on the corresponding presented functions and qualimetric approaches; 2) in the field of scientific instrumental research of man (as a system) at the cellular-molecular-atomic level with the help of artificial intelligence, able to "read" thoughts, intentions, directions of human actions in real space and time. These areas should be the subject of further theoretical and applied research.

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The authors declare that they have no competing interests.

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