Oleksandra TSYRA[1], Kateryna SHULAKOVA [2]

Opiekun naukowy: Nataliia PUNCHENKO[3]

PARADYGMAT SYNERGICZNY DLA PROJEKTOWANIA ZŁOŻONYCH SYSTEMÓW TECHNICZNYCH TRANSPORTU MORSKIEGO

Streszczenie: W artykule rozważono koncepcję złożonego, wieloskładnikowego systemu nawigacji technicznej, charakterystykę relacji pomiędzy komponentami systemu oraz relacje z otoczeniem zewnętrznym. Zastosowano teorię systemów Niklasa Luhmanna, która opiera się na adaptacji rozwoju systemów biologicznych i społecznych do złożonego, wielokomponentowego systemu technicznego. Struktura systemów ujawnia się poprzez opis komponentów, jako podział komponentów na aktywne i pasywne.

Słowa kluczowe: złożone systemy nawigacji technicznej, komponent, struktura systemu, teoria systemów Luhmanna, środowisko zewnętrzne

SYNERGY PARADIGM FOR DESIGNING COMPLEX TECHNICAL SYSTEMS OF SHIPPING

Summary: The paper considers the concept of a complex multicomponent technical navigation system, the characteristics of the relationships of the system components and the relationship with the external environment. The theory of systems by Niklas Luhmann is applied, which is based on the adaptation of the development of bio and social systems to a complex multicomponent technical system. The structure of systems is revealed through the description of the components, as a classification division of components into active and passive.

Keywords: complex technical navigation systems, component, system structure, Luhmann systems theory, external environment.

1. Introduction

The current outlook makes it clear that the world that surrounds us is a single and indivisible core. But in research, individual phenomena perform structuring.

[1] Senior Lecturer Ph.D., O. S. Popov Odesa National Academy of Telecommunications, Aleksandra.tsyra@gmail.com

[2] Senior Lecturer, O. S. Popov Odesa National Academy of Telecommunications, katejojo29@gmail.com

[3] Assoc. Professor PhD., Odessa State Academy of Technical Regulation and Quality, the department of automated systems and information-measuring technology, iioonn24@rambler.ru

Structuring takes place at a time when the post-industrial information society is being formed, the dominant problem of which is an increase in the proportion of artificial self-organizing regulators in a single integral system "society – Technosphere – nature". Mostly, interest is significantly focused on the current management problems that are associated with resource conservation, the new organization of socio-economic systems, environmental and nuclear safety of an open society. The concept of technological practice in the 21st century is significantly different; it consists in the development of significantly changed types of objects and processes, which are positioned as complex self-developing macrosystems. In macrosystems, cooperative phenomena can arise that are based on information interactions. The result of the expression of cooperative effects in developing systems is the emergence of a new structure without external force effects. We can see that structuring leads to the principle of a system that connects hierarchically arranged interacting subsystems. One can observe vertical and horizontal structured ordering of subsystems. Horizontal structuring of subsystems leads to the fact that there is a decisive influence on each other due to the presence of complex feedbacks between them, which cannot allow producing a vertical hierarchy of subordination of goals. When the hierarchy is vertical, the systems are structured according to the level of complexity for decision making. The principle of determinism of each subsystem regardless for the type structuring is described by the corresponding model with variables and parameters immanent to a specific level of abstraction. We can say that the processes of universalization, which are studied by modern nonlinear dynamics and synergetic, can arise in complex macrosystems.

Modern complex navigation systems demonstrate complexes of diverse subsystems that perform specific technological functions and are coordinated by their functioning, such as intense dynamic interaction, the exchange of energy, matter, and information. This supersystems are represented by nonlinear, multidimensional and multiply systems, where it is observed complex transient processes pass and critical and chaotic regimes are created.

This theory allows us to successfully master such methods as centralized external influence on a variety of objects. But it can be stated that the period has come for rethinking power approaches in management tasks and the transition to the ideas of self-organizing synergetic. From the above, such a need arises as the search for ways of oriented influence on such a process as self-organization in nonlinear dynamic systems. It became necessary to create methods of formations and resonant excitations of the internal force for interactions, which generate the sought structures in the phase space of the synthesized systems – attractors adequate to the physical essence of the system.

2. The structure of active technical systems

The term complex technical navigation systems mean systems in which it is not easy to simulate behaviour due to the variety of dependencies between their parts or because of the complex interaction of the system and the environment [1; 2]. "Complex" systems are endowed with such properties as nonlinearity, heterogeneity, partial stochasticity, uncertainty, feedback loops (cycles) and others [3-5]. The application of these systems is diverse [6], therefore, general characteristics of systems are distinguished.

Consequently, we immediately notice the dissimilarity of modern complex technical systems and complex technical systems that existed in the "pre-computer period". When drawing a parallel, information technologies of this time differ from pre-computer information technologies (telephony, telegraph). By analogy, modern complex technical navigation systems differ from the existing complex technical navigation systems by the fact that the information computer and telecommunication component was included. Hence, it follows that modern complex technical navigation systems are often denoted by the term "complex information and technical navigation systems", although it is not widely used, but in terms of meaning it is that suits such systems. Therefore, when we are speaking about complex technical systems of navigation, it always means that there is an information component in the systems as the main one. The study of complex technical systems involves changing the internal relationships between parts and external relationships with the environment. But here it is necessary to consider that the external environment and human are not elements of a technical system [9].

When studying complex systems, attention is paid to structural analysis [8] and structural modelling.

We must not forget about the fundamental difference between systems analysis and the theory of complex systems. Systems analysis in the study of complex systems uses the same abstraction for different subject areas. It does not consider the characteristic features of complex technical systems and reduces to abstract and simplified models of complex systems. Essentially, systems analysis wants to eliminate "system complexity" and treat such systems in a simplified form.

Complex systems theory has taken a direction that studies complexity as the main characteristics of complex systems and complex technical systems. Consequently, the theory considers the approaches of all factors that can influence the creation of complex systems. When considering complex technical systems of navigation as a complex system the concept of a distributed system is approached. What follows is a chain when studying distributed systems, we come to the concept of a network or a network system. Therefore, it is possible to compare complex technical navigation systems with network systems or a network.

The difference between complex systems and complex networks is that the network reflects the simple formation and interaction of links between nodes. By its structure, a network can only characterize the state of an object, or the transition of an object from one point of the network to another. The network includes many objects, the network itself is a characteristic for these objects. Therefore, an important characteristic for a network is the transition between its nodes. The network reflects the structure of communication and the interaction between nodes.

The structure of complex systems often characterizes one object. The characteristic of the relations between the components of the system and the relationship with the external environment constitutes the structure of a complex technical navigation system. Complex systems have additional properties in relation to the network: integrity, emergency, unergativity [10], multilevel structure, as well as the presence of relations that are not connections, but affect the functioning of the system.

The principle of complex systems are blocks or components, which are combinations of elements according to common functional purposes. This principle is nothing more than a physical one, since the components or blocks of a system are represented as small systems that have a common input and output.

Studies of the autopoiesis of a complex technical navigation system show that modern complex technical navigation systems use elements of artificial and natural intelligence. The concept of autopoiesis is used exclusively for this type of systems. The term “autopoiesis” was introduced by sociologist Niklas Luhmann in his theory of social systems, which is based on three concepts that are linked together in his work [13]. These are the following concepts: systems theory as a theory of society; communication theory; evolution theory. These provisions were developed in his work [14]. The main categories that underlie the theory of Luhmann's systems are as follows: complexity, reduction, reflection, autopoiesis, functional differentiation. It should be noted that the theory of Luhmann systems differs qualitatively from most theories of systems of other authors [3–7]. Classical systems theories are based on abstract models that are dependent on logic and mathematics. Luhmann's theory of systems is based on the development of bio and social systems.

The difference between wholes (systems) and parts (blocks of systems) in Luhmann's theory is transformed on the differences between systems and the environment. This principle is new in relation to the classical theory of complex systems since the concept of complex systems is often interpreted with closed systems. The theory of Luhmann systems is between the classical theory of systems and the theory of dynamical systems [3]. At various stages it is constructive to various kinds of complex technical systems, including complex technical systems of navigation. Figure 1 drive the basic principles of the theory of social systems.

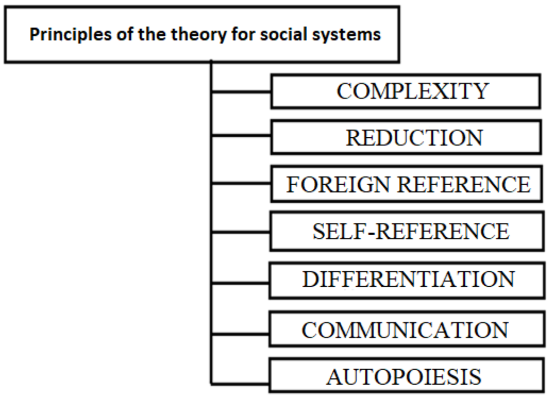

Figure 1. Basic principles of Luhmann's theory of social systems

Using Luhmann's theory of systems, it is noted that autopoiesis is a connecting link between systems theory, communication theory and the theory of evolution. Using this connection, classes of autopoietic systems were identified abroad, which it became possible to include complex technical systems of navigation.

A complex technical system is characterized by dependence on the cognitive factor.

Without exception, all blocks of complex technical navigation systems are controlled using the principle of their own or external intelligence. Information interaction of the system blocks with other blocks connected with them is carried out. A separate block of the system has the possibility of development or self-development. And, through any block it is possible to influence other blocks associated with it. Information exchange between blocks contains uncertainty. Due to this, between the blocks, after some time, there is an accumulation of information asymmetry and a violation of information correspondence occurs. In the presence of blocks with intelligence, the adaptability of a complex technical navigation system and its autopoiesis are ensured. The vital activity of complex technical navigation systems takes place with an acceptable opposition of the external environment. Taking this factor into account, complex technical navigation systems form the functions of counteracting the external environment.

A complex technical navigation system is endowed with such properties as adaptability, resource capacity, the possibility of self-organization, stability, organization, intelligence, integrity, which can be considered basic.

The work of Brodsky Yu.I. and Pavlovsky Yu.N. "Development of a distributed simulation instrumental system" introduced the concept of "components" in relation to the implementation of a closed model isolated from the outside world for the purposes of simulation. The concept of a component is formulated as a complex system that does not allow (does not require) further decomposition for modelling purposes, and the totality of such components forms a model considered by complex technical navigation systems. The device of a component is like the object of classical analysis and has characteristics, events, and methods, but already modified. The concept of components is extended and brought to the highest level for using the description not of models of complex technical navigation systems, but directly of their organizational structures, i.e. transition to the study of multicomponent complex technical navigation systems. We observe how another important integrative variable property of a complex technical navigation system arose – multicomponent. The presence of such a property in a complex technical navigation system generates a new class of complex technical navigation systems – a multicomponent complex technical navigation system. This aspect, which is the cornerstone in the system-synergetic paradigm of considering complex technical navigation systems, does not allow considering complex technical navigation systems from the standpoint of the classical system analysis of complex systems. The multicomponent nature leads to the need to develop new conceptual principles of systems analysis of such systems [13].

3. Component view

A multicomponent complex technical navigation system is a complex system that has a tuple of properties <A1,A2,A3,A4,A5,…> and formed by a compact set of components S={K1,K2,…..Kn}. Where each component positions itself as a separate complex technical navigation system, which is formed by subsystems of a complex technical navigation system. With a variety of purposes of system analysis with one complex technical navigation system, the number of components that have been formed can differ n=var. It follows that the options are diverse, which combine the elements of complex technical navigation systems into components, postulate the problem of the multiplicity of the component description of complex technical navigation systems.

Based on the above, the definition of a multicomponent system is refined. A multicomponent technical navigation system is a complex hierarchical system with the property of multi-components, functioning under conditions of uncertainty for initial data, mismatch of local goals and disruption of internal organization due to newly emerging properties, in the process of achieving a global goal.

Formation of components into complex technical navigation systems that have the property of multicomponent, i.e. in the sense of the introduced definition of a multicomponent system occurs on the basis of achieving a single goal or on the basis of elements aggregation by the type of uncertainty. If the global goal of the system changes, the local goals are corrected, which leads to a change in the structural organization of the system and the formation of components. The combination of components based on the uncertainty type is based on the assumption that in order to transfer a multicomponent system to a target state and ensure the stability of this state, a number of subsystems and their elements can form structures, the components of which are affected by similar in nature uncertainties.

Connections between components can be explicit when the influence of one component on another is traced or indirect, when a relationship is observed, but it is difficult, and often simply impossible, to identify its influence on one or another component of the system.

The components interact with each other and the external environment, realizing this interaction by means of organizational relations.

In the context of considering a multicomponent system, the key aspect is the sustainability of its organizational structure. In this case, the relative position of the components can change, but this modification should not violate the explicit connections that ensure the functioning of the multicomponent system to perform the intended consumer functions and achieve the global goal. We must not forget that in case of a violation of communication or structure, it is possible to radically modify the purposeful movements of multicomponent systems, which may not allow the system to be transferred to the target state.

Communication between components of multicomponent systems is ensured through explicit and indirect communication. From this it follows that each component belongs to the class of active or passive in the behavioural sense. It is obvious that the behaviour of a technical system within an organization of components that form an inseparable whole affects its belonging to a certain group of a multicomponent system. An active component is a system that necessarily includes the organs of technical vision and sensory perception, as well as measuring instruments that allow us to build sensory maps of the surrounding space, means of understanding sensory maps, consciously planning our actions and implementing this plan. Let us highlight the main behavioural features of the components in conditions of uncertainty (Table 1).

Table 1. Basic rational behavioural features of components

Feature	Note
The presence of organs technical vision and sensory perception	Allows to build sensory maps of the environment with a selected time interval
The presence of a mechanism for understanding the sensor map and recognizing the current situation	Recognition of the image of the current situation considering the existing uncertainty
Ability to form a plan of behaviour considering the available sensor map	Allows to exclude the influence of uncertainty on the behaviour of the subsystem
Availability of a mechanism for implementing a plan of behaviour	Adaptation in a changing external environment

The sensory map of the environment represents the outline of the situation in which the component can be at a given moment in time. A passive component of a multicomponent system is a technical component that does not possess any signs of intelligence. An active component is a component that has rational behavioural characteristics under conditions of uncertainty. The introduction of two new organizational and behavioural components into the depths of multicomponent systems, in particular the active and passive component, makes it possible to study its heterogeneous subsystems not from the classical position of continuous and discrete production in static or dynamic modes, but, from the point of view of intelligent self-organizing systems with a certain behaviour. This aspect is key in the formation of a new concept of system analysis of MS in conditions of uncertainty of a passive technological process [14].

The most appropriate mathematical apparatus for constructing a model of a passive technological process is the method of artificial intelligence. A detailed classification of artificial intelligence methods in relation to the nature of the tasks being solved is given in a huge number of sources [15].

4. Conclusions

The article emphasizes the type of complex technical systems as a multicomponent system. This type of systems is the next step in navigation systems and can rather be attributed to the direction of "Big Data" than to the direction of classical systems theory. At this stage, it is necessary to modernize the theory of complex systems, since the theory of complex technical systems for navigation applies the principles of self-reference, differentiation, and communication. The concept and principle of autopoiesis is also used, the basis of which we see in more detail in the synergetic theory.

The synergetic approach made it possible to reveal new aspects of the synthesis and design of multidimensional and interconnected systems with a wide class of complex nonlinear dynamic objects.

And having the basis of how to define the organizational structure of a multicomponent system, it became possible to describe a hierarchical structure for managing systems.

After the isolated components of the organizational structures of multicomponent systems have been identified, it is possible to globalize approaches for the system analysis of a certain type of systems.

REFERENCES

1. BAR-YAM, YANEER (2002). «General Features of Complex Systems» (PDF). Encyclopaedia of Life Support Systems. EOLSS UNESCO Publishers, Oxford, UK.
2. TSVETKOV V.YA. Complex technical systems, International Journal of Applied and Fundamental Research. (2016)10-4, 670–670.
3. KUJ S.A. Multidimensionality of consideration of complex systems, Prospects for Science and Education. 1(2014), 38–43.

4. BERTALANFFY VON L. General theory of systems - a critical survey. In the book. Research in general systems theory. Progress 1969, 23–82.
5. MESAROVICH M., Takahara N. General theory of systems: mathematical foundations. Mir 1978, 311.
6. SAVINYKH V. Systematicity in dissertation research, Educational resources and technologies. 2(2015)(10, 92–98.
7. BUTKO E.YA. A systematic approach to the formation of the structure, Slavic Forum. 2(2017)16, 25–31.
8. TSVETKOV V.YA. Structural modelling: monograph. MAX Press, 2017, ISBN 978-5-317-05518-9.
9. PUNCHENKO N., TSYRA O., KAZAKOVA N. Computer-integrated technologies as a global trend of navigation safety of an innovative society. "INFORMATION TECHNOLOGIES AND COMPUTER MODELLING", Proceedings of the International Scientific Conference 2020, May 18-th to 22-th Ivano-Frankivsk, 23–26.
10. TSVETKOV V.YA. Resource and imperativeness of a complex organizational and technical system, International Journal of Applied and Fundamental Research. (2016)5-4, 676–676.
11. LUHMANN N. System theory, Evolutions theory und Communications theory, Soziologische Gids 1975.154–168.
12. LUHMANN N. Introduction to the system theory. Logos, 2007, p. 360. ISBN 5-8163-0076-8.
13. ZAIKOV V. I., ZAIKOV S. V. Mathematical Model of Ships 2-D Motion, Selected Papers of Association of Graduates of the Shipbuilding and Ocean technique Faculty. Vol. 1. Applied Hydrodynamics. State Marine Technical University. St. Petersburg, 1993, 160–169.
14. SHCHERBATOV.A.: PROTALINSKYO.M. Decision support system for operators of poorly formalized TP, Automation in industry. (2009)7, 41-45.
15. BRODSKY YU. I., PAVLOVSKY YU.N. Development of an instrumental system for distributed simulation modelling, Information technologies and computing systems. (2009)4, 9–21.